FINAL REPORT:

Climate Awareness Workshop (CLAW) with an Emphasis on Fisheries Impacts in the Pacific, Adaptation and Loss and Damage Advocacy

CLIMATE AWARENESS WORKSHOP
WELLINGTON NZ FEB 19-22, 2024

Meeting Venue

Wharewaka Function Centre
2 Taranaki Street
Wellington, New Zealand

`

Contents

Introduction to workshop 1
Opening address 1
Day 1 -Climate Change Terminology, IPCC Scenarios, and Basics of Climate Variability and Change 2
Climate change terminology (Espen Ronneberg, SPC) 2
Introduction to IPCC scenarios (Elizabeth Holland, USP) 2
Exploring climate variability (Moleni Tu'uholoaki, SPC) 4
Basics of climate change (Richard Matear, CSIRO) 5
Melting ice and sea-level rise (Richard Matear, CSIRO) 7
Day 2 - Physical and Biological Impacts of Climate Change 9
Ocean warming and marine temperature extremes (Thomas Moore, CSIRO) 9
(The great) tuna fisheries of the Western and Central Pacific Ocean (Steven Hare, SPC) 10
Biodiversity loss and ecosystem disruption (Christophe Menkes, IRD) 11
Ocean and marine ecosystems (Patrick Lehodey, SPC) 12
SEAPODYM and modelling of tuna population dynamics (Inna Senina, SPC) 13
Incorporating climate scenarios in fisheries research (John Morrongiello, University of Melbourne) 15
Day 3 - Climate Change Planning within the WCPO 18
Coastal fisheries and climate change (Brad Moore, NIWA) 18
Case studies on Climate Change Impacts on PICTs – summary (Zulfikar Begg, SPC) 19
Potential economic impacts on tuna fisheries and resource owners (Chris Reed, FFA) 20
Climate-Informed Fisheries Management Strategies (Marina Abas, FFA) 20
Introduction to International Climate Change cooperation frameworks (Todd Croad, MFAT NZ) 21
What regional collaborations are currently ongoing (Simon Nicol, SPC) 22
Data Collection and Modelling for Climate Scenarios (Simon Nicol, SPC) 24
Day 4 - Loss and Damage and Advocacy for Pacific Island Countries and Territories 26
Understanding Loss and Damage (Pasha Carruthers, SPC) 26
Grassroots Organizing and Community Engagement (Ueta Faasili, FFA) 29
Advocacy Strategies for loss and damage (Espen Ronnenberg, SPC) 30
Decision Pathways (Ludwig Kumoru, FFA) 31
International Platforms and Collaborations (Espen Ronnenberg, SPC) 31
Introducing tools that increase accessibility to climate change indicator data (Joanne Potts, SPC) 32
Country perspectives 33
Guam (Brent Tibbatts) 33
Niue (Poi Okesene) 34
Closing remarks 34
Appendix 1 – List of attendees 37
Appendix 2 – Summaries from the Slido surveys 41
Appendix 3 – Summaries from the CLAW participant post-meeting survey 46

`

Introduction to workshop[1]

The purpose of this workshop was to present a comprehensive overview of the nature and impacts of climate variability and climate change on the industrial fisheries of the Western and Central Pacific Ocean (WCPO). The workshop was conducted in a seminar style, with many guest speakers from around the Pacific addressing a wide array of topics. The workshop began with defining terminology and the Intergovernmental Panel on Climate Change (IPCC) scenarios. Over the course of four days, participants were briefed on the basics of Climate Change and how it differs from Climate Variability, and the broad ecosystem impacts of climate change and specifically focuses on the fisheries and oceanic ecosystems of the WCPO. Additionally, participants were briefed on how climate change scenarios are being incorporated into fisheries research and management and was concluded with a full day on Loss and Damage and Advocacy for Pacific Island Countries and Territories. The subject matter of the workshop was suited to senior-level decision makers within the Fisheries, Environmental and National Resources ministries of the Pacific Island Countries and Territories (PICTs) of the Western and Central Pacific Ocean and their policy advisors. The intent of the workshop was to "climate educate" fisheries managers and policy experts and enhance awareness of emerging issues related to climate change.

Opening address

The workshop was opened with a prayer followed by an address from Stephen Harris from New Zealand Ministry of Foreign Affairs. Stephen welcomed the group to Wellington and noted his old friends and some of the Pacific leaders in the room. He noted that his team helps to translate work from meetings like this to the Pacific leaders so that they can deal with these emerging issues. This work is about the environment, the economy and the maintenance of livelihoods and social and cultural wellbeing throughout the region.

With climate we are all in the same boat and what comes out of this week's discussion will impact how we advance our various programmes and the address intergenerational challenges facing us. New Zealand has new team members and this is a good opportunity for them to kick off their work for the year.

He noted that SPC is a core partner and thinks that partner led initiatives are critical for MFAT and a key role in how they progress their partner led spending. This is a good example of how the work is unfolding. Kowing how tuna will be responding to future climate conditions will allow you, the countries whose tuna it is, to respond better in planning how to catch the fish and develop processing and handling investments in future and to negotiate more effectively to protect your rights.

This workshop is an important element in that programme of work and he thanked the organisers for pulling it workshop together. He encouraged participants to get the most out of the workshop and the opportunities that it will provide. He wished the participants well. He concluded by saying. Be strong, be steadfast and be bold.

[1] The organizing committee of the CLAW was comprised of Simon Nicol and Steven Hare of SPC, and Ludwig Kumoru, Marina Abas and Ueta Faasili of FFA. The organizers wish to acknowledge and thank Stephen Brouwer for serving as rapporteur for the workshop and assembling the bulk of this Final Report. Funding for the CLAW was provided by the New Zealand Climate Science to Ensure Pacific Tuna Access (CSEPTA) project.

Day 1 - Climate Change Terminology, IPCC Scenarios, and Basics of Climate Variability and Change

Climate change terminology (Espen Ronneberg, SPC)

Espen Ronneberg from the SPC presented the paper on climate change terminology. This clarified essential terminology such as greenhouse effect, carbon footprint, adaptation and mitigation. The presentation also clarified key concepts to establish a common understanding between participants. Overall, he noted that it is important for all sectors to be cognizant of the language used by other sectors, and to enhance climate change literacy at all levels. Climate change terminology needs to be unpacked in terms that the broader public can understand. As an example, the usage of the concept of a blanket of greenhouse gases can be quite effective when talking about warming, and that the increased emissions contribute to the thickening of that blanket. This in turn increases the level of energy of the atmospheric system, leading to more extreme impacts of what is already observed from climate variability.

Discussion

During the discussion it was noted that *climate justice* is not a term that was used in the presentation, rather the terms l*oss and damage* was referred to. Climate justice is used in fisheries in the Pacific. Climate justice was brought to the climate change discussions by civil society and it is used to highlight the injustice of the problem. For example, Pacific Island Countries (PICTs) produce the fewest impacts globally but get the brunt of the damage from the impacts of climate change. However, the term climate justice has not been accepted internationally. Oil producers say that stopping oil production is an injustice for them, so they are unwilling to use that term. Some aspects such as security around climate change are acknowledged and this may be more constructive terminology to use when engaging with polluters.

It was also noted that climate change and climate variability are defined on different scales. Climate change is a longer-term impact and climate variability is more short-term such as a switch in ENSO state, but both are caused by climate change. Variability has short-term impacts but the system usually can revert back to its original state, whereas climate change is longer-term and cannot be reversed.

Positive impacts of climate change tend to be highly localised from a global perspective. For example, you may get increased rice production in a small local area, but globally rice production will decrease. As a result, the small positive local changes are overwhelmed in effect by the global scale negative changes.

Introduction to IPCC scenarios (Elizabeth Holland, USP)

Elizabeth Holland, formerly from the University of the South Pacific, gave an introductory presentation to Intergovernmental Panel on Climate Change (IPCC) scenarios. Her introduction clarified the role of the IPCC, and o included an overview of (Representative Concentration Pathways(RCPs) and explored how climate models predict future changes in temperature, currents and ecosystems.

This overview of the Sixth IPCC Assessment Cycle (AR6) included a series of Special Reports including the Special Report on Global Warming of 1.5°C and the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) requested by Pacific leaders. The first IPCC Assessment report was released in 1992 and the most recent report was released in 2023. The IPCC is the authoritative voice summarizing the state of the climate and projected impacts.

The ocean is the largest thermal sink for the warming resulting from climate warming. The ocean has warmed to below 2 km, ocean pH has declined with resulting ocean acidification. Marine heatwaves are increasing in frequency and extent. Deoxygenation of the ocean, decreased pH, increased ocean acidification are all changing that state of the ocean. The top three Greenhouse Gases (GHG) are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). To understand the increase in GHG concentrations in the atmosphere, it is important to understand the global and local carbon cycles. The state of the carbon cycle was presented covering emissions, the importance of sources and sinks in determining atmospheric carbon dioxide concentrations, the most important of the greenhouse gases involved in climate change.

The Shared Socioeconomic Pathways (SSP) scenarios used in the AR6 project a range of temperature increases from 1.5°C to more than 4°C of surface warming in our changing climate. At the higher SSPs with increased GHG emissions and associated warming, the ocean is unable to continue to remove the carbon dioxide from the atmosphere thus increasing the proportion of carbon dioxide in the atmosphere at the higher SSPs. The combined effects will further accelerate warming and thus further amplify the impacts including acceleration of sea level rise. Only the SSP1 scenarios, SSP1-1.5 and SSP1-2.6. ensure that Arctic ice sheets are protected throughout the year.

The SROCC, the AR6 reports, and the special reports highlight the need for urgent action to decrease GHG emissions. Sea level rise projections for 2300 increased to 5.4 m with further increases possible for the high impact/low probability projections of sea level rise that include more detailed presentation of ice loss. At 1.5°C of warming, there is a high risk of losing 70 to 90% of global coral reefs and associated services for humankind with even more loss at 2°C. The ongoing strong El Niño resulted in dramatic ocean warming and the global mean temperature increase exceeded 1.5°C in June 2023.

Discussion

It was suggested that for a fisheries audience, IPCC could be considered similar to a fisheries management strategy evaluation and we can use it to develop options for to explore how the world may work under alternative climate change forecasts.

There was a lack of information from the Pacific in early IPCC reports. As such it was felt that there is a need to focus more on the Pacific, and that Pacific-based climate scientists and managers should work harder to bring this information to the forefront of international discussions. It was noted that capacity within the region is growing, and as an example over the last few years, within the region, more than 200 post graduate students have completed theses on climate-related work. In addition, some New Zealand universities, such as Canterbury, are doing more work using Pacific data which gets

this information into peer reviewed journals. However, there is still a need for more information on local Pacific knowledge and local descended knowledge that needs to be elevated to the international community.

It was noted that climate scientists are concerned about the impact of climate change on the future of the habitability of the planet. However, there is no official climate change doomsday clock to summarise the combined impacts of all climate related issues. What we do know, is that currently we are running out of carbon budget but there is no clear plan as to what to do when it is reached or exceeded. There is also no common agreement about which method to use to predict capture carbon requirements in future.

The lack of a single body regulating emissions was noted. The International Court of Justice (ICJ) has no responsibility over bunker fuel or aviation fuel. Bunker fuel is regulated under the International Maritime Organisation (IMO) and aviation fuel is regulated by the International Civil Aviation Organisation (ICAO) neither of these entities are responsible for any climate regulated activities. This is problematic and agreements on who takes the responsibility still need to be resolved and where the boundaries for that responsibility lies. For example, for an airline or shipping company, who pays for the carbon, is it the purchaser, airline/shipping company, country of destination or country of departure? Under the climate change convention there are also different responsibilities for developed and developing countries. This concept is not in the IMO nor ICAO. The Marshall Islands, as a country with a large fleet of ships, has started to do this voluntarily, but shipping companies are trying to avoid any levies and are resisting changes. To get more clarity on the scale of the situation, SPC is developing a system to house extended knowledge on bunker fuel and other related issues.

Models for predicting the impacts of climate change are good and getting better as we get more information to feed into them. Some areas such as the carbon budget and impact of carbon are well refined and the science community has a high degree of certainty in them. There are areas where improvement is needed, but some of these are hindered by the diverse community. Moreover, some of the models are the result of a negotiated outcome and as such are likely to be conservative. It was noted that in order to make things more explicit and meaningful for non-experts, the IPCC should put statements into threshold groupings for clarity.

Exploring climate variability (Moleni Tu'uholoaki, SPC)

The presentation on exploring climate variability was presented by Moleni Tu'uholoaki. This included defining climate variability which are natural fluctuations in climate patterns; as well as providing an understanding of short-term variations and their impacts on weather patterns.

The presentation covered various topics related to climate change and its impacts. It emphasised the importance of understanding climate variability and its effects on weather patterns. The topic of climate variability in the Pacific was explored, focusing on the impact of large-scale climate drivers. The discussion covered the West Pacific, the role of warm water and wind, and the Southern Hemisphere's atmospheric and oceanic systems. The presenter has analysed rainfall patterns in the Pacific, the formation of tropical cyclones, and the potential impacts of climate change. He mentioned

ongoing research and the need for extensive data to differentiate between climate change and natural variability.

This talk explored major climate variabilities in the Pacific. The distinction between weather, climate and climate variability were discussed, including various factors influencing the climate, particularly large-scale climate drivers which were responsible for large-scale variations in rainfall, temperature and sea level distributions at a scale of weeks, months, years or several years and even decades in the Pacific.

The key drivers of climate variabilities in the Pacific such as the Western Pacific Warm Pool (WPWP) Intertropical Convergence Zone (ITCZ), South Pacific Convergence Zone (SPCZ), Trade Winds, the Madden-Julian Oscillation (MJO), El Niño–Southern Oscillation (ENSO) were discussed. This included their variations due to movements and intensity that impact weather patterns in the Pacific. A reference to changes in winds, temperature, tropical cyclone genesis and sea level with different phases of ENSO in Tonga is presented to highlight the need to redefine ENSO at the local scale. There was also a discussion on an unusual variation of sea surface temperature anomalies and the position of the SPCZ in January 2024. This resulted in the highest monthly rainfall ever recorded in Tongatapu, which is uncharacteristic during El Niño events.

Discussion

Local impacts on different islands during ENSO changes were discussed. In Tonga, during the recent El Niño, the ocean was unexpectedly cool. This is due to the wind driven upwelling locally, resulting in Tongan local conditions being different from the overall general predictions. As a result, while you can have broader subgroupings of areas, island specific information will likely show that each country will be different and will need to be investigated separately.

The SPCZ moves south in La Ninia events, but the most recent event seemed to have been the most extreme. It was highlighted that seasonal variability can mask the changes of climate change as such when evaluating the scale of climate change the long-term effects need to be assessed in order to overcome the interannual and seasonal fluctuations. But more local long-term records will help elucidate what these impacts may be for local communities.

Lastly, it was highlighted that the concepts of ENSO are challenging to convey to the public, and it is difficult to get the correct messages across. It considered that the best way to convey these messages was in terms of impacts as that is something that people can relate to.

Basics of climate change (Richard Matear, CSIRO)

The basics of climate change were presented by Richard Matear from CSIRO. The presentation focused on differentiating between climate variability and climate change and introduced anthropogenic factors causing climate change and environmental changes associated with climate change.

The presentation emphasised the role of oceans in the climate system. The oceans absorb most (90%) of the anthropogenic heating and will be the ultimate repository for about 80% of our anthropogenic

carbon dioxide emissions. Unfortunately, the ocean uptake of carbon dioxide is slow (1,000s of years) in preventing climate change. Thus, it is important to actively manage greenhouse gases to achieve global climate change goals. The world is making positive steps to reduce emissions, but these need to be accelerated.

The climate has changed in the Pacific over the last 70 years (e.g., the surface has warmed), but separating anthropogenic climate change from natural variability is challenging because the region has large interannual (e.g. ENSO) and decadal variability that have large impacts on the climate and the weather.

The future climate will continue to change as the earth warms. Climate change occurs at the global, regional and local scale, and there is a need to understand the local impacts. The impacts of climate change, such as on fisheries, are also both chronic and acute.

Climate change may alter the climate, amplify the ENSO cycle and alter the frequency and magnitude of extreme climate events. For example, as the region warms, one expects increased frequency and severity of heat waves (land and marine); coral bleaching, which will damage plants and other organisms which will have cascading impacts on ecosystems (e.g. loss of seagrass due to warmer water reducing key habitat for the juvenile fish altering the fish biomass and diversity of a region). Corals are starting to inhabit areas that were previously not suitable habitat due to high temperatures shifting poleward, suggesting a grim future for coral reefs in the tropics if global warming continues. The compound risks, such as stressing organisms and removing important species, could lead to the prevalence of invasive species.

The consequences of climate change may have unforeseen consequences. For example, there was a massive mortality event of snow crabs in the North Pacific because the warming water increased their metabolism faster than their ability to eat enough food and they died of starvation.

The importance of considering complex risks and how they can amplify the consequences of climate change was noted. The impacts of climate change are not confined to local areas, as events such as sea level rise can lead to global migration. The importance of local information in understanding the impacts of climate change and developing a project on ocean certification would be useful. Increasing the number of monitoring stations in a region could provide valuable insights, improve the accuracy of models and reduce uncertainty. The complexity of climate and weather systems and the need for quantitative measures to understand and predict changes was stressed.

The relationship between climate change and tropical cyclones is difficult to predict due to their infrequent occurrence. There may be a decrease in the frequency of tropical cyclones, but an increase in intensity due to the higher heat in the atmosphere.

Discussion

The risks of how things compound as the climate changes was discussed. It is relatively common to oscillate between rain, drought and fires. As an example, climate change can cause droughts resulting in the die off of vegetation, which can result in increased fires, this can be followed by heavy rain

which then causes flooding and washes the soil away as there were no plants to hold it in place. These impacts are all extreme and can result in compounded effects in sequential seasons or years. In addition, when you push a system and damage it, other organisms will take over so impacts like coral bleaching can cause a proliferation of unwanted species that can cause additional damage to the system.

Ocean acidification information is generated from a limited network but these data are important. There can be big CO_2 oscillations in a short period of time and it varies locally, so local data collection is critical and data from many local areas around the Pacific is required.

Climate scientists use an ensample of models and both the observation of the event and the observations of the parameters are required to improve the models and both are equally important to evaluate the impact of climate change and the consequences of that change. Cyclones, for example, are difficult to predict, there seems to be a link between ENSO and cyclones. However, the numbers are small, and developing models based on few observations is challenging to resolve this and more observations are needed. There may be fewer but larger cyclones as the atmosphere warms.

El Niño had an impact on the 2023 record temperatures and sea surface temperature trends at the equator. Analysis of the event showed that the heat gradient from east to west was steeper than expected and this is inconsistent with the model predictions. Understanding these physical changes and how they may alter future current flows and other physical ocean characteristics is important.

Melting ice and sea-level rise (Richard Matear, CSIRO)

In order to assist the understanding of the cause of the melting of glaciers and polar ice, as well as the implications for sea-level rise and coastal erosion on vulnerable communities, Richard Matear from CSIRO presented on sea level rise and coastal impacts.

The presenter discussed the importance of knowledge-sharing sessions and the potential impacts of climate change on sea level rise, coastal inundation and erosion. He highlighted the uncertainties involved in quantifying the melting of ice sheets and their contribution to rising sea levels, the potential long-term impacts of global warming on sea level rise, the impacts of sea level rise, tides, winds, and waves on the coastal environment, and the need for adaptation strategies. He also discussed the impacts of climate change on localized environments and the role of the Pacific Ocean in driving global climate.

Uncertainties remain in quantifying the melting of ice sheets and their future contribution to rising sea levels. It was noted that climate models do not include dynamic ice sheet models, which adds to their uncertainty. The rise in global sea level is not uniform across the globe, with regional variations arising due to factors such as ocean currents and heat storage. The importance of vertical land motion as a contributor to sea level rise at a local scale was also noted.

Even if the target of holding temperature at 1.5 degrees is met, sea levels will continue to rise due to the melting of ice sheets. It has been estimated that over the next 2,000 years, an additional 3 to 6 meters of sea level rise can be expected. If the temperature increases to 2 degrees, the rise could be

up to 6 to 13 meters over 2,000 years. The melting of ice sheets happens much faster than their growth, and proposed mechanisms such as subsurface melt in Antarctica by ocean water and elevation-induced warming in Greenland are contributing factors, and these impacts might be challenging to reverse. Consideration needs to be given to the compounding effects of sea level rise, storm surges and tides could create extreme water levels leading to significant impacts.

The impact of extreme water levels on coastal inundation and erosions will be very region specific and local information will be crucial to understanding the potential impact and developing adaptive policies and planning mitigation.

Discussion

SPC is currently working on wave inundation and have 3D models for Majuro.

While it is possible for coral to grow as the sea level changes it may be difficult for the coral to keep up with the rate of the sea level rise. Some of this island building may be through coral breaking and the material contributing to beach growth which is not sustainable. The impacts are very local and dependant on the local topography so local response models will be needed.

Indonesia is having issues with land subsidence which is linked to sea level rise. In response they are building sea walls which is generating much discussion locally as these will also have an impact on the environment. Country specific responses also need to be evaluated and they will depend on the area, number of people living there, and where the vertical land motion is increasing or decreasing.

The long-term impacts of the cyclones need to be considered as should their frequency. It was noted that Niue had a category 5 cyclone 20 years ago and they are still recovering from that. If the events are more frequent then systems may not be able to recover fully between events. Additionally, changing weather patterns may impact the functioning of the fishery support structures, which will impact the overall fishery. For coastal fisheries, issues such as changing storm frequency and the scale of lagoon flushing rates or damage to reefs and mangroves could impact the recruitment patterns of fish.

Following the presentations for Day 1, there was a general discussion. It was noted that while the overall picture is bleak, by tackling these problems head on we help to mitigate and resolve the issues. In addition, the best form of climate resilience is to be proactive by integrating climate impacts into our management systems, to build that resilience and having well managed fisheries.

It was noted that storms can also release pollutants from inland sources, and these can be serious and significant for local inhabitants and biological systems. If you push the system too far it may shift to an altered stable state and it's very hard to get the system back to its original condition. It also takes more time to fix a system than it does to damage it.

The Pacific Ocean is very important from a climate change perspective as the Pacific is so large its capacity to hold heat means that it is globally significant.

Day 2 - Physical and Biological Impacts of Climate Change

Ocean warming and marine temperature extremes (Thomas Moore, CSIRO)

Thomas Moore (CSIRO) presented ocean warming and marine temperature extremes. This explored the connection between climate change, rising marine temperatures, and ocean heat content, as well as global and regional marine heat waves and cold spells. The presentation covered the oceans' role in storing heat due to global warming, its contribution to rising sea levels, and the challenges in making precise forecasts. It also explained the concept of a marine heat wave and its impact on local conditions and species, and highlighted the importance of understanding climatology and the role of global climate models in predicting more frequent and intense events. The limitations of ocean models, the complexity of the climate system, and the gaps in observations of oceans were discussed. The oceans' role in storing heat due to global warming was emphasised, as was its contribution to rising sea levels, and the challenges in making precise forecasts due to incomplete observations and uncertainty. The increase in the rate of ocean warming over recent decades and the significance of changes in global heat content and sea surface temperatures was noted. Additionally, it was explained that a marine heat wave is defined as a period of upper-range ocean temperatures lasting at least five days.

The severity and frequency of marine heatwaves impacts local conditions and species. There is therefore a need to understand climatology and the role of global climate models in predicting more frequent and intense events. The severity of these events depends on future greenhouse gas emissions, with higher emissions leading to more severe outcomes. Marine heat waves are already affecting Pacific Island communities and it is projected an increase in the region, posing a threat to food security. Using observations and models, it was demonstrated that the number of moderate, strong, severe, and extreme marine heat waves has been increasing over time. Modelling has evolved, with more recent models focusing on smaller scales to better capture local features.

There is a need for more observations, particularly in the equatorial regions and Southern hemisphere, but challenges remain in obtaining observations in the deep ocean. The role of ocean robots in increasing the coverage of observations and the importance of these observations in establishing ocean climate and validating model outputs was noted.

Discussion

It was noted that El Niño changes rainfall patterns and rainfall impacts the surface salinity locally, and that may impact some species on a relatively small scale. It was noted that you need to design the questions so that they are relevant to the fisheries you are interested in and then use physics to try and predict how these changes could impact those fisheries.

Dynamic models can be used to fill data gaps, but if you are asking specific questions about a specific place, if you don't have local data then getting locally relevant answers may be challenging at a small scale (10's of Km) but you may still be able to answer the large scale (100's of Km) questions. The focus therefore should be on designing appropriate questions and exploring the relationships between different factors that influence the climate models. The discussion stressed the importance of considering the reasons behind different approaches to filling data gaps and the variability in findings due to these differences.

(The great) tuna fisheries of the Western and Central Pacific Ocean (Steven Hare, SPC)

The tuna fisheries of the Western and Central Pacific Ocean was presented by Steven Hare (SPC). This introduced the importance of tuna fisheries for the region's economy and food security as well as an overview of key tuna species and their distribution in the Pacific and stock status and management of the four target tuna species. The presentation emphasized the significance of fisheries for Pacific Island countries and territories' food security and financial stability, outlining the biology and distribution of major tunas, the status of tuna stocks, and their management. The economic implications of fisheries were highlighted, as was the impact of climate change, and the challenges of managing the WCPFC tuna fisheries.

Worldwide, tuna are managed by five Regional Fisheries Management Organizations (RFMOs) globally. The biology and movement patterns of tuna in global oceans, the diversity in the diets of the four main tuna species, along with the various methods of tuna fishing were presented. There has been a shift in fishing effort by gear type over time, with longline fishing efforts peaking around 2010 and then declining. In the purse seine fishery, there is a difference between free school sets and FAD sets, noting that about a third of free school sets do not result in any catch. The pole-and-line fishery has significantly declined and there is a concern that the yellowfin tuna fishery might be reaching its limit. Ranking the catch by EEZs in 2022, showed that PNG had the highest catch, followed by Indonesia. The top ten countries are responsible for approximately 90% of the tuna catch, with distant water fishing nations, such as Indonesia, Japan, Korea, and Chinese Taipei among the top countries catching tuna.

A stock is considered overfished if it has declined below 20% of its unfished state. Comparing the catch of the Western and Central Pacific Fisheries Commission (WCPFC) to other tuna RFMOs showed that the WCPFC is the largest catcher of tuna with an average catch of about 2.7 million tons annually over the past five years, and the WCPFC stocks are all in a healthy state, but some billfish and sharks are not.

Discussion

The stock structure and the level of local and regional mixing is still under discussion and to get over this the assessment teams use the long-term larger scale recruitment patterns to and broad stock regions that match the fish movement results from tagging to model the stocks.

A discussion on marine protected areas (MPAs) suggested that MPAs are good for protecting local stocks particularly those that do not move long distances. But for tuna, MPAs are not that effective as the fish move around a lot and will get caught outside of the MPA so the control of fishing effort is more effective for managing these stocks than closing areas.

Biodiversity loss and ecosystem disruption (Christophe Menkes, IRD)

Christophe Menkes from the IRD presented biodiversity loss and ecosystem disruption which explored the impact of climate change on ecosystems and species; discussed the consequences for biodiversity, habitat loss and ecosystem services; and considered the consequences for marine life, coral reefs and seafood resources.

The impact of climate change on biodiversity was discussed, emphasising the role of climate drivers such as light, temperature, ocean currents, nutrients and acidification in affecting marine ecosystems. The need for more observations to understand regional changes was stressed and suggested the use of sensors on fishing vessels as a way to gather more data. Climate variation is a significant driver of projective risks for species extinction and the importance of understanding the main climate drivers in studies was emphasized.

When discussing the complexities of ecosystem resilience in the face of climate change, the role of biodiversity in maintaining resilience was emphasised as was the potential for species extinction in the event of low biodiversity. The compounded effects of various stressors, such as elevated CO_2, lower oxygen levels and the impacts of changing temperature on species distribution was noted. The potential for mismatches between predator and prey populations due to species shifts and the potential issues that could arise from warming temperatures, including a decrease in food supply and habitat shifts was also noted.

The concept of ocean climate velocity, which is the rate at which temperature is changing in the Pacific ocean particularly in the vertical range, was introduced. Reviewing 70 years of data shows that temperature is increasing everywhere, particularly in the western Pacific. In one study, of the 300 species worldwide investigated, the species shift was not as consistent as expected from pure climate or temperature data, indicating that other factors might be influencing their movement. However, he emphasized the limited data available for this study and the large uncertainties in the research. But generally, while large uncertainties remain, there is a general species shift towards higher latitudes due to climate change, could lead to a loss of biodiversity in the tropics.

The need for more observations to understand regional changes overall was highlighted, and the large gaps in observations was highlighted particularly for micronekton which constitutes the main food for tuna.

Discussion

Spatial and temporal shifts in predators and prey occur as both predators and prey will follow isotherms which change in the water column. In addition, tuna can switch prey so the drivers of

movement are difficult to predict but the tuna modelling will answer this more effectively and local knowledge may not be enough as a result the entire stock movement should be considered.

The carrying capacity of a region could change one way or the other but for tuna the east-west distribution is well known and this would move fish as warm pool expands and contracts. We also note that there have been some range extensions or changes in species distributions but we don't know if new species have entered the Pacific system as a result of climate related changes.

Reviewing the high predicted loss of biodiversity in the tropics, it was noted that tuna were not included in the analysis. Moreover, the overall conclusions are biased and based on a relatively small data set with species which limits the models' utility.

Adding sensors to purse seine vessels to collect data can be done and temperature profilers could collect useful information but someone has to arrange for the gear to be installed in the vessel, retrieved and then analysed.

Ocean and marine ecosystems (Patrick Lehodey, SPC)

Patrick Lehodey from the SPC presented on ocean and marine ecosystems. The presentation explored how climate change affects ocean temperatures, currents, and acidity. The need to understand the link between rising ocean temperatures and tuna behaviour was discussed as well as the implications for tuna migration patterns, spawning grounds and feeding habits. In addition, the discussion covered how climate change affects fish stocks, distribution, and productivity.

The presentation explained how climate change affects temperatures, dissolved oxygen, productivity and ocean acidification, as well as its consequences on tuna behaviour and habitats. Depending on the species and their affinity for tropical or more temperate environments, the responses are graded with overlap. Changes in individual behaviour have population-level implications for distribution, migration patterns, spawning grounds and feeding habits. Temperature and oxygen levels dictate the vertical and horizontal distribution of species' habitats and climate change would likely alter these conditions. The potential threats that ocean acidification poses to marine life are still poorly understood and require further research. For tuna, the risk appears higher for larval stages, particularly in the eastern tropical Pacific.

The presentation then focused on the effects of interannual (ENSO) and decadal (IPO) climate variability to illustrate the effects of changes in the ocean environment on the recruitment and dynamics of tuna populations, and the consequences on the management of fish stocks and their fisheries. Modulation of ENSO event frequencies on an interdecadal scale generates multidecadal regimes of low and high productivity in tuna stocks with possibly opposing responses between skipjack and albacore. But climate change is likely to modify these relationships. We need to intensify studies on larval recruitment mechanisms in relation to climate variability to better understand the effects of climate change. The consequences for management and perspectives for observation and modelling are discussed. In particular, it is necessary to increase co-management between regional organizations, develop networks for observing essential variables of the ocean ecosystem and improve models simulating the primary production, zooplankton and micronekton.

Discussion

Warmer water will hold less oxygen, but this does not mean that it will be too low for the tuna to exist in a region. The lower oxygen will unlikely impact tunas, however, warming will increase the stratification of the ocean so the area for photosynthesis may be reduced. But there are a lot of mechanisms that are unknown at this stage.

SEAPODYM and modelling of tuna population dynamics (Inna Senina, SPC)

The Spatial Ecosystem And POpulation DYnamics Model (SEAPODYM) and modelling of tuna population dynamics was presented by Inna Senina from the SPC. This elucidated how the model estimates tuna habitats, biomass distributions and abundance; as well as explained the differences among the four target tuna species. Existing uncertainties in modelling of tuna population dynamics were discussed as was the projected biomass redistributions under climate change and related implications for the Pacific Island Countries and Territories.

The presentation was structured to:

i) explain the dynamic model for tuna population dynamics,
ii) describe how tuna abundance and spatial distributions are estimated, and
iii) describe the climate change impacts on Pacific Islands' and WCPFC tuna stocks as predicted by quantitative models.

In the first part, the conceptual view of the model was provided and discussed the complexity of the minimal model enabling description of tuna population dynamics and study of the impacts of climate change on tunas. The importance of including spatial dynamics was noted as was a description of the reproduction, mortality, and movement, all of which are influenced by environmental conditions such as primary production, temperature, oxygen, food resources and absence of predators. It was noted that different behaviours of juveniles and adults dictate the need to consider age and life stage structure. On the other hand, how the model could be simplified by considering a two-dimensional space was presented, focusing on three distinct layers based on the micronekton vertical distribution. The model presented feeding habitat as the accessible forage biomass, which drives tuna movement, and explained the different types of movements, including directional and non-directional movement and their effect on tuna distributions. Real-world examples were used to illustrate the model's performance.

The importance of parameterizing the model informing dynamic rates and habitat parameters from observations, validating the model, and addressing potential uncertainties was highlighted. The use of different types of data in estimating abundance, spatial distribution, and movement of tuna species was discussed. The presentation highlighted the limitations of each data type, such as biases in fisheries data and the difficulty to accurately estimate spatial distribution and movement from catch and length frequency data alone. The impact of data on the predicted distribution and movement of a species, using the model of skipjack tuna was illustrated as an example, and discussed the uncertainties in the estimation process, including data coverage, ocean forcing variables and model structure.

The effects of climate change on the four main Pacific tuna populations was discussed, and its implications for Pacific Islands countries and territories. She mentioned using different forcing models to predict the warming under RCP 8.5 and 4.5. The biomass and catch decreases under RCP 8.5 and have less severe impacts under RCP 4.5. The model showed that stocks were stable for the first half of the century but saw a decrease in late 2040, particularly for the skipjack and yellowfin tunas. Using the skipjack example, she attributed this to the reduced availability of mesopelagic micronekton, which migrates at night to the surface and represent a key food resource of skipjack tuna in the warm pool area. The uncertainties in predicting the effects of climate change on tuna populations was discussed, emphasizing the importance of including uncertainties in projecting temperature and primary production. Despite model uncertainties, agreement between different models on distributional shifts, suggesting that changes are inevitable. Highlighting the need to collaborate with others to address these general questions.

Discussion

It is currently unknown weather light levels or availability within the ecosystem will change. It is also not known what the long-term changes to the depth of the thermocline may be.

Due to the accumulated uncertainties, the projections stop in 2050 as the further into the future you go the larger the compounded error. In addition, most of the interest is currently for the closer time frames, i.e. up to 2050.

The biggest source of uncertainty is ocean forcing bias and the other large unknown is the observations of the biology many of which are missing. The model is age structured and starts at age 0 to capture recruitment trends. The survival of larvae is predicted and information on recruits are included from the fisheries data. The larval distribution data are predicted as the larvae are distributed by currents and influenced by temperature and other the density of other plankton, as well as micronekton at surface which results in larval mortality. Larval observations are sparse and getting more observations would be beneficial for the model. In addition, observing the fish movement for a bigger age window than we have currently would be helpful. For example. for bigeye tuna only fish aged 1-2 are tagged in large numbers and the model would benefit from data for older fish.

The modelling can be EEZ specific but if there is strong connectivity between the EEZ and outside it's not useful. The model can be easily separated along obvious natural boundaries such as the equator. Once a model is developed one can zoom into the EEZ but if the EEZ is small then it may not be that beneficial.

Model timeframe relies on a projection window of the modelled data, so the time scale for a modelled period can be shortened e.g. if the forcing data are available at a 1 year level then the model can be refined down to a single year. The model does get validated by looking back in time to see how well it goes when compared to existing ocean data.

SEAPODYM will be extended to the Atlantic Ocean and the Indian Ocean and once that is done interocean data can be compared.

If the fish population is reduced by fishing, the prey limiting aspects of the model are still valid as the model is linked to the absolute size of the biomass. Fishing vessel acoustic data can be used in the models, but they are very sparse so are not widely used currently, but they could be used in future if more data become available.

Currently all the modelling is done on tuna, but modelling more spatially restricted species such as non-migratory species could be included in future.

Incorporating climate scenarios in fisheries research (John Morrongiello, University of Melbourne)

John Morrongiello from the University of Melbourne presented incorporating climate scenarios in fisheries research covering methods for integrating climate scenarios into fisheries research design, and included case studies demonstrating the application of scenarios in fisheries research.

The presentation explored the three keyways that ocean warming can impact fisheries. These include distributional changes, reduced body size, and alterations to the timing of key life history events (phenology). It highlighted the extreme events, such as marine heatwaves, which are forecast to become more frequent and intense in a warmer future. These could result in key biological thresholds being surpassed sooner than would be expected based on the longer-term average sea surface temperature trend. Climate change will also likely cause shifts in the frequency and intensity of ENSO events.

It is important to consider a species' ecological niche when exploring climate-driven distributional shifts. The ecological niche is the set of conditions in which a species survives and reproduces. These conditions determine where a species lives and how it responds to environmental changes, such as warming oceans. Warming can allow species to expand their existing ranges as previously unfavourable areas become habitable. Range expansions can be driven by changes in the physical environment, or removal of other species that may have competitively excluded a species. Warming can cause species to undergo a range shift, whereby their distribution tracks preferable conditions. Here, it might get too hot on the equatorial edge of a distribution and more favourable on the poleward edge of a distribution. Warming can cause a range contraction. This usually occurs when conditions in part of a species' range become unfavourable, but they lack the capacity to track these conditions further poleward. Lastly, warming can cause changes in the depth distribution of species as they move deeper into cooler water. There are limits to the capacity of species to move deeper, driven by other aspects of their ecological niche. Two case studies, from waters around the USA and tuna in New Caledonia were discussed, to explore these different types of distributional changes.
Fisheries managers can consider the following points to help address the potential for distributional changes in their stocks:

- Properly define stocks in the first place (using tagging, genetics etc.);
- Monitor spatial distribution of stocks (including depth);
- Be prepared to re-evaluate stock identification;
- Be prepared to re-evaluate stock area; and
- Be prepared to update stock models.

The ‘temperature-size rule’ describes the observed phenomena of increased juvenile growth, earlier maturation, reduced lifespan, smaller adult size at higher temperatures. While the mechanisms underpinning temperature size rule remain debated, the implications of reduced body size on the viability of populations and productivity of fisheries are clear. Of particular note is the fact that bigger fish produce disproportionately more offspring than smaller fish. Reductions in body size thus affect the reproductive potential of a stock. Furthermore, smaller individuals often experience greater natural mortality due to predation. Documenting changes in body size of a stock can be difficult without good time series of fish length/ weight data. One way to address this data shortage is to use the growth information naturally achieved in fish otoliths. Here, a few otolith collection events can be used to recreate growth dynamics of a population over decadal scales. Climate signals can then be explored in these growth series.

Fisheries managers should, whenever possible:

- Monitor size and age structure of their stock’s catch (through time and/or space);
- Consider targeted studies (e.g. otolith growth) to assess sensitivity of stock to current and future warming;
- Don’t assume that life history parameters (e.g. age- or size-at-maturity) used in stock assessment models are stationary. Try to monitor these periodically (gonads or new maturity proxies);
- Be prepared to update stock models with new knowledge; and
- Promote preservation of big fish.

Rapid warming can alter cues used by species to stimulate reproduction and developmental rates. Significant impact to populations can occur if these shifts in reproduction, or other life history events, become out of sync with environmental conditions. The match-mismatch hypothesis stipulates that recruitment is highest when newly hatched larvae encounter a food-rich environment. Advanced spawning timing that is not matched by advanced food availability causes recruitment failure.

In summary, climate change can impact on fish and fisheries in a number of ways. In turn, fisheries managers need to understand how warming will likely affect their stock. This could be through dedicated investigations or based on other existing knowledge. Regardless, it is important that managers continue to monitor their stocks as best as possible to ensure any changes in distribution, size or phenology can be identified and appropriate actions put in place to potentially offset productivity risks.

Discussion

The SST does not change much between day and night, however, if there is wind causing upwelling that will impact the water temperature over a small timeframe. As the ocean warms the metabolic rate of ectotherms increases, so larvae will grow faster and increase the rate at which they use of their yolk stores, if there is not enough food at that time as a result of lower zooplankton levels, they will starve. If the temperature goes too high that can also cause mortality, or for survivors that were living

for prolonged periods in suboptimal conditions, there can be other impacts such as a reduction in the immune system.

A good complex model allows you to explore many linked things but you also run the risk that you try to get too complex which can take a long time to perfect, and you ignore the simpler models in the pursuit of perfection you may never get answers.

Fish weight is important to measure, but weight fluctuates more than length and is harder to measure, so models tend to use length data.

Rivers are influenced by rainfall and big storm events will have impacts on rivers. These will impact the areas close to river mouths, estuaries or mangroves but tend not to be that influential over a larger scale. They can however have some locally important influences.

Day 3 - Climate Change Planning within the WCPO

Coastal fisheries and climate change (Brad Moore, NIWA)

Coastal fisheries and climate change was presented by Brad Moore from NIWA. Current status of Pacific coastal fisheries; summary of impacts of climate change to Pacific coastal habitats and species; and projected impacts of climate change on Pacific coastal fisheries catches were presented.

Coastal fisheries are critical for food security, livelihoods, social well-being and cultural identity across the Pacific Islands region. Climate change will impact the finfish and invertebrate species that support these fisheries in at least two ways: 1) directly, through changes in distribution and biology (e.g. growth, reproduction), and 2) indirectly, through impacts to supporting habitats (e.g. coral bleaching).

In one example, a progression was noticed on a reef from a healthy to a bleached state which then progressed to a macroalgal-dominated state, and is now potentially moving towards a crustose coralline algae state. It was noted that this transition is important for coral recruitment which increases on crustose coralline algae dominated reefs. There are winners and losers in this transition, with species dependent on corals being at risk, whereas others that feed on algae could benefit in the short-term. These projections indicate that climate change will cause declines in fish and invertebrate biomass and reductions in harvesting in all Pacific Island countries and territories by 2050. However, the extent of these declines will depend on the status of fished populations, growth of human populations (demand for food), and the longer-term capacity of coastal resources in each PIC to support increased harvest.

Discussion

Ciguatera is variable in space in time and across species. The modelling did not account for ciguatera but it is likely that the species that carry ciguatera will change over time. This is an under researched area.

There are challenges with collecting coastal fisheries data. This analysis used the best data available to it While there are some catch estimates they are generally considered to be underestimates. SPC is developing tools to help quantify the species and size of the fish being caught with apps and species identification sheets, this will improve the estimates of coastal catch over time.

Both coastal and pelagic fisheries will be impacted by changes in the ocean, but reef fish don't have the option to move. Their distribution could shift as some of the larvae may find new habitat in more favourable environments but the adults are unlikely to be able to move too far.

In a coastal sense it is hard to uncouple a coastal and estuarine system as they are highly linked habitats. Lots of the coastal species use coastal, sea grass and estuarine habitats through their life cycle. When we look at habitat change the modellers only look at coral and sea grass for most countries, but in PNA mangroves are also included due to their abundance. The modelling at this stage does not partition the species and habitats as the data are not fine enough.

Case studies on Climate Change Impacts on PICTs – summary (Zulfikar Begg, SPC)

Zulfikar Begg (SPC) presented a summary on case studies on climate change impacts on PICTs. Identifying specific climate impacts on Pacific Island communities. Discussing sea-level rise, extreme weather events, and threats to livelihoods.

This presentation covered the impacts of climate change on subsistence catch, coastal fisheries, and habitats such as mangroves, seagrass, and coral reefs. It underscored the need for improved data collection and accurate modelling for effective planning and decision making. Finally, the importance of assessing freshwater quality issues in coastal regions after tropical cyclones was emphasised.

There are challenges associated with biomass modelling in coastal fisheries due to the high variability and potential changes in species composition. This, along with poor data collection results in an underestimation of subsistence catch, highlighting the need for improved data collection. Recent developments in tools to quantify the catch of coastal fisheries are likely to improve this. Climate change can result in species range shifts. The presenter noted the importance of coastal habitats such as mangroves, seagrass, and coral reefs for fish populations.

The need to package information to support national decision making and to inform communities was highlighted. In 2022 country-scale information was documented. The presenter discussed early warning system initiative, underscoring the challenges faced in ocean science and the limitations in localised observations. The importance of aligning national and regional strategies for development projects, was emphasised and the need to ensure projects meet the specific national requirements was noted as was the need to baseline information. For example, Tuvalu's required accurate topography data for effective planning.

Base line information is important in supporting decision-making processes, particularly regarding coastal inundation. Waves cause coastal flooding and the SPC team is working with local counterparts to enhance risk knowledge. They are collaborating with government departments to collect risk information and develop impact-based forecasting. But it is necessity to improving communication and dissemination of information. A dashboard with climate change scenarios and risk information for Tuvalu's National Disaster Management Office has been developed.

Discussion

Future extreme water heights and waves are considered, which included tropical cyclones. Following on from cyclones there are freshwater quality issues and post disaster assessments that are undertaken which include water testing in boreholes and water galleries. Ground water assessment is not continuous but is important post cyclone particularly looking at salinity of the water following extreme water heights.

The Tuvalu LIDAR survey cost about $4m. These surveys are being undertaken in some other countries to collect the baseline data. The survey is only one aspect of the work; the rest is the analysis, which will take a few years to do all the countries around the Pacific. The French territories have not been

included as only the 14 countries that are partners are included, but the territories (including American Samoa) will hopefully be included later in 2024.

The tools developed for the early warning systems are helpful and needed for the big category events. It was noted that 10-15 years ago people were concerned about the wind and water runoff, but the recent priorities are coastal damage from waves and inundation.

Potential economic impacts on tuna fisheries and resource owners (Chris Reed, FFA)

This presentation provided an overview of the economic significance of tuna fisheries in the Pacific region and a discussion of the challenges posed by changes in the abundance and distribution of tuna stocks and their potential impacts on the tuna harvest and associated sectors. Following this, a discussion of economic repercussions for resource owners through, for example, changes to access fee revenue and economic activity was provided.

Discussion

In order to model the future loss as a result of climate change, FFA will need to collaborate with other institutes. In the past, the models used biomass changes to equate to revenue changes. But we also need to know what the re-distribution of the fishery and processing plants would be as these will have cost implications for the fisheries as a whole.

The Pacific is not operating in a vacuum and, if other regions are affected, then that will impact supply and demand of Pacific fish. If the Indian Ocean and Eastern Pacific declined substantially that would impact the price of tuna but that is also not straight forward, and a comprehensive analysis would need to be done to investigate this.

There is a lot of capacity to process fish onshore within the Pacific region and this is a big driver for some countries. Currently only ~7% of the catch is processed onshore in this region.

The PNA vessel day scheme (VDS) revenue will decline if the fish move outside PNA waters, so those countries need to start planning for this eventuality. They will need to entrench their rights to those fish and the fisheries while planning for the future. The rate of change is also an important consideration as that will impact the planning schedule. However, the science still has a lot of uncertainty and requires some resolution, we therefore need more investment in this type of science.

Climate-Informed Fisheries Management Strategies (Marina Abas, FFA)

A presentation on climate-informed fisheries management strategies was delivered by Marina Abas from the FFA. The aim of the talk was to delve into managing climate related risks to the fisheries, by working towards developing adaptation strategies, which will help build resilience to the fisheries sector.

The IPCC first introduced the climate change risk assessment framework which evaluates risk by considering hazard, exposure and vulnerability. Hazards encompasses climate-related impacts like sea level rise, ocean acidification and storm intensification. Exposure involves the presence of people, livelihoods, species, ecosystems and assets in areas susceptible to adverse effects. Vulnerability, comprising sensitivity and adaptive capacity and gauges the predisposition of communities to hazards. Sensitivity in fisheries is assessed based on dependence, while adaptive capacity assesses the ability to cope and implement preventive measures against climate change impacts. This framework aids in understanding the aspects that contribute most to risks, and working on strategies to manage those climate change related risks in various contexts, including fisheries.

Through an introduction to climate-resilient fisheries management approaches already in use, how management strategies can be used as climate change adaptation strategies was discussed. Four foundations for climate resilient fisheries were introduced: effective fisheries management systems; strong participatory processes; precautionary systems that deal with uncertainty and risks; and adaptive fishery management systems.

Discussion

Each sector can start by doing its part to cooperate and work together as partners when developing adaptive strategies, as social communities and ecosystems are linked and will impact each other in a changing climate. Many of the approaches described are already in place but they need to be considered through a climate lens. We can manage for the change in the fisheries but how we address the problems in future and when do we begin talking about loss and damage and rights to resources that have moved spatially required discussion.

To address these issues, which are new to us, we will need to start thinking outside the box, and develop new approaches. We will need to look at all the aspects, identify weak points and try and respond to them, this will need to be addressed by managers, scientists and communities working together. We also need to evaluate what happens within the intermediate periods, which is something that has not been tested as we tend to focus on the extreme scenarios only.

When stakeholders consider the overall risk to the stock, the community will need to assess the hazards within a risk assessment framework e.g. risks to vessel (e.g. vessels fishing in increasingly stormy seas) vs a stock moving outside of the area so that we can rank risks/hazards and model these aspects. In addition, these individual risks/hazards will need to be weighted within the framework to assess the overall risk.

Introduction to International Climate Change cooperation frameworks (Todd Croad, MFAT NZ)

Todd Croad from MFAT New Zealand presented introduction to international climate change cooperation frameworks. Summarising processes at UNFCCC and Paris Agreement, Implications for Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs).

This talk on multilateral climate frameworks outlined the history and evolution of the UN climate change regime – including the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol and the Paris Agreement. Key themes included the broader thematic coverage and coverage of emissions under the Paris Agreement. Some specific features of the Paris Agreement were discussed including the global stocktake (the ambition mechanism), Nationally Determined Contributions (NDCs), adaptation, and enhanced transparency framework. These features were discussed in relation to incentivising ambition, and the role of transparency in building trust and confidence.

Discussion

The IPCC reports for many countries are the fundamental basis for analysis of the global stock taking process. But this may change in future with an increase in the time period of the stock take period (currently 5 years).

The Paris meeting was the 1st time loss and damage was included as a standalone article, at the previous meetings there was an agreement to set up a fund, and at COP in 2024 parties agreed on the fund ~$700m USD was made available.

Prior to 2020 there were two parallel systems with mandatory requirements for developed countries to report efforts on carbon budgeting in biennial reports but not for developing countries. Now there is a common set of biennial reporting (transparency reports) develop at Paris for all countries, and but developed countries still need to do what they are doing for emissions reductions. Countries nominate their own indicators for NDC success and the transparency reports require countries to report against their nominated indicators.

Action at the UN has the capacity to deal with climate change, but it is currently not on track (to limit global temperatures to a 1.5^{o}C increase). The system has the capacity to limit emissions and gaps are being closed, so as we move ahead we will move to a system that will achieve it at some point in future. There is recognition that we need to track these elements and some of these are now built into the UN process. Importantly, this has created an expectation that a system is built around realising those expectations.

How do we keep track of it all is challenging, and there is a recognition that the measures have built in protocols to track how we are going for example there is the global stock take. There are also similar exercises around NDCs and where that will get to in terms of temperature rise. As the Paris agreement is built around the expectations the system is built around how to make realise these expectations.

What regional collaborations are currently ongoing (Simon Nicol, SPC)

A presentation on regional collaborations, CROP agencies initiatives and regional strategies was presented by Simon Nicol (SPC). The presentation highlighted the critical role of international cooperation and science in addressing climate change. It underscored the importance of climate action across various dimensions and the need for collaboration within SPC. The presenter

emphasized the role of different divisions within SPC in providing technical support in the fishery sector and the need for fast tracking the development of technical expertise within national authorities and decision makers. The presentation noted the challenges of raising the urgency around climate mitigation, particularly in relation to fisheries, and the difficulty in engaging students from Pacific countries in climate research.

The significance of international cooperation was discussed as was the role of science in addressing climate change. The non-binding nature of many agreements and the impact of negotiations on real-world outcomes was noted. The Paris agreement, while not explicitly stating a 1.5-degree goal, has led to its implementation in national legislation and company actions. The integration of climate change considerations into various regional policies and strategies, and the importance of defining key dimensions to effectively implement climate change action was also noted.

The heads of fisheries directive is important and should emphasize the need for knowledge, capability building and solutions development. There has been a significant focus on oceanic fisheries, with a budget of around 15 million dollars to study climate impacts. However, there is a disconnect in the collaboration between tuna and coastal fisheries, with the latter being underfunded. National authorities should implement loss and damage actions, while regional agencies can support and advocate for finance. Monitoring processes and stock-taking against the responsibilities of regional agencies is required.

Collaboration across various organizations and agencies is needed to address climate change. SPC, FFA and PNAO can provide technical expertise for these collaborations. Regionalism in addressing climate change is required and tuna fishery management in the Pacific Islands is a good example of how this can be successful. While decisions may be made at a national level, the most successful outcomes often result from a regional approach. The existing collaboration networks are well established and have potential for further development. But it is important to ensure that the right people and collaboration networks are required to ensure that the right questions are being asked and to make better decisions. This is not an academic exercise or a regional agency directive, but rather a collaborative effort to provide necessary information for decision making.

Discussion

There is a big problem in sourcing students from Pacific Island Countries, and it is challenging to transfer this knowledge back to the PICTs through personnel development. Nevertheless, there are academic and other skills transfer initiatives that train scientists and managers. There are formally educated PICT personal trained at USP and other universities and this number has increased over the last 15 years. There is a real opportunity for the CROP review to demand more of USP and it was noted that the weakening of the USP marine program is a concern which needs to be resolved. There is a mismatch between USP and the French system which makes linking the systems challenging. This issue is more than just an academic development issue, as we need more expertise on the ground. There is value in creating knowledge exchange initiatives where local specialists and organisations such as the CSIRO share knowledge in both directions to strengthen the regional and local capacity.

The regional co-operation is good, but better intersectoral co-operation is required at the national level. For example, there needs to be explicit links between national fisheries and climate scientists. PICTs need to co-ordinate regionally to present the SIDs cases in the international fora so that we speak with one voice and get a higher level of recognition for our region.

There will also be value in having a single forum of scientists and managers involved in environment, fisheries and climate to develop and share knowledge. If such a forum is developed these specialists need to coordinate nationally and regionally to elevate these issues.

Data Collection and Modelling for Climate Scenarios (Simon Nicol, SPC)

Simon Nicol (SPC) presented data collection and modelling for climate scenarios. Subjects covered included: importance of collecting and using climate-related data for fisheries modelling; data we aren't yet collecting but should be, and Advance Warning systems. The presenter discussed the importance of data collection in tuna fisheries management, emphasizing the need for robust indicators and vulnerability analyses to prioritise areas for investment. It highlighted the need for transitioning from basin-scale to local or national-scale monitoring and improving the resolution of ocean models for more detailed economic analysis. The presentation stressed the need for proactive integration of climate impacts into tuna fisheries management; establishing baselines and understanding population structures to better manage tuna resources; and upskilling and regional autonomy.

Data collection and modelling in the context of climate change was emphasized and the importance of observations to establish baselines and quantify change was stressed as was the need for robust indicators in the areas of biology, distributions and oceanography. There is a need for vulnerability analyses to prioritise areas for investment data collection is required to identify the impacts of climate change.

The need for different types of data and information to make strategic decisions and forecasts for the upcoming year was discussed. There is a need to transition from basin-scale to local or national-scale monitoring and to improve the resolution of ocean models for more detailed economic analysis. This underscores the importance of understanding biomass changes in specific areas. The New Zealand government is funding a project to build tools to assist our understanding of the dynamics at a EEZ scale.

Establishing baselines and understanding population structures to better manage tuna resources is required. There is also a need for upskilling scientists and managers within the region and developing regional autonomy. Furthermore, scaling up fisheries and ocean monitoring is needed. We need high-resolution models to capture finer scale processes and accurately estimate biomass within exclusive economic zones. To achieve this, we need to scale up e-reporting and identify gaps in ocean data, and find future partnerships to fill these gaps.

Ocean monitoring is required but there are challenges in obtaining precise data, particularly at lower trophic levels. There are a limited number of observation tools and is a need to balance physical parameters and biological components. There are advantages in using genomics data for modelling fish populations. Genomics can provide a cleaner data set, free from assumptions associated with standard tagging data, and can estimate absolute abundance and spawning potential.

Discussion

Data collection of meteorological data along a ships track is possible, however, acoustic data is problematic. Not all vessels are good for collecting useable acoustic data. The biggest challenge, however, is the requirement for a research permit (according to UNCLOS) to do any biological work. A discussion is therefore needed as to how this could work and how it can be permitted. This will not really be a problem if we know what it is that we wanted to do, however, it can't be rolled out without some agreement/permitting in place.

The tuna fisheries harvest strategy process is currently under development. Within this framework, some of the biological variability is captured by the biological data going into the model. If that underlying biology changes then the model will need to be updated. If that change is extreme, then this may need to take place through the exceptional circumstance clause. At the time the change is noticed a decision needs to be made as to whether it is "normal" and/or consistent between consecutive years; or an outlier; or a change in state that is becoming commonplace. If that variable is influential within the model, then a model change may be required. Forecasting tuna distribution and size can be predicted by looking at the past data to predict the future conditions, and then modelling what that change may look like in the future.

Models currently are large in the scale concerning the area that they can evaluate and a downscaling exercise is underway. The time frame for starting a downscaling exercise of the oceanographic models is known. Models that are being reoptimized for the best fit for the downscaling to EEZ scale to evaluate impacts will be completed within 6-12 months. For the wider climate models, a 4-5 year time horizon is required if we are using an ensemble model approach for the 4 tuna models at a 1^{o} resolution. SPC is closer to developing models base on genetics and close kin scalers of abundance. It is estimated that for albacore, reliable results will be available in 12 months and calibrated epigenetics for all 4 tunas is expected by August 2024. But skipjack is problematic as the computing power is too restrictive currently, the population is too big and this work may take another 5-6 years to be able to develop a fully realised model.

Day 4 - Loss and Damage and Advocacy for Pacific Island Countries and Territories

Understanding Loss and Damage (Pasha Carruthers, SPC)

Pasha Carruthers (SPC) presented understanding loss and damage including defining loss and damage and its relevance to vulnerable communities in PICTs. Exploring the ethical, social and human rights dimensions of climate impacts and other processes such as ICJ.

The presentation highlighted the importance of considering and addressing fisheries loss and damage that exceeds the capacity of existing systems for adaptation or disaster management processes due to climate change. This presentation explained the difference between loss, which is irreversible and includes damage to ecosystems such as species loss or displacement, and damage, which is recoverable or repairable harm. It highlighted that loss and damage can be caused by both rapid onset events like marine heatwaves, storm surges and cyclones, as well as slow onset events such as sea level rise and ocean acidification, as well as a combination these impacts.

Fifteen questions related to Climate Change Loss and Damage in respective countries were discussed in a 15-minute interlude by groups, but not presented.

The presentation covered international efforts to address loss and damage associated with climate change impacts in developing countries, particularly through the UNFCCC process and the Paris Agreement, focuses on averting (greenhouse gas mitigation), adapting and addressing loss and damage. It covered the Warsaw Implementation Mechanism (policy focused), and the Santiago Network (technically focused) along with the five working groups under these, and now the Loss and Damage Fund approved at COP28 and the role of the World Bank with that.

In terms of regional and national actions, the interconnectedness and complexity of the systems and the amount of work to be done emphasised the need for risk assessments, including analysis of recent and potential loss and damages, the importance of scientifically justifying and attributing climate change impacts, along with the need to integrate local indigenous knowledge with peer-reviewed science.

The draft living glossary developed for CLAW was highlighted. It is being developed for participants to add new terms they would like defined for addressing climate change impacts and associated loss and damage. This document will be maintained separately from this report and updated periodically.

During the presentation, a list of questions for participants to answer was circulated (to 14 groups). The list of questions and answers was as follows:

Question	Group answers
1) What kind of irreversible permanent pelagic fisheries losses (economic and non-economic) might your country/community see due to ocean acidification and other slow onset climate change	Building a forecasting and warning system; Improve community capacity; and Develop adaptive production models.

impacts other than temperature? Any thoughts on how to start to address this?	
2) What kind of irreversible permanent coastal fisheries losses (economic and non-economic) might your country/community see due to ocean acidification and climate change other than temperature? Any thoughts on how to start to address this?	Building a forecasting and warning system; Improve community capacity; Develop adaptive production models; and Changing occupations for fishermen.
3) What kind of pelagic fisheries damages (ELD & NELD) might your country & community see due to temperature changes? Any thoughts on how to start to address this?	Changing fishing grounds; Changing fishing seasons; Change species composition and exploitation size; Building a system for forecasting fishing grounds; Raise awareness and knowledge for the community; and Developing sustainable and responsible fisheries.
4) What kind of coastal fisheries damages (ELD & NELD) might your country & community see due to temperature changes?, any thoughts on how to start to address this?	Changing fishing grounds; Changing fishing seasons; Change species composition and exploitation size. Building a system for forecasting fishing grounds; Raise awareness and knowledge for the community; and Developing sustainable and responsible fisheries.
5) If the fisheries sector in your country is hit by an extended marine heatwave, what are some of the likely impacts? What can be done to adapt to these. If the adaptations don't work what would be your recommendations?	Affects the health and work performance of fishers; Fishing output decreased; and Economic efficiency is reduced.
6) We know that heavy rainfall on land can cause a lot of damage & loss of life, to the point where there is forced internal relocation. What are some issues around heavy rainfall & fisheries? Are there any response options to these?	Limit deforestation; Maintain and regenerate forest ecosystems; and Planting and regenerating forests.
7) What are some non-economic loss and damage (culture, health, food security, in the fisheries sector that are likely to go beyond feasible adaptation projects)?	Migrate; Poverty, unemployment; and Illiteracy.
8) What would be the biggest compound risk for loss & damage to fisheries in your country,	Raise awareness and knowledge for the community;

combined slow onset & rapid onset. Is there anything that you would want to start work on to prepare for this in your country?	Building a system for forecasting fishing grounds; and Developing sustainable and responsible fisheries.
9) What economic losses might result from changed distribution of pelagic fisheries, how could affected communities & countries start to plan for and address these?	Developing sustainable and responsible fisheries; and Develop development plans and adaptive management solutions.
10) What kind of data & modelling needs are there for your countries to know/ get early warnings what types of pelagic fisheries loss and damage (economic and non-economic) there will be?	Data on climate change and impacts of climate change; and Develop models for forecasting, warning, impact assessment, decision support, and adaptive management.
15) What are some examples of fisheries adaptations for your countries that might not be possible within your existing financial & technical capabilities to implement before both ELD & NELD losses and damages become inevitable?	Develop models for forecasting, warning, impact assessment, decision support, and adaptive management.
11) What kind of data & modelling needs are there for your countries to know/ get early warnings what types of coastal fisheries loss and damage will be.	Data on climate change and impacts of climate change.
12) What kind of fisheries investment choices and decision maker support is needed to address risk of more intense cyclones compounded by sea level rise to fisheries infrastructure, ships, safety at sea?	Building a forecasting and warning system; Raise awareness and knowledge for the community; and Develop models for forecasting, warning, impact assessment, decision support, and adaptive management.
13) Are there any insurance type measures in your countries that might help with addressing loss and damage from fisheries, either existing options that might be scaled up or new mechanisms?	Accident insurance; and Fishing vessel crew insurance.
14) What are issues for boundaries/EEZ to sovereignty, fish management mechanisms, institutional arrangements that your countries need to consider once limits of feasible adaptation exceeded/boundary islands lost? Are there any solutions to this threat.	Determining maritime boundaries; and Signing/Cooperation Agreement.

Discussion

It is hard to predict when a final negotiated settlement could be expected, but there is a lot of pressure to show attribution. There is a Loss and Damages fund but the mechanisms for distribution of the money within the fund are not agreed. In addition, fisheries are not included in those discussions. To access the fund all the data will need to be presented to justify the case as well as specifying the timeframes.

Some issues like bushfires can be triggered by arson, but if there was an extended drought prior to the fire then an application for relief could be made.

Local indigenous knowledge will need to come in with the science to build the case and be integrated within the models, and governments will need to bring this to the fore when discussion issues such as cultural loss etc. Seasonal wages that are impacted will come under the Warsaw Implementation Mechanism which looks at seasonal and migratory workers.

The disaster management responses are separate from loss and damage, which goes beyond the usual disaster management. However, the funding disbursement agreement is still not finalised. No cases have been submitted successfully.

Grassroots Organizing and Community Engagement (Ueta Faasili, FFA)

Ueta Faasili (FFA) presented grassroots organizing and community engagement, showcasing grassroots initiatives for climate justice in PICTs and discussing the role of local communities in driving change. The importance of community engagement and organizing, particularly in the context of climate change initiatives was discussed. He emphasized the crucial role of local communities in driving change and empowering them to identify and solve their own challenges. He also highlighted the need for capacity building, cooperation, networking, and advocacy in these initiatives. Furthermore, the challenges faced in implementing grassroots initiatives and the importance of a cooperative approach in community engagement to mitigate the impacts of climate change and adapt to its effects were discussed.

Discussion

It was noted that an alternative term for loss and damage is *disproportionate burden* which is a term used frequently in fisheries negotiations.

There was a discussion that suggested that a well-educated grass roots population is a key to good fisheries management. If the users have a good understanding of the issues and proposed solutions it will make the management actions more implementable.

Through education, children can develop an understanding of these complex issues if the information is packaged in a digestible way. One of the approaches is to have hands on teaching and awareness initiatives so that the children can experience it for themselves. Keeping the information and stories simple so that young people can understand them is important as is using our expertise to assist teachers in developing materials. Developing materials and skills with teacher aids is something that is currently ongoing.

As there are many disparate projects and having a central place where the materials is developed would be helpful. SPREP is trying to coordinate this and include local knowledge. But it was also noted that community group work is challenging and is currently something that is underfunded. The gap in getting traditional knowledge from the elderly members of communities was highlighted as something that is urgently needed.

Advocacy Strategies for loss and damage (Espen Ronnenberg, SPC)

Advocacy Strategies for loss and damage was presented by Espen Ronnenberg (SPC), exploring effective advocacy approaches tailored to PICTs, communities and COP Pacific Pavilion. Emotive arguments alone do not carry the day. Facts and science are difficult to dispute and eloquence and moral high ground of small island states is paramount. Patience and sound arguments have succeeded in finding consensus, but still a danger that if all PICTs, are most vulnerable, then how can any preference be given one over the other.

Discussion

Loss and damage is an issue that is important but we need to take care that is it not used against us by others who may deny the science. Importantly, we need decisions as to what point to trigger compensation claims for the impacts of carbon emission. The financing for loss and damage is specifically for the most vulnerable developing countries. As impacts grow there may be a redirection of resources, but words like climate justice and compensations are not used, or allowed in negotiations, rather the terms rehabilitation and redress are used and it is in this light that it may be possible to leverage funds.

Climate adaptation discussions are ongoing in Tasmania and one of the results from those discussions is that the Australian government does not accept any responsibility for loss or damage on private land. Assessing the structural issues such as physical space, human resources, distance to market etc. all need to be considered when assessing the risk and compensations for developing states. Small island states have articulated their circumstances well, but within the UN process there is no buy-in from the development partners.

The terminology of loss and damage tends to get put into an insurance framework. We need to move away from this and look at the loss and damage in the future and the access to the opportunities such as maintaining rights to the fish no matter where they move to in future.

Outside of the UN climate change system, there will likely be some aspects for compensation or resolution through other mechanisms such as UNCLOS or IMO, but it all needs to be addresses by the UN climate change body. We need to get resources into all aspects including data collection and expanding the evidence base and we need to be able to argue that some of that will need to be set aside for sectors such as fisheries.

Tracking of the finance is challenging as climate related work can occur in many different government departments. The public climate related expenditure has been evaluated by some countries but not others. There is no international agreement on how to do this or what climate related expenditure actually is.

At the national level, there will need to be decisions made about how much gets spent on fisheries, which will depend on the importance of that sector for each country. We have projections under different scenarios but not all loss will be easy to quantify. When do we start to advocate for funds? Is it sector-specific spending and do we do it when we get to a point where we show that something is about to happen, or has happened in the past? This is something that also still needs to be discussed.

Decision Pathways (Ludwig Kumoru, FFA)

Ludwig Kumoru of FFA discussed the FFA climate strategies and decision making pathways. There is a concern over the lack of action on climate change and the need for clear pathways for decision-making, particularly within the fishery space. The information might not be reaching decision makers or and there are no clear pathways for decision-making. There has been a progression of addressing climate change within the fishery sector, where the WCPFC adopted a climate resolution in 2019 to the establishment of a specific item in the commission agenda for climate change in 2022. Addressing climate change, particularly in relation to the tuna sector, is needed as is the need for a clear pathway for all organisations to work together on addressing climate change. It would be useful to develop a 'climate smart' consensus and implement flexible open strategies to address the effects of climate change. This will require bringing decision makers, scientists, and policymakers together to discuss these issues.

Discussion

There are clear differences between the way decisions are made within different PICTs and within Pacific CROP agencies. It is good to have different avenues for raising the issues but they need to be shared so we can ensure that everyone can be responsible for the decisions that get made.

Climate change agendas are being raised in many fora, and this topic is relatively new in the tuna sector. We need to be aware that climate fatigue can set in and we need to make sure that we will be able to connect the dots and ensure that within the Pacific, we should set a clear path and not take on too much at one time so that we remain effective. Noting that climate change is now a standing agenda item at the WCPFC commission and all subsidiary bodies, is an important step in getting this topic recognised and continuing the work required to address it.

Giving climate change official recognition means that we can address the issue, plan for the future and ensure that we are all heading in the same direction. This workshop was designed to bring all sectors together in one place to ensure that we are all moving forward in a unified direction.

International Platforms and Collaborations (Espen Ronnenberg, SPC)

Espen Ronnenberg (SPC) presented international platforms and collaborations. This discussed opportunities for PICTs to engage on the international stage, and presented an overview of regional and global platforms for climate advocacy. Engagement and dialogue at national and regional level is critical, facts and science are indisputable around impacts on fisheries eloquence and moral high ground of small island states is paramount, given that the Pacific is only sustainably managed regional fisheries.

Discussion

The tuna fishery in the Pacific is one of the largest in the world and has had massive investment into its management. However, the international response to threats to this fishery is muted. These issues need to be raised with international leaders, highlighting the issue of threats to food security and

threats to PIC citizens ability to make a living in future in some areas. These messages need to be made when having discussions with other world leaders.

We need more than stories when considering the evidence base. The importance of peer reviewed literature was highlighted as an evidence log for these issues. It is therefore imperative that national and CROP agency scientists publish their work in peer reviewed journals to build the evidence base and make the results available to the wide public.

Adding better visualisations to our package if information considered useful. Providing good visuals and good data makes the interventions more meaningful and conveys the required messages easier than just speaking.

Knowing what developed state duties and responsibilities are and documenting whether they are living up to those obligations is required. Within a national jurisdiction litigation is possible, but interstate litigation is less likely to be effective.

Within regional organisations, we note that many different divisions are doing climate change work and this needs to be communicated back to the national teams. Building and increasing capacity is required. In addition, a sensible regional calendar to limit the stress on officials should be developed.

Another problem that was raised was the issue of personnel fatigue from small administrations. PICT governments have small administrations with few personnel and they often play multiple roles. To ensure they function effectively we need to limit overwork stress. The Pacific countries are dealing with more complex issues now than in the past, and the agendas are much larger than they were previously. It is becoming a real organisational challenge to manage all this work, nevertheless PICTs are not diminished and are performing well internationally.

Nationally, in Fiji, they are aligning climate change work across government departments and this should be mirrored in other countries and regionally to make work more efficient. PICTs need to be stronger internationally, and we need to put more effort into getting information out into the information highway in both the news and social media.

Introducing tools that increase accessibility to climate change indicator data (Joanne Potts, SPC)

Introducing tools that increase accessibility to climate change indicator data was presented by Joanne Potts (SPC). The presentation discussed the numerous tools that currently exist for accessing climate data and introduced a new platform from SPC that includes environmental inputs and biomass outputs based on SEAPODYM.

The Pacific Ocean Portal (https://oceanportal.spc.int/portal/ocean.html) provides a front-end tool for increasing accessibility of data from other providers (e.g., NOAA, BoM, NIWA) on a variety of issues such as coral reef bleaching predictions, sea surface temperature anomalies, significant wave height, across user-defined spatial and temporal scales.

The Climate Impacts on Tuna dashboard (https://ofp-sam.shinyapps.io/ofp-FEMA-climate-dashboard/) is a user-friendly tool to access SEAPODYM model outputs of the tuna fishery between 1950 and 2100. Users can explore historical model forcings (i.e., 1950-2022) data of input variables

(e.g., sea surface temperature, oxygen at depth, etc.) and predictions of tuna biomass (bigeye, skipjack and yellowfin) over user-defined temporal and spatial scales. Future development will focus on how relationships between model forcings and predicted biomass can be modelled, and implementation of breakpoint analyses to identify tipping points in time series of these data. Users are invited to provide feedback on any features they would like developed in this dashboard.

Discussion

The data within the models are validated by the stakeholders who do the local investigations. But currently these data are not fed back to the model itself. This would be a good value add for the future of the model. Moreover, this project is not connected to the Pacific Data Hub but it is hoped that in future it would be.

At the regional level, climate bulletining is produced in collaboration with SPREP and there is some commonality of practice between the organisations.

The underlying data do come from places like NOAA. But SPC is looking to get real time data on tides and waves. Historically meteorological data have been difficult to obtain, as some organisations won't share these data or they charge for it, but this is changing.

The work is also looking to identify breakpoints in the data. This work is under development, the statistics are there but they are not presented in the portal yet. The project is also looking at code sharing and users will be able to get code and data to make their own graphics and learn from the experience and develop their skills. Data are largely pre-uploaded as a data file in a manageable size so they are quicker to download and use locally than the complete data set, which is very large. Some data sets may still be large and sluggish to use, but it was noted that consideration has been given to the balance between data and user freedom so it was decided to use a course data set which may make things easier to use but it was noted that there is always a cost and benefit to this type of trade off.

Country perspectives

Guam (Brent Tibbatts)

Brent Tibbatts from Guam shared some of his experience from Guam showing declines in transhipment and fish catch, and increases in coral bleaching. The presentation featured two sets of data; the first, showed Guam transshipment data from 1989 until 2020. In the early part of the time series, Guam transhipped more than 11,000 mt of fish annually. By 2020, the that had declined to approximately 400 mt, a drop of 96%. All vessels and agents left Guam after 2020. One reason given was the fish had moved east, and the vessels followed. Guam experienced a strong El Niño in 1997-98. There is a corresponding dip in the transshipment data for that year.

In addition, bottom fish CPUE for from 1985-2022 were presented. The lowest CPUE of the time series was recorded in 2018. This corresponded to a time period (2013-2017) in which Guam experienced coral bleaching in four of the five years. Guam also experienced a very strong El Niño in 2015. Coral bleaching historically was a decadal phenomenon in Guam. However, over last 30 years bleaching events have increase in frequency of.

Niue (Poi Okesene)

Poi Okesene from Niue shared Niue's experience with tropical cyclone Heta a category-5 cyclone that hit Niue 20 years ago. He noted that Niue's coastal and reef areas particularly on the western side of the island are still recovering from the cyclone. Coral species, coral cover, displacement of certain marine coastal species and biodiversity are the biggest impacts to marine life. Loss of biodiversity and introduction of invasive species into open spaces has also been noted.

Economic loss affected many people who lost their houses and assets. Coastal areas are still affected by ongoing rough seas from time to time during cyclone seasons, it has been reported that it is taking longer for some coral species to be fully recovered. There has also been a general decline of edible coastal fish species experienced by people. Some seasonal coastal fish species are not always present in the season where they were historically present. Niue has noted a decline in marine species contributing and overall reduction in food security. The only wharf was damaged and is repeatedly damaged by rough seas.

Discussion

The disaster resulted in two casualties, this low mortality was largely attributed to the cyclone happened during the daytime. It is speculated that had it occurred at night the situation would have probably resulted in more casualties. The cyclone recovery cost 90 Million NZD to fix houses and government infrastructure.

People were complacent to cyclone warnings issued by Met Services and now they pay more attention to them. After the cyclone canoe traditional fishers were still able to fish from their canoes to access to traditional fishing grounds despite the fact that major infrastructure including the port was damaged and access to electricity was not possible. After the cyclone ciguatera poisoning became a problem.

Closing remarks

Simon Nicol followed with a few closing remarks and word of thanks. Simon offered a big thanks to all and, in particular, to Steven Hare who did much of the hard work in actually making the CLAW happen. He additionally thanked Natalie Lemesle, Helene Ixako and Paul Judd who diligently stuck at the job, dealing with SPC's new travel system, working about 13 to 14 hours a day for about eight weeks to get everyone here. Simon also thanked all the speakers and noted the dedication form Patrick Lehodey and Inna Senina, who travelled halfway around the world to get here. He also thanked the New Zealand Ministry of Foreign Affairs and Trade, and particularly Jonathan Peacey and his team, as well as Stephen Harris specifically for providing the resources and the encouragement to get all of us to Wellington.

In a broad sense, our intention for the CLAW was to try and address some of the gaps that we noted during our Climate Change work over the past few years in terms of where we were, and to make sure everyone was connected and on the same page when it came to tuna fisheries, climate change and climate change processes. We don't know whether that was successful or not: The participants will tell us over the next month when you get home after spending a week in in Wellington and you'll be able to reflect on that, and then provide feedback back to SPC noting whether it was worthwhile or

not. This feedback will determine whether we try and convent the CLAW again. The other feedback we would really love to get, even if you say no to another CLAW, is what are the things that you just didn't like or that didn't really work? If you say yes to another CLAW, what would be the things that you would want next time? The next CLAW doesn't have to be in the same format, nor does it have to cover the same topics. But if you see value in the CLAW and you want to see it happen again, then we're happy to instigate it.

One other thing to say, this can be seen as an SPC led activity, but the genesis of this came from discussions with FFA and the PNA, so it really is a joint SPC, FFA, PNA endeavour. This was not just an SPC endeavour, it's the three regional agencies working together as best that they can. Thanks everyone for your contributions.

Jonathan Peacey closed the meeting on behalf of the New Zealand Ministry of Foreign Affairs and Trade. Jonothan thanked SPC, partner agencies, partner governments, workshop organisers, workshop presenters, and workshop participants.

Jonathan noted that this was an excellent workshop that has achieved the key objective of building capacity of fisheries managers to integrate climate change considerations more effectively into management of the taonga or treasure that is Pacific fisheries. It has been great to see the interactions between fisheries managers, fisheries and oceans scientists, and climate scientists. There has been excellent exchange of information and mutual learning, and good links have been made.

Thanks were also offered to the wider CSEPTA Team (or Tuna Early Warning System or, as Ludwig told us on the video, Climate Intelligence System). For agencies like MFAT, for Stephen as Pacific Oceans and Fisheries Unit Manager, and for me as Activity Manager, there are reputational issues when investing in large projects such as CSEPTA. After all, we are stewards of NZ taxpayer funds. Important considerations include efficiency (is the project being delivered in a cost-effective manner?), and the risk of late delivery or non-delivery. These are especially relevant for large, complex projects such as CSEPTA – which is really a programme comprising many projects. Simon highlighted the complexity of CSEPTA at the Steering Committee meeting yesterday – there are so many people contributing to CSEPTA that the names don't all fit on one PowerPoint slide. And the Team is from different organisations and different parts of the world. But with SPC and the CSEPTA skills and systems and strong commitment to making the project successful, I am confident CSEPTA is in safe hands – and because of that, my stress levels are low! Thank you.

Another important consideration is value-add. Is our investment in CSEPTA making a difference? And the answer to that is an emphatic, "Yes". We are excited about the value of CSEPTA. The fine-scale forecasting of climate change impacts on tuna fisheries will make an important contribution to future management of these fisheries for the benefit Pacific Island countries. And we are excited about the wider benefits of CSEPTA, including: establishing a new genetic sampling programme, a genetic material cold chain system, and a marine specimen bank; implementing an improved stock assessment approach based on close kin mark recapture; and laying the foundations on which the Green Climate Fund project will build.

And this leads to my final point – my personal interest in CSEPTA. Johann Bell and I first pitched what is now the Green Climate Fund proposal, Adapting tuna-dependent Pacific Island communities and economies to climate change, at the SPC Heads of Fisheries meeting in 2017. I subsequently moved on from Conservation International while Johann and colleagues in CI and SPC persevered with the

proposal. It is a privilege for me to join MFAT and be appointed MFAT Activity Manager for CSEPTA, a project that is building the foundations for the GCF project that Johann and I pitched all those years ago – and which is now close to implementation. I was convinced of the value of the initiative then; I am even more convinced now.

Thank you all, and I wish you well. I leave you with a traditional Māori blessing for your journey home and in your longer journey to address climate change impacts on fisheries:

Kia hora te marino, kia whakapapa pounamu te moana, kia tere ai te kārohirohi i mua tonu i o koutou huarai. (May the calm be widespread, may the sea be as smooth as the surface of greenstone and may the rays of sunshine forever dance along your pathway.)

Appended to this document is a list of participants (Appendix 1) and the results from the Slido surveys undertaken during the CLAW (Appendix 2). After the workshop concluded, a survey was undertaken to gain insights into the participants experience at the CLAW and to ascertain changes that might improve a potential CLAW 2025. These are reported in Appendix 3.

Appendix 1 – List of attendees

AMERICAN SAMOA	
Domingo Ochavillo Dept. of Marine & Wildlife Resources	Moleni Tu'uholoaki Pacific Community Ocean Prediction and Monitoring
AUSTRALIA	Netani Tavaga Ministry of Fisheries
John Morrongiello University of Melbourne	Pasha Carruthers Pacific Community Climate Change and Sustainability
Richard Matear CSIRO	Taributi Bebeia Ministry of Fisheries
Thomas Moore CSIRO	Zulfikar Begg Pacific Community Ocean Prediction and Monitoring
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS	**FRENCH POLYNESIA**
Christina Tudela Dept. of Lands and Natural Resources	Marie Soehnlen Marine Resources Department
COOK ISLANDS	**GUAM**
Peter Graham Ministry of Marine Resources	Brent Tibbatts Department of Agriculture
FEDERATED STATES OF MICRONESIA	Michael Duenas Department of Agriculture
Bradley Phillip Pacific Community Oceanic Fisheries Programme	**INDONESIA**
Chandra Legdesog Dept. Environment, Climate Change and Emergency Management	Fayakun Satria Research Centre for Fishery
Correy Abraham Dept. of Environment, Climate Change, Emergency Management	Lilis Sadiyah Research Centre for Fishery
Eugene Pangelinan National Oceanic Resource Management Authority	**KINGDOM OF TONGA**
Jamel James National Oceanic Resource Management Authority	Jane Elaine Havealeta Ministry of Fisheries
FIJI	Siolaá Malimali Ministry of Fisheries
Espen Ronneberg Pacific Community Climate Change and Sustainability	Sione Vailala Matoto Ministry of Fisheries

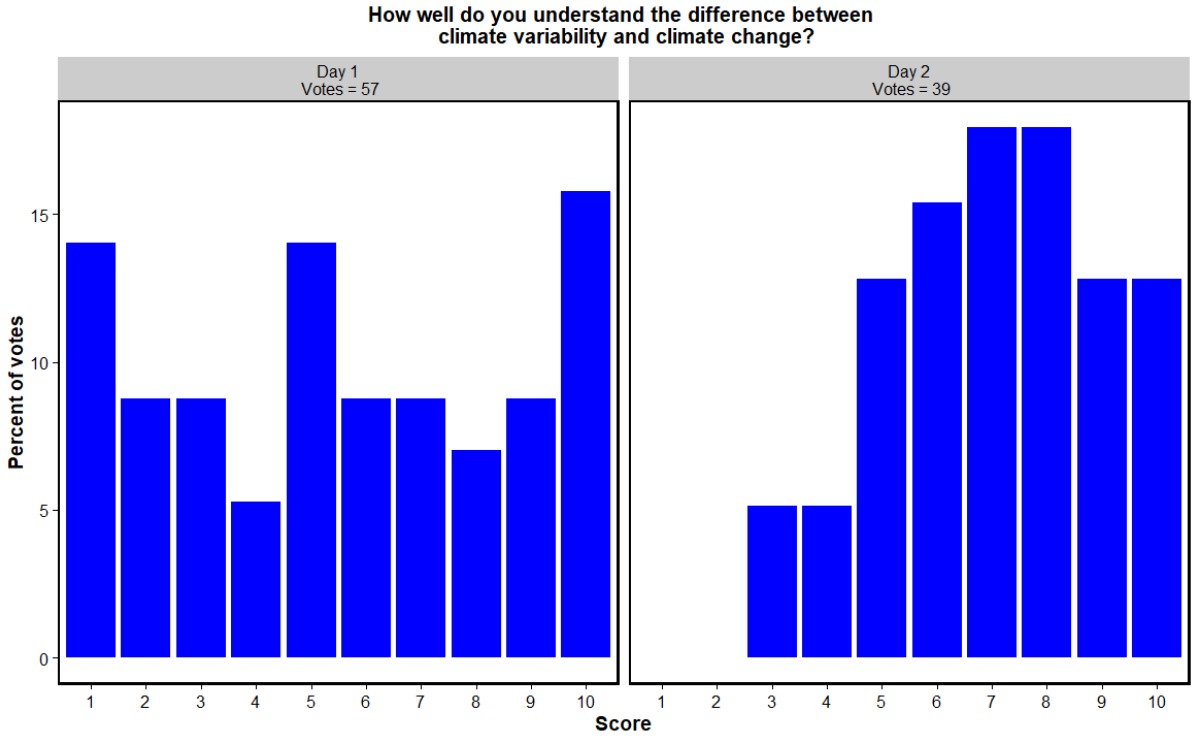
KIRIBATI	Manasa Babitu Pacific Community Oceanic Fisheries Programme
Kaon Tiamere Ministry of Fisheries & Marine Resources Development	Mickael Lercari New Caledonia Government, Fisheries department
Uati Tirikai Ministry of Fisheries & Marine Resources Development	Nathalie Lemesle Pacific Community Oceanic Fisheries Programme
MARSHALL ISLANDS	Patrick Lehodey Pacific Community Oceanic Fisheries Programme
Beau Bigler Marshall Island Marine Resources Authority	Paul Judd Pacific Community Oceanic Fisheries Programme
Berry Muller Marshall Island Marine Resources Authority	Rodrigue Tiavouane Government of New Caledonia
Francisco Blaha Marshall Island Marine Resources Authority	Simon Nicol Pacific Community Oceanic Fisheries Programme
Glen Joseph Marshall Island Marine Resources Authority	Steve Menzies Pacific Community Consultant
NAURU	Steven Hare Pacific Community Oceanic Fisheries Programme
Charleston Deiye Nauru Fisheries & Marine Resources Authority	Toky Rasoloarimanana Pacific Community Fisheries, Aquaculture & Marine Ecosystems
Julian Itsimaera Fisheries and Marine Resources Authority	Tuikolongahau Halafihi Pacific Community Oceanic Fisheries Programme
Kaleki Deiye Fisheries and Marine Resources Authority	**NEW ZEALAND**
NEW CALEDONIA	Andrea Gilbride Ministry of Foreign Affairs and Trade
Christophe Menkes Institut de recherche pour le développement	Arnaud Grüss National Institute of Water and Atmospheric Research
Helene Ixeko Pacific Community Oceanic Fisheries Programme	Brad Moore National Institute of Water and Atmospheric Research
Inna Senina Pacific Community Oceanic Fisheries Programme	Charlotte Mortimer Ministry for Primary Industries
Joanne Potts Pacific Community Oceanic Fisheries Programme	Chelsea Roberts Ministry of Foreign Affairs and Trade
Jone Amoe Pacific Community Oceanic Fisheries Programme	

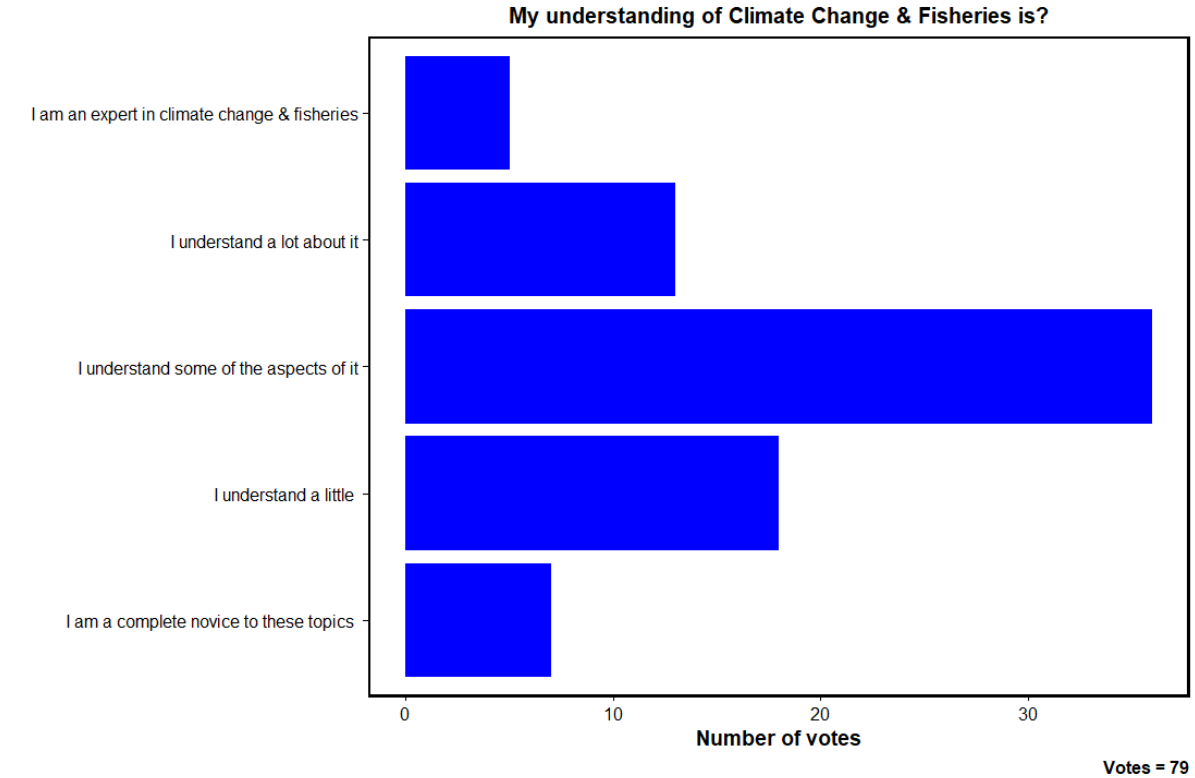
Gabrielle Faletoese Ministry of Foreign Affairs and Trade	**PAPUA NEW GUINEA**
Hilary Ayrton Ministry for Primary Industries	Aisi Anas National Fisheries Authority
Jeff Tang Ministry of Foreign Affairs and Trade	Andy Bill National Fisheries Authority
Jonathan Peacey Ministry of Foreign Affairs and Trade	Angela Kwapena National Fisheries Authority
Lucy Jacob Ministry for Primary Industries	Noan PAKOP National Fisheries Authority
Matt Dunn National Institute of Water and Atmospheric Research	Simon Kaumi National Fisheries Authority
Matt Pinkerton National Institute of Water and Atmospheric Research	**SAMOA**
Michaela Hildreth Ministry of Foreign Affairs and Trade	Fatutolo Iene Ministry of Natural Resources and Environment
Molly Powers-Tora National Institute of Water and Atmospheric Research	Lui Bell Pacific Community Oceanic Fisheries Programme
Richard O'Driscoll National Institute of Water and Atmospheric Research	Moli Amosa Iakopo Ministry of Agriculture and Fisheries
Stephen Brouwer Saggitus Environmental Science	Roseti Imo Ministry of Agricultre and Fisheries
Stephen Harris Ministry of Foreign Affairs, New Zealand	**SOLOMON ISLANDS**
Todd Croad Ministry of Foreign Affairs and Trade	Adele Dutilloy Pacific Islands Fisheries Forum Agency
NIUE	Charlyn Golu Ministry of Fisheries and Marine Resources
Josie Tamate Government of Niue	Chris Reid Pacific Islands Fisheries Forum Agency
Poi Okesene Dept. of Agriculture, Forestry & Fisheries	Don McKay Pacific Islands Fisheries Forum Agency
PALAU	James Teri Ministry of Fisheries and Marine Resources
Keith Inawo Ministry of Agriculture, Fisheries, and Environment	Lily Wheatley Pacific Islands Fisheries Forum Agency
Zilah D. Oiterong Ministry of Agriculture, Fisheries and Environment	Ludwig Komoru Pacific Islands Fisheries Forum Agency
	Manu Tupou-Roosen Pacific Islands Fisheries Forum Agency

Marina Abas Pacific Islands Fisheries Forum Agency	UNITED STATES
Peter Kenilorea Ministry of Fisheries and Marine Resources	Beth Holland Fisheries Consultant
Ueta Faasili Pacific Islands Forum Fisheries Agency	Jason Philibotte National Oceanic and Atmospheric Administration
TOKELAU	VANUATU
Feleti Tulafono Fisheries Management Agency	Rocky Kaku Fisheries Department
Lesley Gould Fisheries Management Agency	Sunny Seuseu Secretariat of the Pacific Regional Environment Programme
Luisa Naseri-Sale Fisheries Management Agency	Tony Taleo Fisheries Department
TUVALU	**VIETNAM**
Sam Finikaso Fisheries Department	Duong Nguyen Quy Department of Fisheries
Semese Alefaio Fisheries Department	

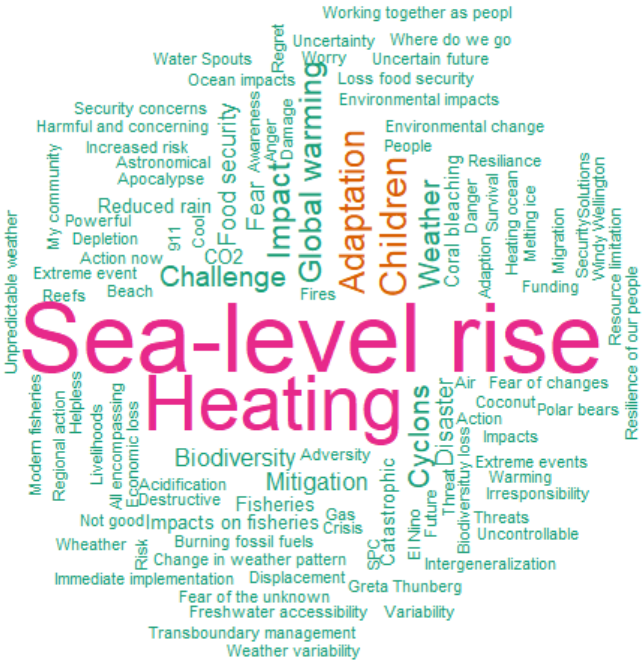
Appendix 2 – Summaries from the Slido surveys

There were a number of surveys throughout the workshop. These were undertaken using Slido (Slido.com) and the results are presented here as either bar graphs or word clouds where the largest words were used the most frequently. Within each plot the question posed is in the plot header.

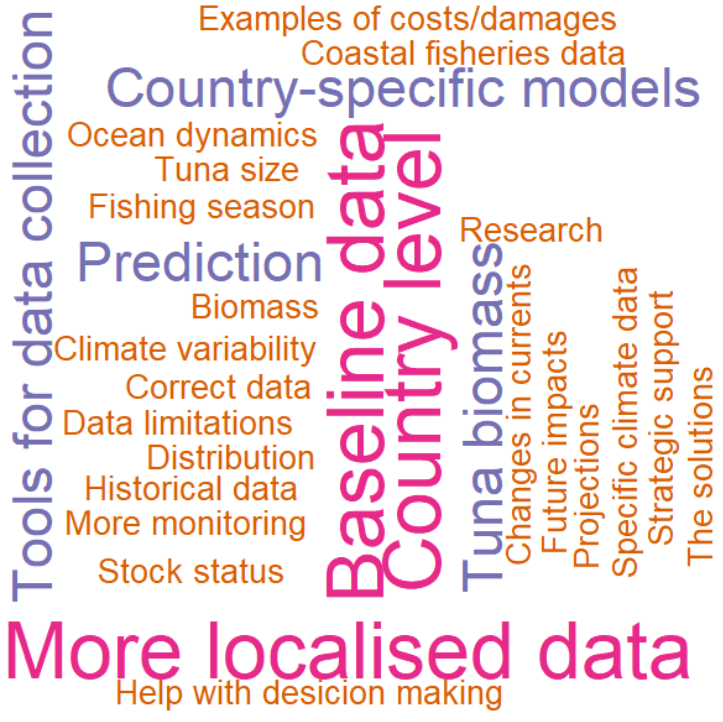




When you hear the phrase climate change
what are the first three things that pop into your mind?

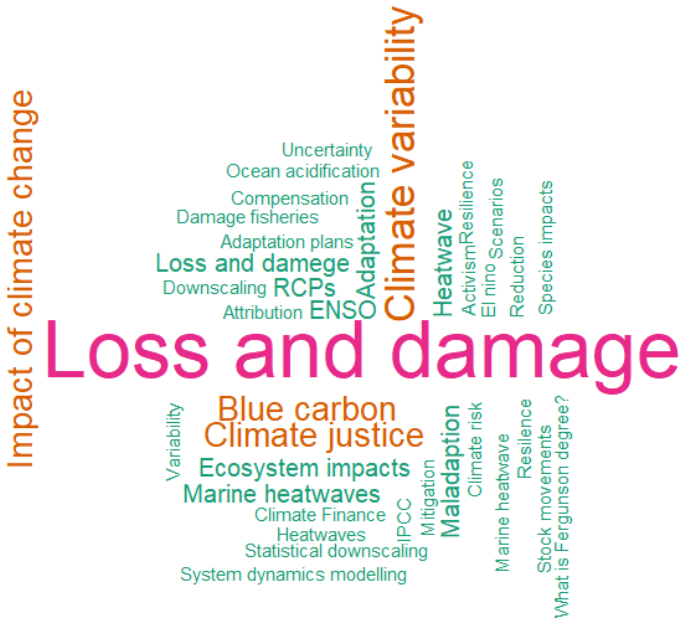


What information do you need to make decisions about climate change
and Tuna fisheries within your country/territory?



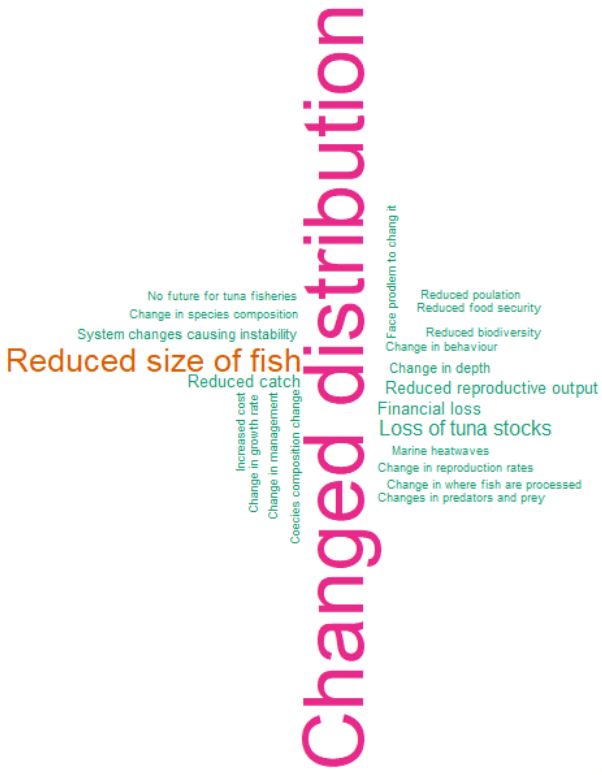
Votes = 36

What Climate Change Terms do you want to know more about?

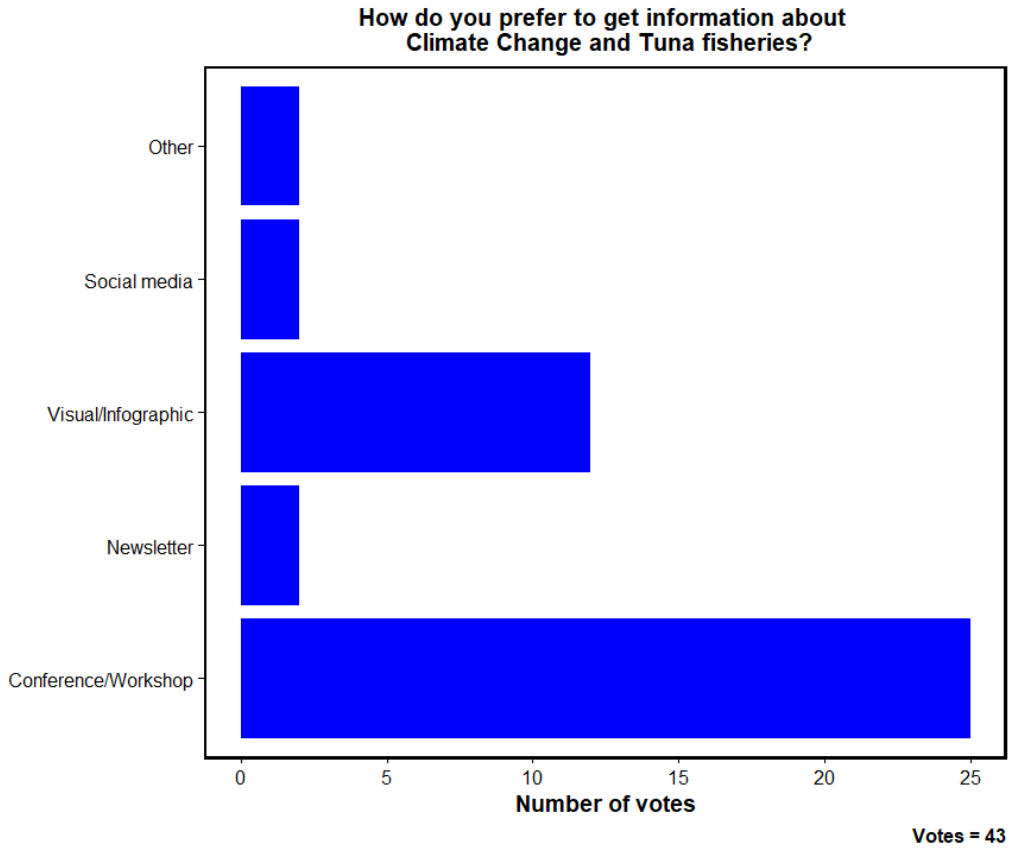


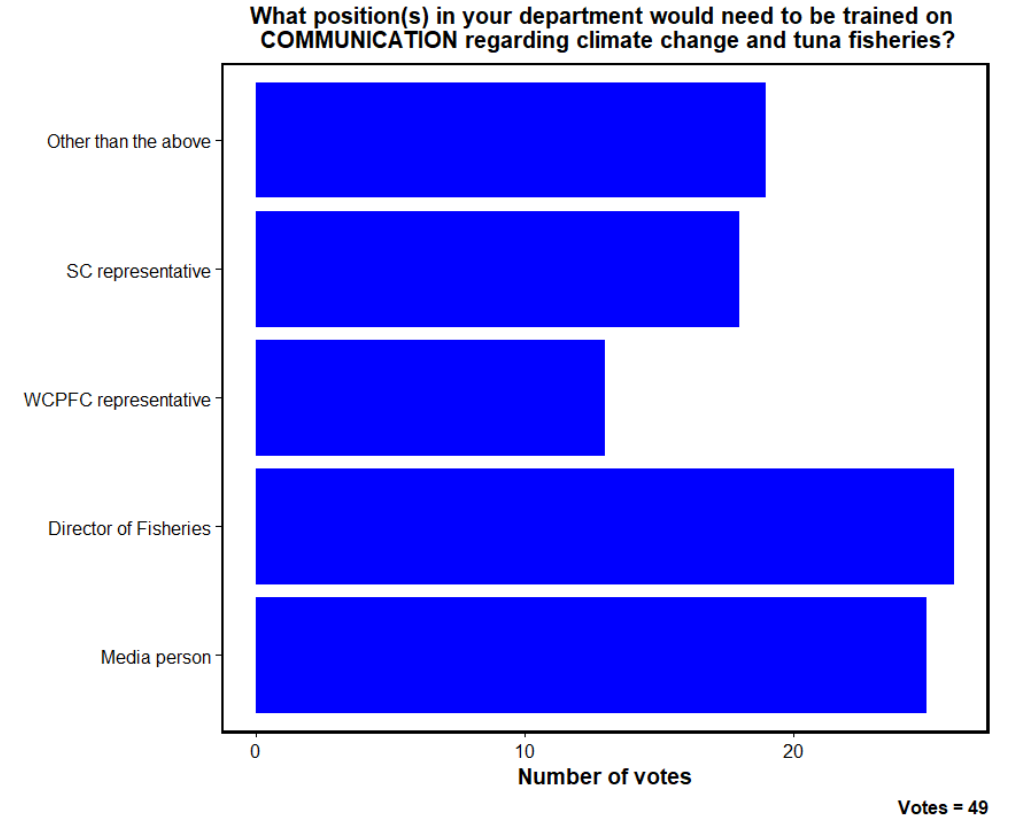
Votes = 45

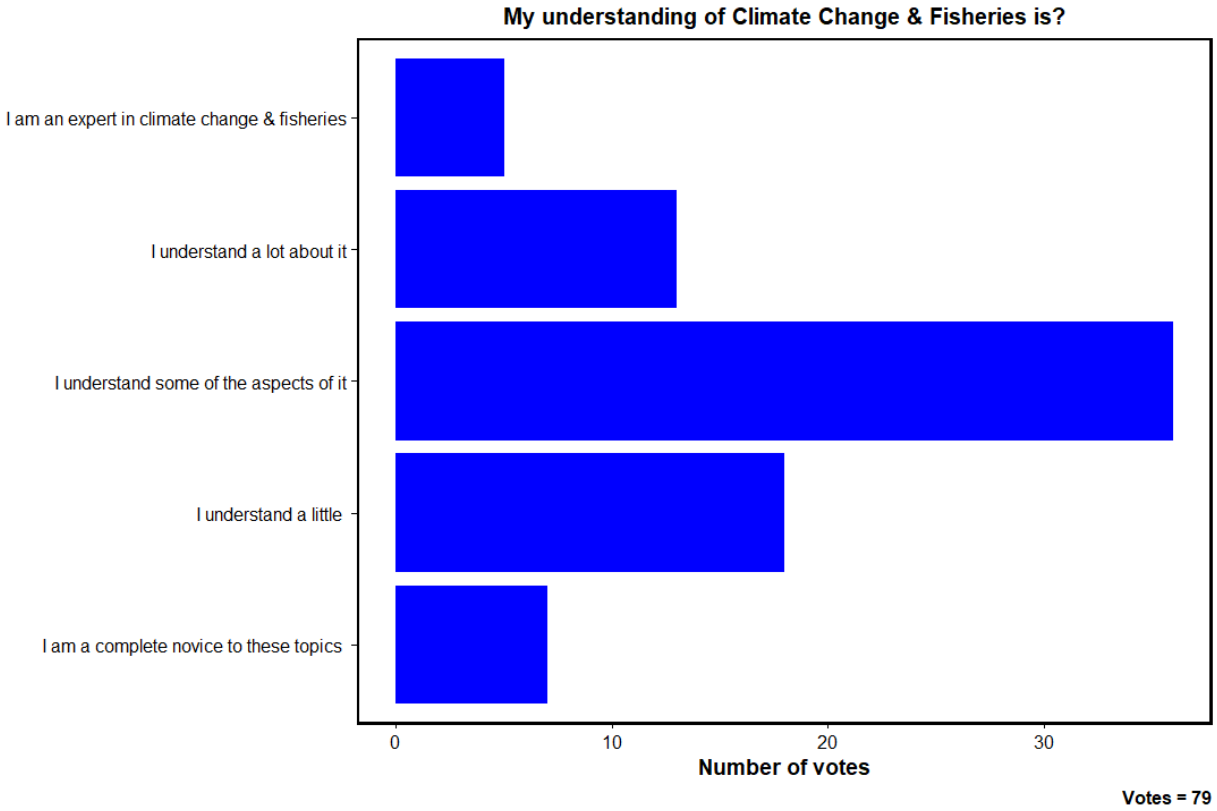
Based on what you've heard so far in CLAW, and your own knowledge, how will tuna, and the tuna fisheries, be impacted by climate change?

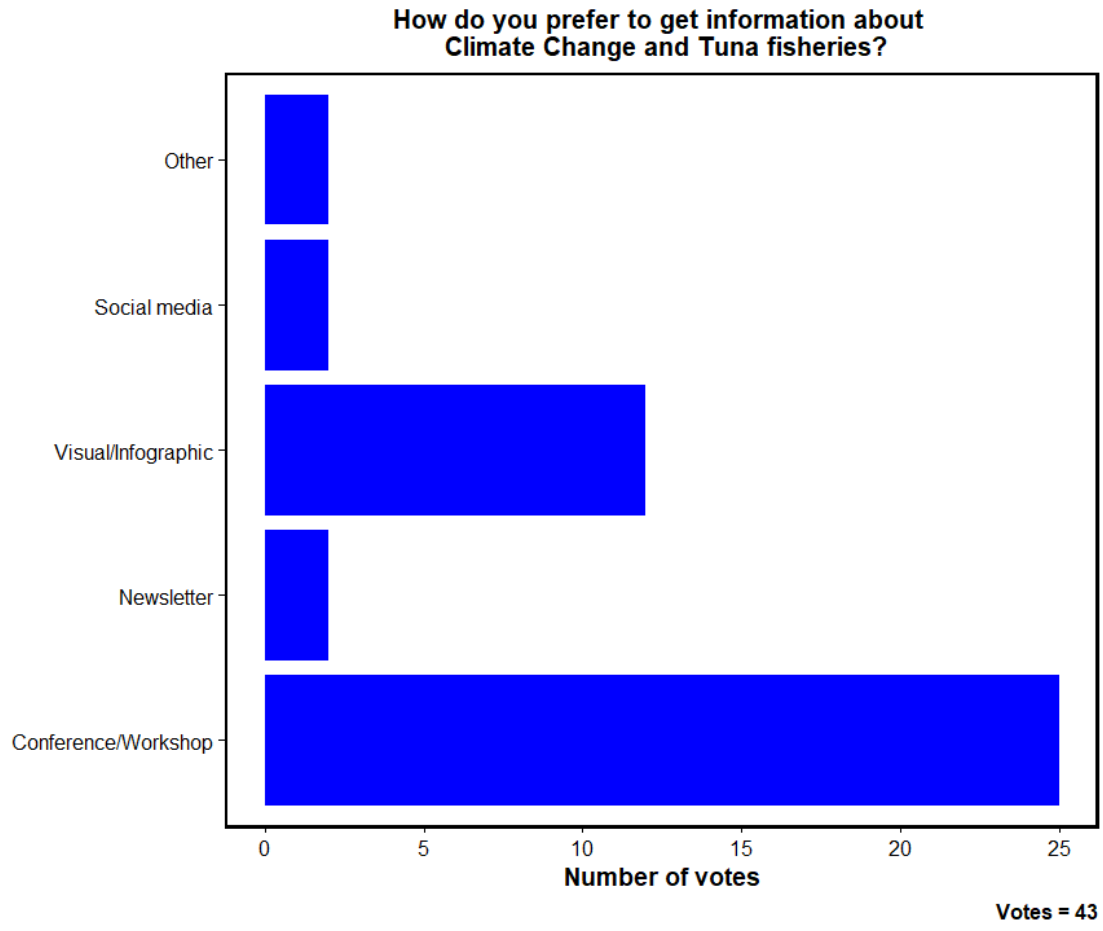


Votes = 45


How do you prefer to get information about
Climate Change and Tuna fisheries?
Other
Social media
Visual/Infographic
Newsletter
Conference/Workshop
0
5
10
15
20
25
Number of votes
Votes = 43

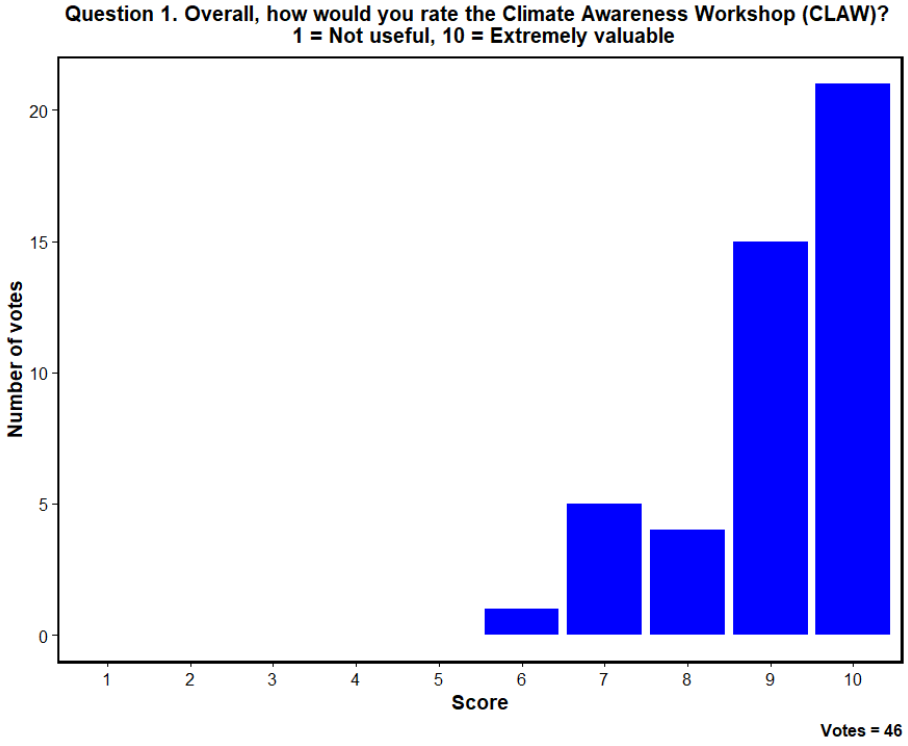

What position(s) in your department would need to be trained on
COMMUNICATION regarding climate change and tuna fisheries?
Other than the above
SC representative
WCPFC representative
Director of Fisheries
Media person
0
10
20
Number of votes
Votes = 49

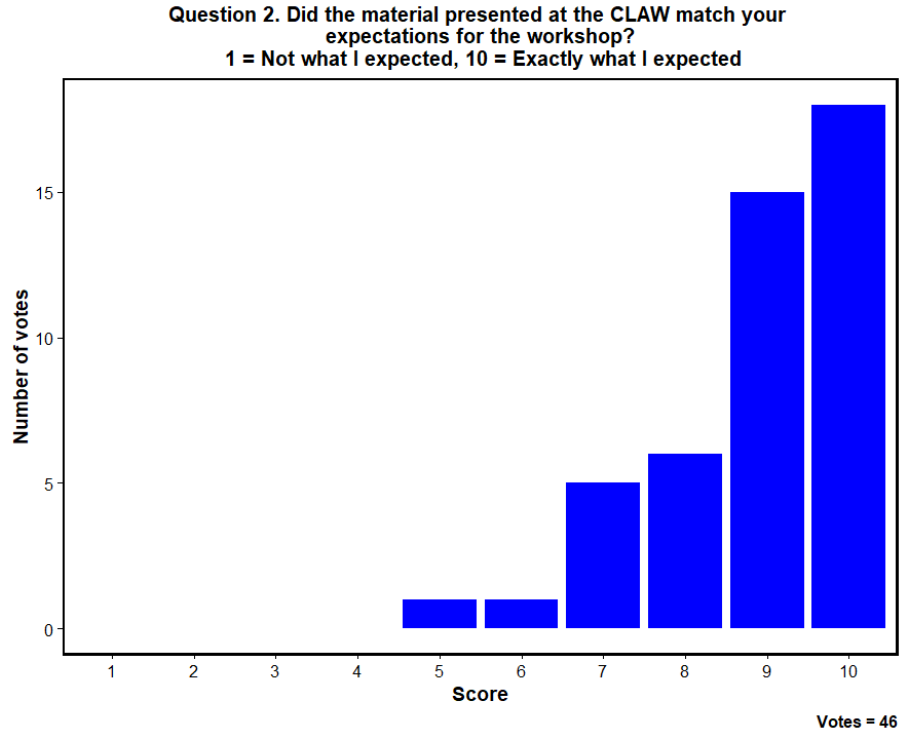

My understanding of Climate Change & Fisheries is?
I am an expert in climate change & fisheries
I understand a lot about it
I understand some of the aspects of it
I understand a little
I am a complete novice to these topics
0
10
20
30
Number of votes
Votes = 79

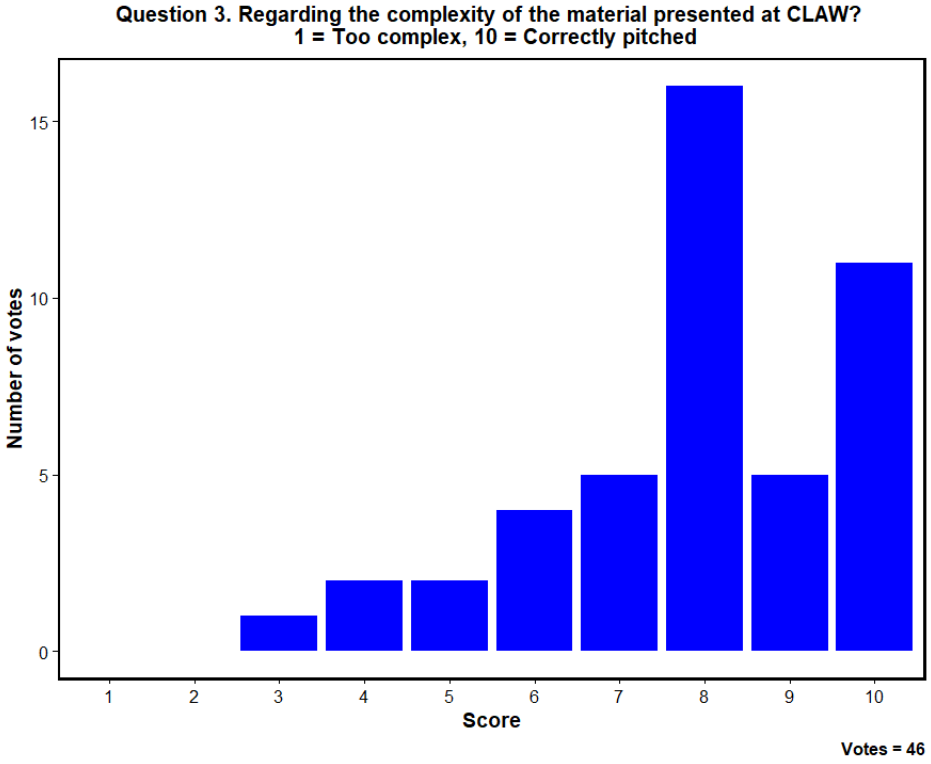

How do you prefer to get information about Climate Change and Tuna fisheries?
Other
Social media
Visual/Infographic
Newsletter
Conference/Workshop
0
5
10
15
20
25
Number of votes
Votes = 43

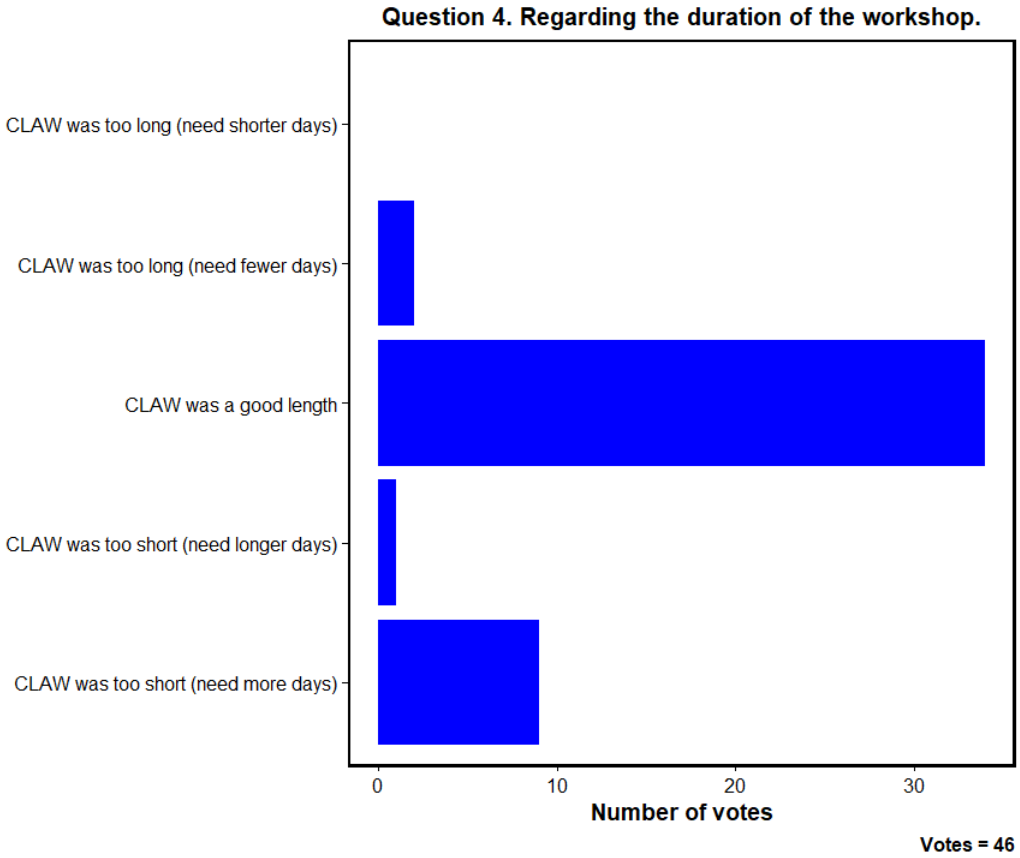
Appendix 3 – Summaries from the CLAW participant post-meeting survey

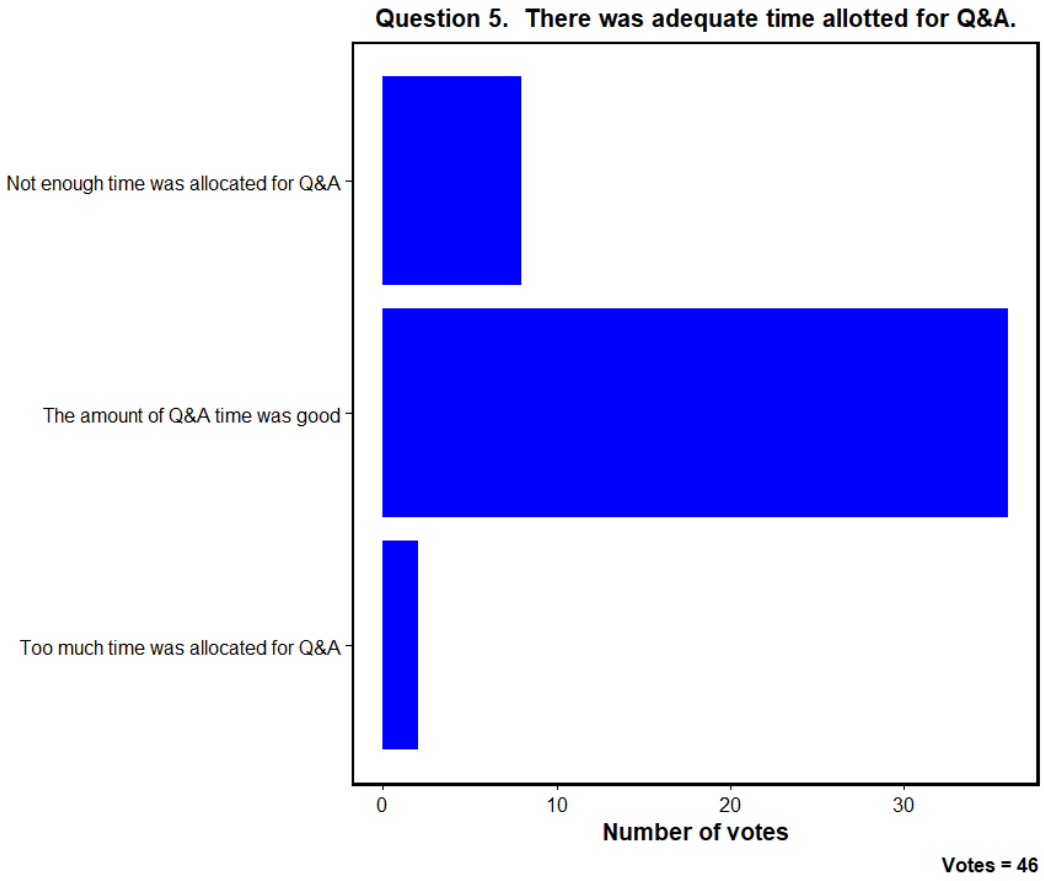
After the CLAW was finished the organisers sent out a survey to gauge the participants experience and learning from the CLAW. The survey consisted of 10 questions followed by the opportunity to provide feedback. The question results are presented in bar charts and the participant feedback is presented exactly as received.

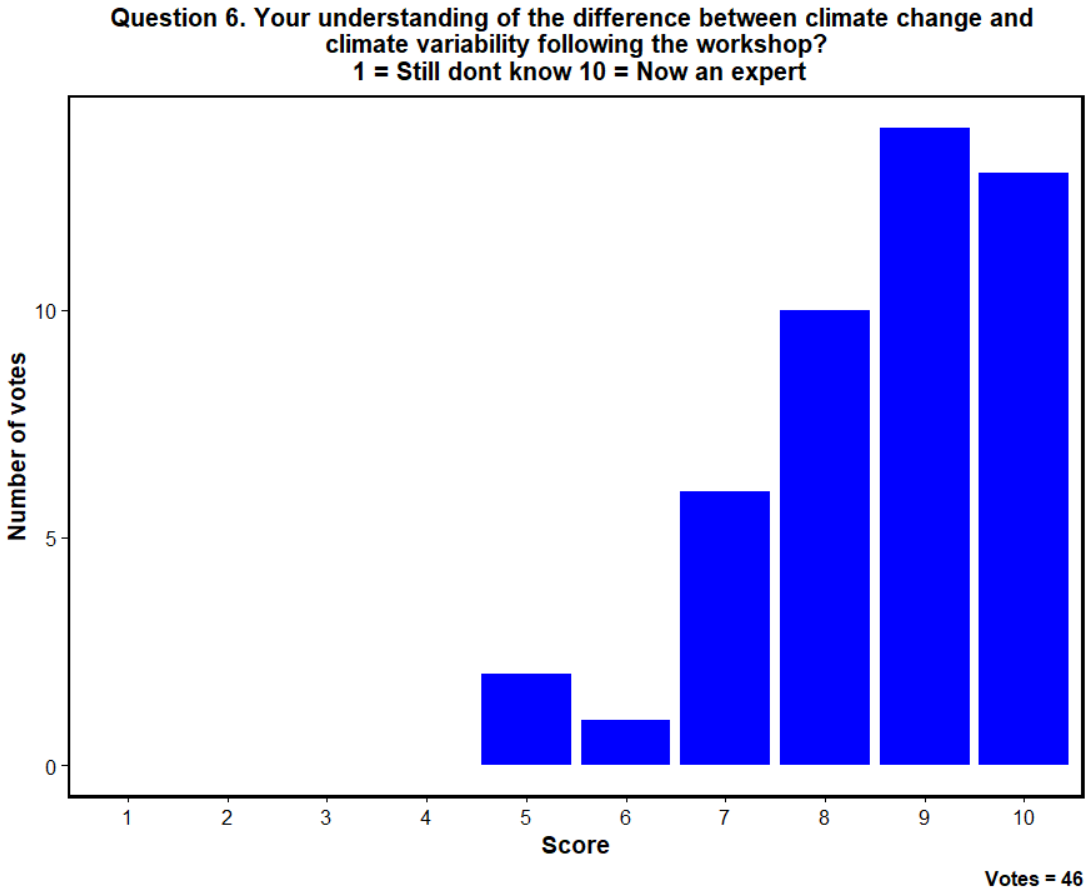


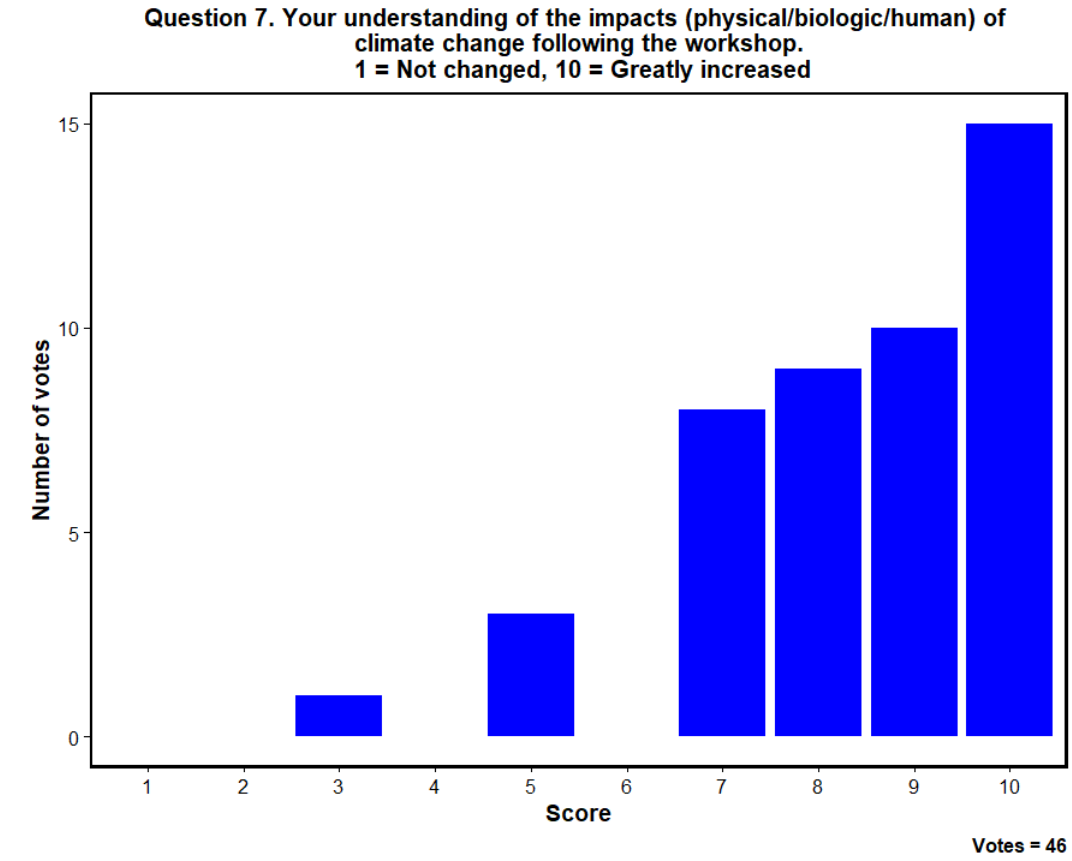


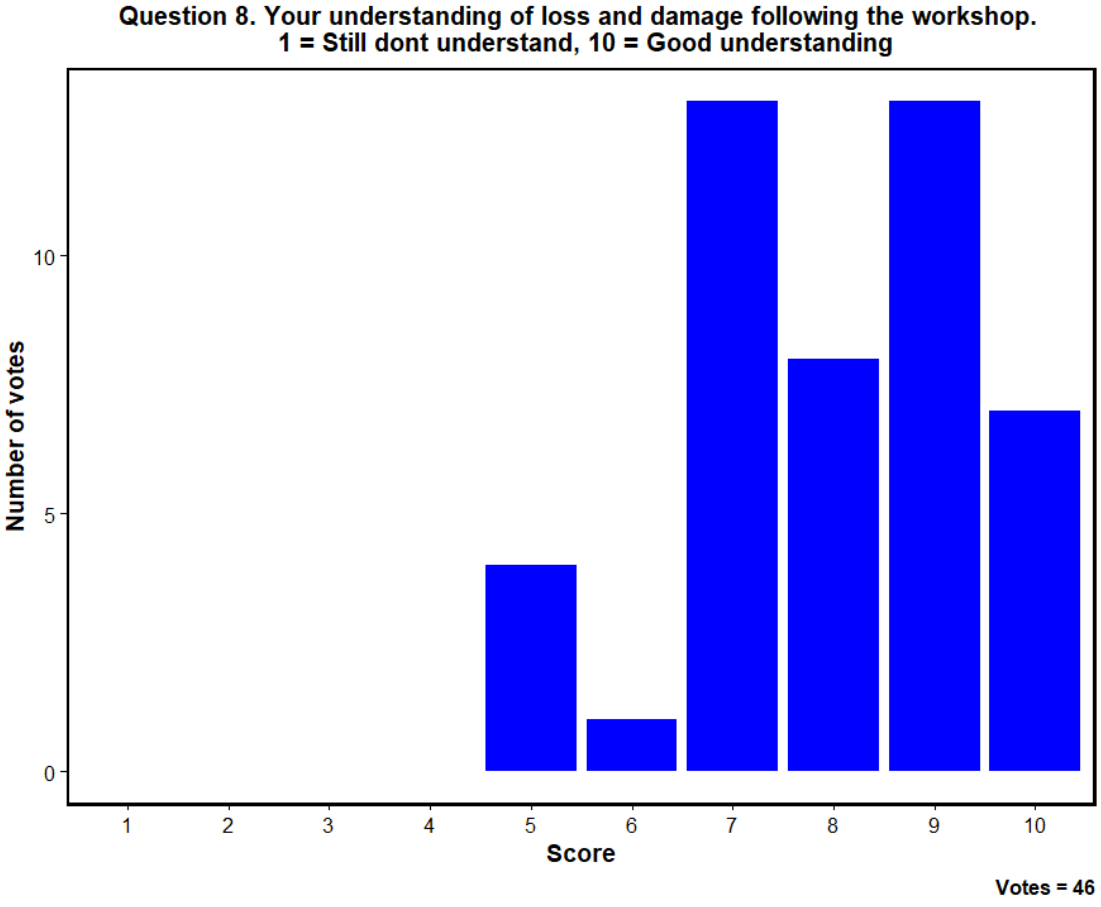

Question 3. Regarding the complexity of the material presented at CLAW?
1 = Too complex, 10 = Correctly pitched
Number of votes
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Score
Votes = 46

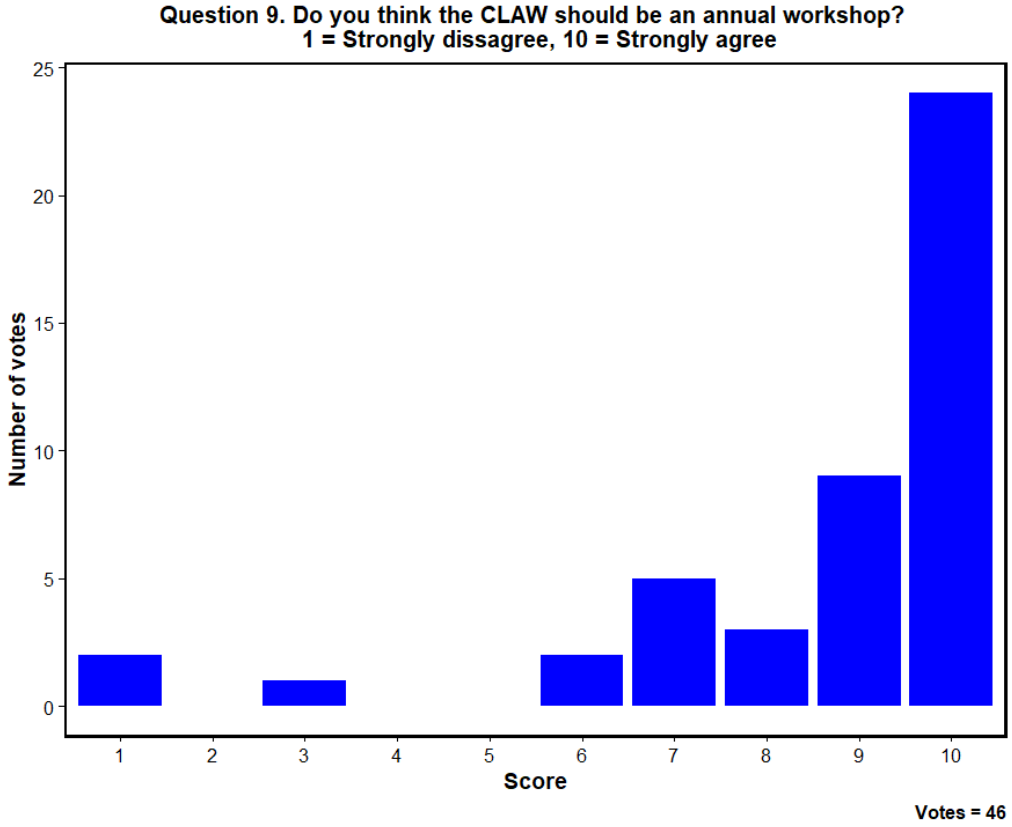

Question 4. Regarding the duration of the workshop.
CLAW was too long (need shorter days)
CLAW was too long (need fewer days)
CLAW was a good length
CLAW was too short (need longer days)
CLAW was too short (need more days)
0
10
20
30
Number of votes
Votes = 46

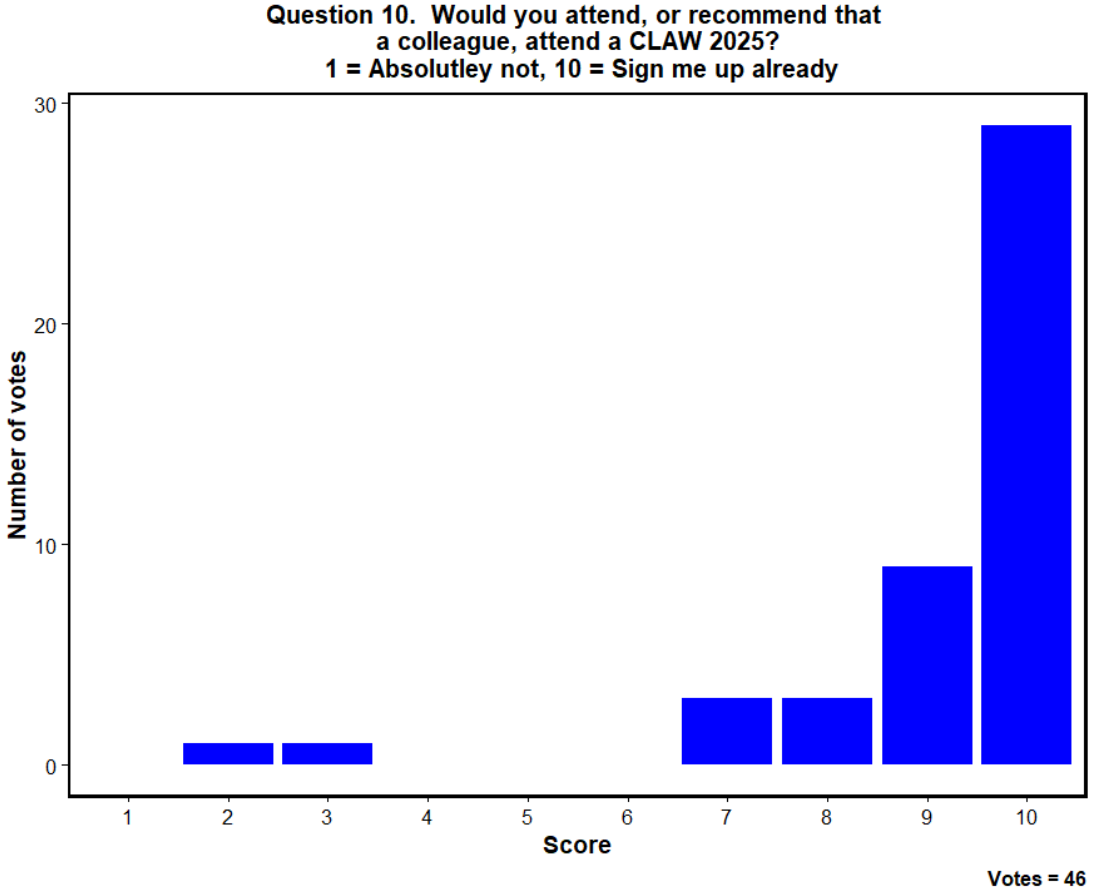

Question 5. There was adequate time allotted for Q&A.
Not enough time was allocated for Q&A
The amount of Q&A time was good
Too much time was allocated for Q&A
0
10
20
30
Number of votes
Votes = 46


Question 6. Your understanding of the difference between climate change and climate variability following the workshop?
1 = Still dont know 10 = Now an expert
Number of votes
0
5
10
1
2
3
4
5
6
7
8
9
10
Score
Votes = 46


Question 7. Your understanding of the impacts (physical/biologic/human) of climate change following the workshop.
1 = Not changed, 10 = Greatly increased
Number of votes
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Score
Votes = 46


Question 8. Your understanding of loss and damage following the workshop.
1 = Still dont understand, 10 = Good understanding
Number of votes
0
5
10
1
2
3
4
5
6
7
8
9
10
Score
Votes = 46


Question 9. Do you think the CLAW should be an annual workshop?
1 = Strongly dissagree, 10 = Strongly agree
Number of votes
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
Score
Votes = 46


Question 10. Would you attend, or recommend that
a colleague, attend a CLAW 2025?
1 = Absolutley not, 10 = Sign me up already
Number of votes
30
20
10
0
1
2
3
4
5
6
7
8
9
10
Score
Votes = 46

As part of the post-CLAW survey, the opportunity to provide comments – constructive or otherwise was provide. This is the list of the raw unedited comments received..

Do you have you any comments, suggestions, ideas for improvement or change for the next CLAW?
Shirt is a must - Steven I like the shirt
Huge congratulations to the organising committee for this amazing initiative
It was good. Would have been good to see more country experience presentations, and hear the concerns and/or goals at the national level.
For the next claw to be held in a Pacific Island where climate change impacts is visibly seen to give more urgency to the situation.
Could there be some pre-event effort to collate and curate big questions from the PIN community?
I learned so much and the content was much more than I was expecting. I recommend allotting time for the island areas to give a presentation on how Climate change has impacted them. I know it was in the original agenda and had to be cut, but just sharing stories around the room during breaks was very informative and should be incorporated into the next CLAW.
Thanks for the well organised workshop. I would suggest to find a venue where all participant can face the screens and speakers (the round tables were not adapted thus uncomfortable posture sometimes).
I think the opportunity for individual PICTs to present on the effects of climate change would be useful. Climate change does not affect everyone equally in the Pacific
The period it took to cover for the workshop was sufficient and the length of each sessions per day. I now have a better understanding of climate change, its impact on the ocean, fisheries, the economy and biodiversity. More case studies from the Pacific to better demonstrate the real impacts on fisheries.
I recommend allotting a day for participants to present country data and information on climate change impacts.
CLAW to be held every two years to allow for more time to collect data and complete research
Have some development partners involved.
Provide country short presentation of the impact of Climate Change on Fisheries
Probably, the next time we can focus on studies on the impacts. also on regional monitoring of cc
The CLAW workshop is a very informative and resourceful workshop for not only fisheries technical and researchers but very critical to the fisheries industry as well as for decision making at all levels of fisheries. It is also important that the scientific information could be also relayed to the tuna fisheries industries so that they can also understand the scientific aspect, not to only interested in the economic aspect in terms of monetary value that they earn through fishing but also the scientific side of it and more importantly the fisheries management part of it to ensure that there is a balance in harvesting, management and restoring of stack. Moreover, i would also suggest that in the next CLAW meeting if the secretariat could consolidate all climate projects funded and state what are the effectiveness of these projects on our fisheries stock and in terms of fisheries management. FFA and SPC to also present on projects or works that are in the pipeline to be implemented in view of addressing (with regards to Adaptation, Mitigation, Loss and Damage Projects /strategies/policies/activities/initiatives) the impacts of Climate Change on the fisheries resources.
I think at the end of each day a set of recommendations could be developed for PIC managers would be useful. I think slido could be used a bit more to gauge the progress of understanding through the meeting.
Great workshop and good learning platform, please continue working on future workshops as such

It was really useful to have an up to date overview of the available information / just how much we do not know. A hybrid approach would have been really useful. Some colleagues were unable to travel so had to miss the CLAW completely and I had to miss two days because of clashing commitments. Having a link to dial into the meeting would have allowed me to follow at least some of the presentations on the days I was not able to attend in person. I also noticed several sick people in the room - a hybrid approach might have helped them too.
Highly appreciate the great support and assistance provided by the secretariat of the CLAWS. Keep up the good work and looking forward for more CLAW. Further Thank you to Steven, Simon and especially to Nathalia for everything.
Perhaps practical demonstrations around the models used... for example, when the stock assessment people present PIMPLE functionality, one gets to "see" the modelling in action. thanks
If possible, to present the outcomes (adopted decisions) of the international fora (e.g. COP meetings) on climate change in the CLAW workshops for information purposes for the participants.
1.Projections to be narrowed into specific EEZs. 2.Awareness for fishing industries and relevant stakeholders at the regional and national level.
I think it would be great to have a slide or two just to show the list of everyone present and their title / contact info so we could reach out to anyone we did not get to meet during the duration of CLAW. Other than that the workshop was wonderful, there was a great deal of useful knowledge shared, time was moderated efficiently, and I'd love to attend it again and go back so that we could share our progress/successes and other updates with one another.
Session on loss and damage needs to be strengthen, audience needs to understand ways and processes to calculate or estimate loss and damage and the international process (if there's any) to compensate for this.
More workshop type agenda items should be included (rather than just presentations from experts) - e.g. breakout groups, small group discussions
Round table discussions are needed as it was mainly presentations for 4 full days and not much participant interactions but only questions or comments. Round tables to also provide input and feedback rather than just questions raised through Slido.
To bring by countries their challenges on CC
Scientists not to question other scientists during workshop, presenters should have consulted with each other's presentations beforehand. Minimise uncertainty through multiple studies showing the same result
Look forward to the next CLAW, quite an invaluable opportunity to talk amongst experts in both CC and Tuna Fisheries Management
Bigger venue would help.
I would suggest every 2 or 3 years rather than each year and more preparation and feedback from PICs on what they have observed in their own area
Excellent arrangements and a very engaging agenda. May need to involve climate change officials in the next iteration of the agenda.
Group discussion, visual materials, videos, infographics.
The sessions were very heavy with information. Have fewer but key information sessions and more opportunity for group interaction and discussion.
Needs some practical session with interaction with participants. another issue is the circulating of the workshop, utilize regional fisheries bodies to covey the importance of the workshop to members, PNG delegation nearly missed this important workshop. possibility of another funded participant.
Not really, just want to say once again a big THANK YOU!
Just a recommendation to add in the agenda for the next CLAW more presentations on the impacts of climate change coastal environment and ecosystems and any solutions to counter CC.