FFA CONTRIBUTION TO SECRETARY GENERAL REPORT ON SUSTAINABLE FISHERIES MANAGEMENT IN THE FACE OF CLIMATE CHANGE.

Introduction

The Pacific Islands Forum Fisheries Agency ("FFA" or "the Agency") is an intergovernmental organisation which was established in 1979. Its role is to facilitate regional cooperation and coordination on fisheries policies between Member countries, so as to achieve conservation and optimum utilisation of marine living resources, in particular highly migratory fish stocks, for the benefit of the people of the Pacific Islands region, in particular developing countries.

The Agency's vision is to enable the people of its Member countries to "enjoy the highest levels of social and economic benefits through the sustainable use" of fisheries, for many of whom it is their major resource.

To this end, the Agency assists its Member governments and administrations in applying a coordinated and mutually beneficial approach to the conservation, management and development of regional tuna stocks. As well as its policy coordination functions in tuna fisheries management, and monitoring control and surveillance, the FFA Secretariat also has a substantial role in assisting its Member countries in tuna fisheries development. This includes economic analysis, appraisal and promotion of investment opportunities, and supporting of national standards that maintain access to major foreign markets. The FFA Secretariat is based in Honiara, Solomon Islands.

The Membership of the Agency predominantly comprises Pacific Small Island Developing States (SIDS). Its Members are Cook Islands, Fiji, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Australia and New Zealand.

FFA Members are parties to the Western and Central Pacific Fisheries Commission, and as such contribute to the development and enforcement of Conservation and Management Measures, and are responsible for complying with these provisions.

Pacific Island Forum Leaders, comprising the Heads of State and Government of the region, have characterised Climate change as the single greatest threat to the livelihood, security and wellbeing of Pacific people. Climate change has noticeable effects on tuna fisheries. Continued

greenhouse gas emissions are projected to alter the abundance and distribution of tuna species, shifting biomass from WCPO to the Eastern Pacific Ocean and from national jurisdictions to the high seas. In a business-as-usual scenario, 20% of tuna caught in Exclusive Economic Zones (EEZ) of Pacific Island Countries and Territories (PICTs) is expected to move to the high seas, a figure reduced to 3% with global mitigation efforts. Recognizing the comprehensive impact of climate change, collaborative efforts are essential to proactively manage risks and enhance the resilience of offshore fisheries.

Around 55 % of the world's tuna landings come from Western and Central Pacific waters. Climate-driven redistribution of tuna threatens not only to disrupt Pacific Small Island Developing States' economies, but the sustainable management of the world's largest tuna fishery.

The crucial importance of sustainable fisheries management for FFA Members

Pacific Small Island Developing States (PSIDS) are vitally dependant upon the ocean environment in which they live, and its fisheries resources. In their Exclusive Economic Zones they manage over 10 % of the world's ocean and 20 % of the global marine jurisdictions. They are in turn heavily dependent upon their marine living resources, including their coastal fisheries and offshore fisheries[1] which are now threatened by climate change.

This is a responsibility that FFA Members manage well. The Pacific Islands region has the largest and healthiest stocks of tuna in the world as a result of FFA Member cooperation and their focussed and sustainable fisheries management. The region is unique in its fisheries indicators which show that all of its major tuna stocks are sustainably fished, with none being overfished.

The significance of tuna fisheries to the Pacific Islands region, and in sustaining the livelihoods of Pacific peoples and strengthening their national economies, can be seen from the following figures:

(i) The value of the tuna catch taken by national fleets of FFA Members in 2022 was US$1.8 billion;[2]

(ii) In FFA Members' waters, the majority of the value of the tuna catch (59%) was taken by national fleets of FFA Members, rather than through licensed access by foreign vessels as in the past;

(iii) Additionally, government revenue from foreign access and licence fees is currently around US$480 million per year;

(iv) For four FFA Members over 50% of their government revenue comes from access and licensing fees, six Members are reliant on these fees for at least 25% of their government revenue, and another two Members for 20 – 25% of their government revenue;[3]

(v) 47% of Pacific households list fishing as either a primary or secondary source of income, with national fish consumption in the Pacific islands being three to four times the global average. Pacific Ocean-based shipping and tourism provides an additional US$3.3 billion per year to the national economies of Pacific Island Countries and Territories;

(vi) Around 28,000 jobs are created in the tuna fisheries sector; and

(vii) Around 30% of global tuna supply is sourced from FFA Members' waters, which highlights the global importance of Pacific tuna.

The importance of these fisheries to PSIDS, and their reliance on them, is therefore very clear. Also clear are the serious impacts and threats posed by climate change.[4] Damage to fisheries and loss of fish stock would therefore have a significant negative impact on the income, livelihoods, food security and economies for PSIDS.

The impacts of climate change upon the sustainable management of FFA Members' fisheries

As noted above, the Pacific Islands region's highest political level, the Pacific Islands Forum,[5] has consistently expressed its deepest ongoing concerns about the present and future impacts of climate change upon its Members, particularly its SIDS Members.[6] These concerns include the grave impacts of sea level rise, including resulting threats to security, livelihoods and well-being, and the need to preserve maritime zones in the face of sea level rise.

There are also deep concerns about the impacts of climate change on the sustainable management of Members' fisheries. These concerns, which are dealt with further below, include:

- Ocean warming, deoxygenation and ocean acidification
- Tuna redistributions and related implications for pelagic fisheries;
- Impacts on coastal fisheries;
- Impacts on coral reef systems;
- Marine heatwaves;
- Coastal changes and impacts on coastal communities;

(a) Ocean warming, deoxygenation and ocean acidification

The most recent Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6 Report) shows that ocean warming, ocean acidification and deoxygenation will continue to increase in the 21st century at rates dependent on future emissions of carbon dioxide and greenhouse gases. The IPCC AR6 states with high confidence that ocean warming, and ocean acidification have already affected food production including shellfish aquaculture and fisheries in some regions. Such impacts have already been observed by FFA Members. The capacity of oceans to absorb carbon dioxide will also be diminished under higher warming scenarios. Indeed, the IPCC consistently reports impacts and risks to ocean ecosystems from climate change under various warming scenarios. Observations suggest a higher rate of deoxygenation due to warming than simulated by Earth Climate models.[7]

The ocean has taken up between 20-30% of total anthropogenic CO2 emissions since the 1980s causing further ocean acidification. Open ocean surface pH has declined by a very likely range of 0.017-0.027 pH units per decade since the late 1980s, with the decline in surface ocean pH very likely to have already emerged from background natural variability for more than 95 % of the ocean surface area.

Continued carbon uptake by the ocean by 2100 is virtually certain to exacerbate ocean acidification. Open ocean surface pH is projected to decrease by around 0.3 pH units by 2081-2100, relative to 2006-2015. **This will have significant impacts, including on coral reef systems,**

which will affect ocean health and coastal fisheries on which many PSIDS communities are dependant.[8]

(b) Tuna redistributions and related implications for pelagic fisheries

Recent science in a published study called *Pathways to sustaining tuna-dependent Pacific Island economies during climate change* highlights the impacts of climate change on tuna in the region under different scenarios. Climate change is driving tuna further to the east and into the high seas, threatening the loss of economic and food security of Pacific Small Island Developing States:

(i) Climate-driven redistribution of tuna threatens not only to disrupt Pacific Small Island Developing States' economies, but the sustainable management of the world's largest tuna fishery.

(ii) By 2050, under a high greenhouse gas emissions scenario (RCP 8.5), the total biomass of three tuna species in the waters of ten Pacific Small Island Developing States could decline by an average of 13 % (range = −5 % to −20 %), while a greater proportion could occur in the high seas.

(iii) This redistribution may result in significant reductions in the economic benefits (from access fees to government revenue) some Pacific Island Members derive from these fisheries, as a consequence of a prediction that by 2050 PITCs may experience an average decline in purse-seine catch of 20 % (range = −10 % to −30 %). Further research is needed in this field.

(iv) A rise in ocean temperatures is also expected to alter the distribution of other transboundary species in the Pacific Ocean that contribute to domestic food security needs.[10] There is also significant uncertainty as to what impact changes in ocean temperatures might cause pelagic stocks upon which tuna feed[11]. Current estimates of tuna displacement may be grossly underestimated due to this uncertainty.

(v) The impacts are reduced if greenhouse gas emissions are reduced. Redistribution of tuna under a lower-emissions scenario (RCP 4.5) is projected to reduce the purse-seine

catch from the waters of Pacific Small Island Developing States by an average of only 3 % (range = −12 % to +9 %), indicating that even greater reductions in greenhouse gas emissions, in line with the Paris Agreement, would provide a pathway to sustainability for tuna-dependent Pacific Island economies.

(vi) Not achieving greenhouse gas emissions, in line with the Paris Agreement, will not only impact the capacity for Pacific SIDS to generate income from tuna fisheries but also significantly increase the management costs for these fisheries as greater high seas monitoring, control and surveillance (MCS) is required[13]. In addition, increased uncertainties in stock redistribution and abundances will likely compromise the effectiveness of current management practices that have ensured the sustainability of WCPFC tuna stocks[14]. **The loss of income and government revenue compounded with rising food insecurity and health concerns poses a significant risk of harm to PSIDS.**

(c) Impacts on Coastal Fisheries

The decline in warm-water coral reefs is projected to greatly compromise the services they provide to society, such as food provision. Increases in the risks for seafood security associated with decreases in seafood availability are projected to elevate the risk to nutritional health in some communities highly dependent on seafood. Such impacts compound any risks from other shifts in diets and food systems caused by social and economic changes and climate change over land.

Climate change impacts on marine ecosystems and their services put key cultural dimensions of lives and livelihoods at risk, including through shifts in the distribution or abundance of harvested species and diminished access to fishing or areas. This includes potentially rapid and irreversible loss of culture and local knowledge and Indigenous knowledge, and negative impacts on traditional diets and food security.

(d) Impacts on Coral Reef Systems

The Pacific Region is home to approximately 25% (about 66,000 km^2) of the coral reefs on the planet and is dotted with thousands of islands that differ climatically and geologically. Many of

these reefs are considered to be in good health because of their remote location and low exposure to human impacts.[15]

The ocean warming trend documented in the IPCC Fifth Assessment Report (AR5) has continued, and this has been documented in AR6. Since 1993, the rate of ocean warming and thus heat uptake has more than doubled and is attributed to anthropogenic forcing. The major medium to

long-term threats to coral reefs at the global level arises from climate change-driven intensification of the disturbance regime, including increasing sea surface temperature and frequency of severe tropical cyclones.[16]

The impact of rising sea surface temperatures in particular leads to an increase in frequency and severity of coral bleaching events as reported in several reef areas. Corals are sensitive to changes in sea temperature, and anomalies of 1-2°C greater than normal summer highs can cause severe coral bleaching, a stress response that breaks the zooxanthellae-coral symbiotic relationship and may result in coral mortality depending on the intensity and duration of the warming event.[17] The ocean will continue to warm throughout the 21st century. By 2100, the top 2000 metres of the ocean are projected to take up 2-7 times more heat (depending on the emission scenario) than the observed accumulated ocean heat uptake since 1970.

Warm-water coral reefs are currently impacted by extreme temperatures and ocean acidification. Marine heatwaves have already resulted in large-scale coral bleaching events at increasing frequency causing worldwide reef degradation since 1997, and recovery is slow (more than 15 years) if it occurs.

Almost all warm-water coral reefs are projected to suffer significant losses of area, biodiversity and local extinctions, even if global warming is limited to 1.5º C. [18] With increasing frequency and intensity of bleaching events, the near future coral reefs in the Pacific may struggle to recover quickly enough between consecutive events, leading to an accelerated rate of coral reef decline.[19] The species composition and diversity of remaining reef communities is projected to differ from present day reefs.

(e) Marine Heatwaves

Globally, marine heatwaves have doubled in frequency and have become longer-lasting, more intense and more extensive. It is very likely that between 84-90% of marine heatwaves that occurred between 2006 and 2015 are attributable to the anthropogenic temperature increase.

Marine heatwaves are projected to further increase in frequency, duration, spatial extent and intensity (maximum temperature). Climate models project increases in the frequency of marine heatwaves by 2081-2100, relative to 1850-1900, by 20 to 50 times (depending on the emission scenario). The tropical region is a region where this increase will be the largest. The intensity of marine heatwaves is projected to increase about 10-fold under the high emission scenario by 2081-2100, relative to 1850-1900. This will further impact on fisheries in the Pacific region.

(f) Coastal changes and impacts on Coastal Communities

Coastal communities in the Pacific region have already been significantly affected by the range of climate change impacts to date including those that have manifested in the ocean – such as wave inundation, and coastal erosion, deterioration of coastal food systems and fresh water sources. These climate change-exacerbated environmental impacts have forced many communities to abandon their ancestral lands and important traditional food sources, and relocate to safer areas, often resulting in the loss of cultural heritage, cultural identity, cultural practices, social cohesion, and economic stability and insecurity.

As Pacific Leaders have said[20] ,the displacement of these communities poses significant challenges in terms of safeguarding human rights, ensuring access to basic services, and maintaining community structures. There are also many implications for receiving communities and the ability of nations to effectively relocate communities where there are limited land resources and highly complex land tenure systems.

Accordingly, there has already been observed and experienced displacement of coastal communities in the context of climate change. The impacts of climate change, including ocean warming, sea level rise, and ocean acidification, have had profound effects on the marine

environment and biodiversity, resulting in adverse consequences for the livelihoods and well-being of coastal communities, including their very security and survival.

Experience in sustainable fisheries management in the face of climate change

Effective fisheries management that results in healthy fish stocks is a key enabling condition for building resilience to climate variability and change. The FFA foundational principles on sustainable management of tuna fisheries guide the Agency's work towards climate change resilience in the sector.

As Parties to the WCPFC, FFA Members contribute and enforce the principles and Conservation and Management Measures agreed to by the Commission. Fisheries management in the WCPFC Convention Area includes the use of an ecosystem based approach, a precautionary approach, and pathways to directly incorporate risk in management processes.

FFA Members manage their fisheries through adaptive cooperative management schemes, which also take into account climate variability. These schemes have agreements at subregional scales such as the case of the Parties to the PNA and the recently formed South Pacific Group (SPG), at regional scale as FFA, and at international levels as WCPFC. Key aspects of transboundary cooperative fisheries management in the context of climate change implemented by FFA include sharing scientific data and research, coordinating policies and regulations, including joint efforts for Monitoring, Control and Surveillance, joint development and market initiatives, and fostering communication and collaboration among stakeholders. The goal is to ensure the resilience and sustainability of fisheries in the face of climate-related challenges while maximising the benefits for all involved parties.

The roadmap for developing, adopting and implementing Harvest Strategies by WCPFC, is a notable example of a no-regret climate change adaptation approach. Harvest Strategies with ramped harvest control rules that dictate the fishing rate on a stock based on its biomass indicators, were originally developed to help rebuild a declining stock, but have also been shown to foster adaptation to situations where climate change is affecting a stock's underlying productivity. As they set pre agreed rules on management depending on the stock size, they provide a fast decision making process to respond to risks to the fishery. They can explicitly consider expected changes due to climate change and environmental impacts on stock productivity, by assessing stocks and setting reference points that acknowledge system-level

effects of climate change. WCPFC has agreed to and progressed the work towards having both limit (LRP) and target reference points (TRP) for all four main tuna species, and this is informed by the best available science through the Science Service Provider. WCPFC-adopted Harvest Strategies consider climate change-induced dynamic demographic parameters through the use of a dynamic LRP that accounts for variability in the stock status due to other factors outside fishing pressure. These dynamic aspects of the LRP, account for environmental variability impacts on biomass, as the limit reference point for all four tuna species is a product of the unfished biomass (20% of the unfished biomass), instead of a fixed effort or catch level, which would otherwise need to be revisited and re negotiated, since both environmental variability and fishing pressure impact life history parameters which define the reference points.

The pervasive issue of illegal, unreported and unregulated fishing severely undermines the economies of Pacific Island countries and territories by depleting fish stocks, damaging marine ecosystems, depriving local communities of livelihoods, and hindering sustainable development efforts in the region. This signifies a high exposure factor to sustainable fisheries management, and contributes to increasing the vulnerability of FFA Members' tuna fisheries to climate change. Since its inception, the FFA Members have collaborated in Monitoring, Control and Surveillance (MCS) efforts, guided by the FFA Regional MCS Strategy. The latter has 6 priorities related to i) having clear information on the registered and authorised vessels fishing in FFA waters, ii) strengthening catch, effort and related fishing monitoring and validation through electronic reporting and monitoring tools and real time analysis of data; iii) ensuring authorised vessels' compliance with licensing conditions by providing Harmonised Minimum Terms and Conditions for licensed vessels; iv) ensuring systems are in place to monitor and verify the legality of catch though the supply chain, including implementation of the FFA Port States Measures Framework; v) Advocating and contributing to compliance and strengthening of MCS in the high seas; and vi) strengthening Members capacity to detect, respond, investigate and prosecute IUU fishing. FFA MCS efforts ensure that the rights of FFA Members are secured and protected, and contribute to the sustainability of the fishery by reducing IUU impacts. A shift in distribution of stock from EEZs to the high seas will increase the challenges of effective MCS systems, including the transfer of greater responsibility to the WCPFC, and will pose a risk to the sustainable management of the Pacific tuna fisheries.

Commitments to further strengthen climate action and building resilience to the tuna fisheries

Strong governance systems that consider climate change are also identified as a robust archetype for increasing resilience [20]. The PICTs are taking concrete steps in this regard.

The Regional Roadmap for Sustainable Pacific Fisheries, endorsed in 2015 by Pacific Islands Forum Leaders, was designed to 1) optimise the benefits of tuna resources for economic development, government revenue and employment; 2) ensure that growing human populations have enough fish for food security; and 3) sustain livelihoods derived from small-scale fisheries. This roadmap gives direction to Pacific Island Forum Members and FFA Members on a clear pathway for increasing the resilience of the sector.

More recently, in August 2023 the Forum Fisheries Committee, which is FFA's governing body, adopted an FFA Climate Change Strategy. This Strategy guides Members on progressing work on 6 priority areas 1) Actioning Climate Change Adaptation and Resilience, which include ensuring ecological sustainability in new climate change scenarios, ensuring the maintenance of and securing well defined offshore fisheries rights, and ensuring the economic and social benefits FFA Members receive from offshore fisheries are maintained, 2) Achieving Climate Justice, 3) Accessing Climate Finance, 4) Contributing to Mitigation, 5) Capacity Building and Institutional Strengthening, and 6) Advocacy and Engagement.

There has been continued leadership by FFA at WCPFC both by putting forward proposals to strengthen and progress the sustainable management of the fisheries and by including climate change in WCPFC discussions. In 2019 the FFA led the adoption of the WCPFC Climate Change resolution. The Resolution commits the CCMs to progress the mainstreaming of climate change into the WCPFC work, through ensuring it is discussed by all its Subsidiary Bodies. WCPFC20 agreed to develop a workplan for the implementation of the Resolution, which is being co-lead by the Republic of the Marshall Islands.

FFA is also collaborating with SPC on research to understand the possible impacts of climate change on sustainability, social and economic benefits and rights. Initial assessments suggest regional economic conditions, as well as conditions for certain PICTs, will deteriorate over time due to climate-driven tuna redistributions (for example through reduced government revenue). However, these forecasts rely on assumptions which do not account for transitional pathways,

and factors such as changing fleet dynamics, potential management responses, global economic trends, and technological advancements.

The collaboration with SPC includes an exploration of how fishing fleets can best adapt to evolving tuna distribution stands. Understanding and modelling these adaptations are essential for predicting and shaping future economic outcomes. Central to this is assessing how the composition of the fleet and overall fishing effort can be optimised to efficiently respond to climate-driven tuna redistributions. Integrating this analysis with existing bioeconomic models, will provide insights necessary for developing informed management strategies and could assist in the establishment of frameworks for climate change adaptation at both regional and national levels.

Concluding remarks

In light of these impacts and threats, the FFA through its Climate Change Strategy, will continue to contribute to building resilience of Pacific tuna fisheries to climate change. It will do this through an integrated approach that takes into account cumulative impacts to the tuna resources, ecosystems, livelihoods and rights of PICTs, and advocating for international cooperation towards a global reduction of greenhouse gas emissions, and scaling up greening the fisheries sector.

Furthermore, small island developing states (SIDS) face specific challenges related to limited financial resources, limited human resources and lack of technical expertise, inadequate infrastructure, and overall vulnerability to the impacts of climate change. Enhancing FFAs engagement through the ICSP parties to strengthen support through capacity building and dedicated funding mechanisms is a priority for progressing our work towards ensuring the sustainable management of fisheries and the well-being of our coastal communities.

Footnotes

[1] 60% of the global tuna catch comes from the Pacific region.

[2] i.e. 31% of the total catch value for the Western and Central Pacific Fisheries Commission (WCPFC) Convention Area.

[3] For the low-lying SIDS which are most at risk of climate change, their dependency on fisheries revenue for their economic self-determination is severely at risk from the effects of climate change. The fisheries revenues of low-lying States contribute in excess of 40% of government revenue.

[4] As regards the impact of climate change on tuna, the key marine living resource for most FFA Members on which their economies are vitally dependent, attention is particularly drawn to a recently published study entitled Pathways to sustaining tuna-dependent Pacific Island economies during climate change, by Johann Bell et al and published in 2021 in Nature Sustainability. Other articles of particular relevance include the following (see also footnote below):

> Lehodey, P., Hampton, J, Brill, R. W., Nicol, S., Senina, I., Calmettes, B., Portner, H. O., Bopp, L., Ilyina, T., Bell, J. D., Sibert, J., Vulnerability of oceanic fisheries in the tropical Pacific to climate change. In: JD Bell, JE Johnson and AJ Hobday (eds) Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change. Secretariat of the Pacific Community, Noumea, New Caledonia.
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> Bell, J. D., Allain, V., Gupta, A. S., Johnson, J. E., Hampton, J., Hobday, A. J., Lehodey, P., Lenton, A., Moore, B. R., Pratchett, M. S., Senina, I., Smith, N., Williams, P. Climate change impacts, vulnerabilities and adaptations: Western and Central Pacific Ocean marine fisheries, 305 - 324. In Barange, M., Bahri,
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> T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, S. & Poulain, F., eds. 2018. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper No. 627. Rome, FAO. 628 pp.

[5] The governing body of the FFA, the Forum Fisheries Committee meeting at Ministerial level, reports to the Pacific Islands Forum.

[6] In its work, the FFA collaborates closely with other Pacific regional bodies and agencies. A key partner is the Secretariat of the Pacific Community (SPC), which is the region's primary scientific and technical intergovernmental organisation, whose mandate and work programme have addressed issues relating to climate change, fisheries, marine ecosystems, and coastal geoscience for decades. Scientific and technical information in this document draws significantly upon the work of the SPC.

[7] Schmidtko S., Stramma L., Visbeck M. (2017). Decline in global oceanic oxygen content during the past five decades. Nature 542: 335–339. https://doi.org/10.1038/nature21399

[8] The SPC (www.spc.int) has noted that a lack of specific responses to ocean warming, acidification and deoxygenation across the United Nations Framework Convention on Climate Change (UNFCCC) poses a substantial and currently unaccounted for risk to coastal community resources, well-functioning marine ecosystems, seafood security and economies. SPC has also noted that lack of recognition of acidification and deoxygenation by the UNFCCC risks exacerbating these effects through ocean-based climate interventions that seek mitigation through enhanced primary production or carbon disposal in the deep ocean, as well as geoengineering proposals that would alter ocean chemistry with uncertain consequences.

[10] Palacios-Abrantes et al. 2022. Global Change Biology. https://doi.org/10.1111/gcb.16058

[11] See Vaihola, S.; Kininmonth, S. 'Climate Change Potential Impacts on the Tuna Fisheries in the Exclusive Economic Zones of Tonga' Diversity 2023, 15, 844. https://doi.org/10.3990/d15070844

[13] Goodman et al 2022. Frontiers in Marine Science. doi.org/10.3389/fmars.2022.1046018

[14] Cheung et al 2018. Global Change Biology. https://doi.org/10.1111/gcb.14390

[15] Moritz C, Vii J, Lee Long W, Tamelander J, Thomassin A, Planes S (editors). (2018) Status and Trends of Coral Reefs of the Pacific. Global Coral Reef Monitoring Network (available at: https://gcrmn.net/wp-content/uploads/2022/06/Status-and-Trends-of-Coral-Reefs-of-the-Pacific-2018)

[16], [17],[18],[19] Moritz C, Vii J, Lee Long W, Tamelander J, Thomassin A, Planes S (editors). (2018)

[20] Eurich et al., 2023, Bryndum-Buchholz et al 2020.