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POLICY BRIEF

Implications of ocean acidification on **tuna fisheries** in the Pacific Islands region

Purpose

This policy brief 1) highlights key elements of recent research on the effects of ocean acidification (OA) on tuna and other pelagic fish species of importance to Pacific Island countries and territories (PICTs), and raises awareness of the key uncertainties; and 2) outlines key policy considerations for improving understanding, mitigation and management of the effects of OA on pelagic species and ecosystems of the western and central Pacific Ocean (WCPO).

Key messages

- Ocean acidification is expected to have its greatest impact on the early life phases of pelagic fishes important to the Pacific Islands region (e.g. increased rates of natural mortality and patchiness in species distributions). Significant impacts on the survival and growth of adult stages of pelagic fishes are not expected.
- The impacts of OA are likely to be whole-of-ecosystem and synergistic with other human-induced pollution and climate change stressors, such as increased seawater temperatures, de-oxygenation and the prevalence of marine heatwaves due to climate change.
- There are major gaps in our understanding of the effects of OA on pelagic ecosystems, including for key species sustaining oceanic food webs, as well as the capacity of all components of pelagic ecosystems to adapt to increased OA.
- Climate change adaptation is a priority for policy and governance to reduce the impacts of OA on pelagic fisheries.
- Additional finance, science and assessment, as well as sound policy and governance interventions will be required to develop the range of climate change adaptations necessary for mitigating OA impacts.

Photo: David Itano

Significance of pelagic fisheries in the Pacific Islands region

Pelagic fisheries in the WCPO make important contributions to economic development, employment and food security of the Pacific community. The tuna industry makes extraordinary contributions to the government revenues of many PICTs, and employs over 20,000 people across the region.

With growing human populations and declines in the availability of reef fish, it is estimated that by 2035, 25% of all fish required to ensure food security for Pacific Island peoples will need to be supplied by pelagic species.

What is ocean acidification?

When carbon dioxide (CO_2) dissolves in surface seawater it combines with water to form a weak carbonic acid (H_2CO_3). The carbonic acid molecules then dissociate into bicarbonate ions ($HC0_3$) and hydrogen ions (H+), with the release of hydrogen ions decreasing the pH (i.e. increasing acidity) of surrounding waters. This process is known as ocean acidification.

Anthropogenic activities have caused a significant increase in greenhouse gas (GHG) emissions into the Earth's atmosphere and oceans, with around 30% of the emitted anthropogenic CO_2 having been absorbed by oceans globally since pre-industrial times. This uptake has resulted in measurable changes to ocean chemistry, with recent estimates indicating that the mean pH of tropical Pacific Ocean waters has decreased from around 8.14 to 8.08 pH since the 1950s.

Under continued high GHG emissions, by 2100, the average pH of surface water in the open ocean is projected to decrease by a further 0.3–0.4 pH units by 2100 relative to present-day levels. This translates into an increase in the concentration of H+ ions of 60–100%, and represents the fastest rate of change in ocean pH over the past 300 million years.

Due to the close link between carbonate ion concentrations and pH, declines in the stability of aragonite and calcite – minerals essential to the growth and structure of many marine plankton and invertebrates important to the ecosystem – are expected with declining ocean pH. In addition, the depth at which aragonite dissolves is expected to become shallower.

What does OA mean for fisheries and the ecosystems they are dependent on?

The impacts of OA are not isolated from other impacts on marine ecosystems from increased GHG emissions. OA operates synergistically with other changes in water chemistry and biogeochemical processes, resulting in changes to nutrient cycles, ecosystem structures and productivities.

There is mounting evidence that increased OA, in combination with other stressors, is disrupting carbon and nitrogen cycles in ecosystems, altering migration, distribution and behaviour patterns and changing growth and natural mortality rates of organisms. Reductions in the availability and stability of aragonite associated with increased CO_2 absorption and declining ocean pH is expected to have negative implications for the phytoplankton and zooplankton species that use aragonite to construct their shells and skeletons. Shallowing of the depth at which aragonite dissolves will also likely cause reductions in their available habitat. While the importance of these organisms to oceanic food webs underpinning pelagic fisheries is poorly understood, as is their capacity to adapt to changes in ocean chemistry, reductions in these species may have unpredictable and cascading effects on oceanic food webs.

The direct impacts of OA on fishes include lethal and sublethal effects such as mortality of eggs and larvae, tissue damage and alteration in swimming performance, behaviour and sensory capabilities. The severity of impact varies among species and may be dampened by parental acclimation and genetic

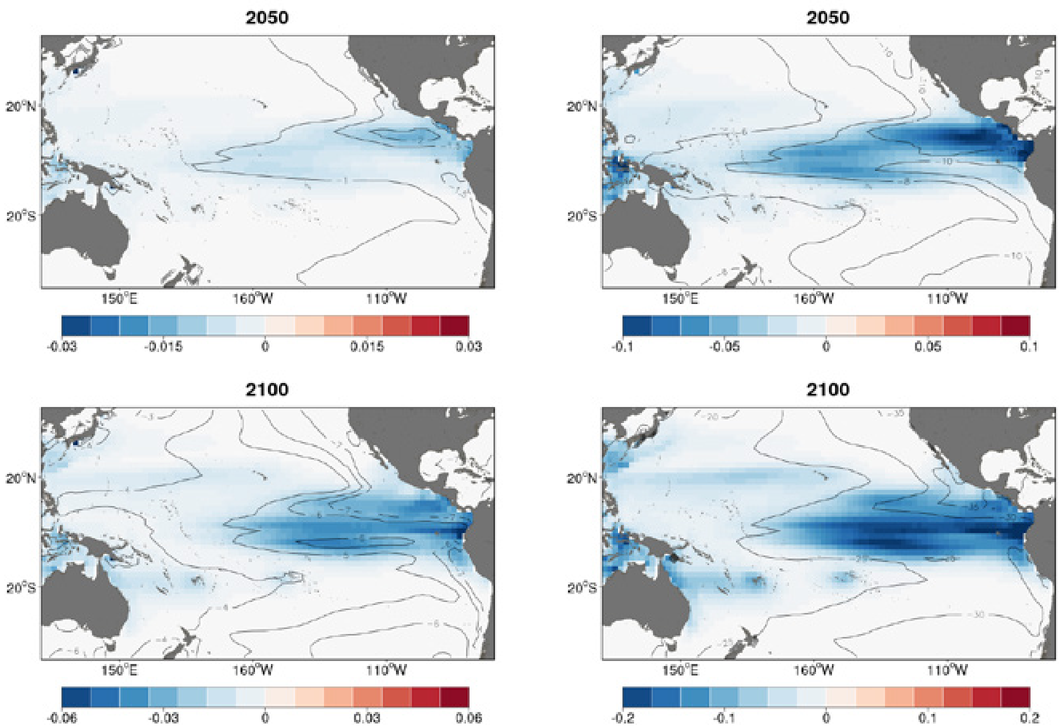


Figure 1. Projected changes in yellowfin tuna larval density in the Pacific Ocean in 2050 and 2100 relative to 2005 under high greenhouse gas emissions and intermediate (left) and high (right) ocean acidification sensitivity scenarios.

adaptation, whereby parental exposure to OA generates more OA-tolerant offspring. Individuals may also detect and preferentially avoid areas of unsuitable water chemistry. An increased ability to adapt to low pH is possible for species that currently range across naturally varying pH levels. Recent studies have demonstrated the ability of some marine fishes to genetically adapt to the effects of increased OA.

Recent physical modelling of ocean acidification has identified likely future hot spots of low pH, including areas in the southern equatorial Pacific. These regions are likely to experience extreme acidification events much earlier than predicted by models using global averages. The emergence of areas of low pH is likely to increase the patchiness of pelagic species, distributions and restrict habitats suitable for larval recruitment.

While information on the impacts of OA on tunas are limited to a few studies, they suggest that lethal and sublethal impacts are likely to become more prevalent below pH levels projected to occur by 2100. Similar impacts have also been observed for yellowtail kingfish, *Seriola lalandi*.

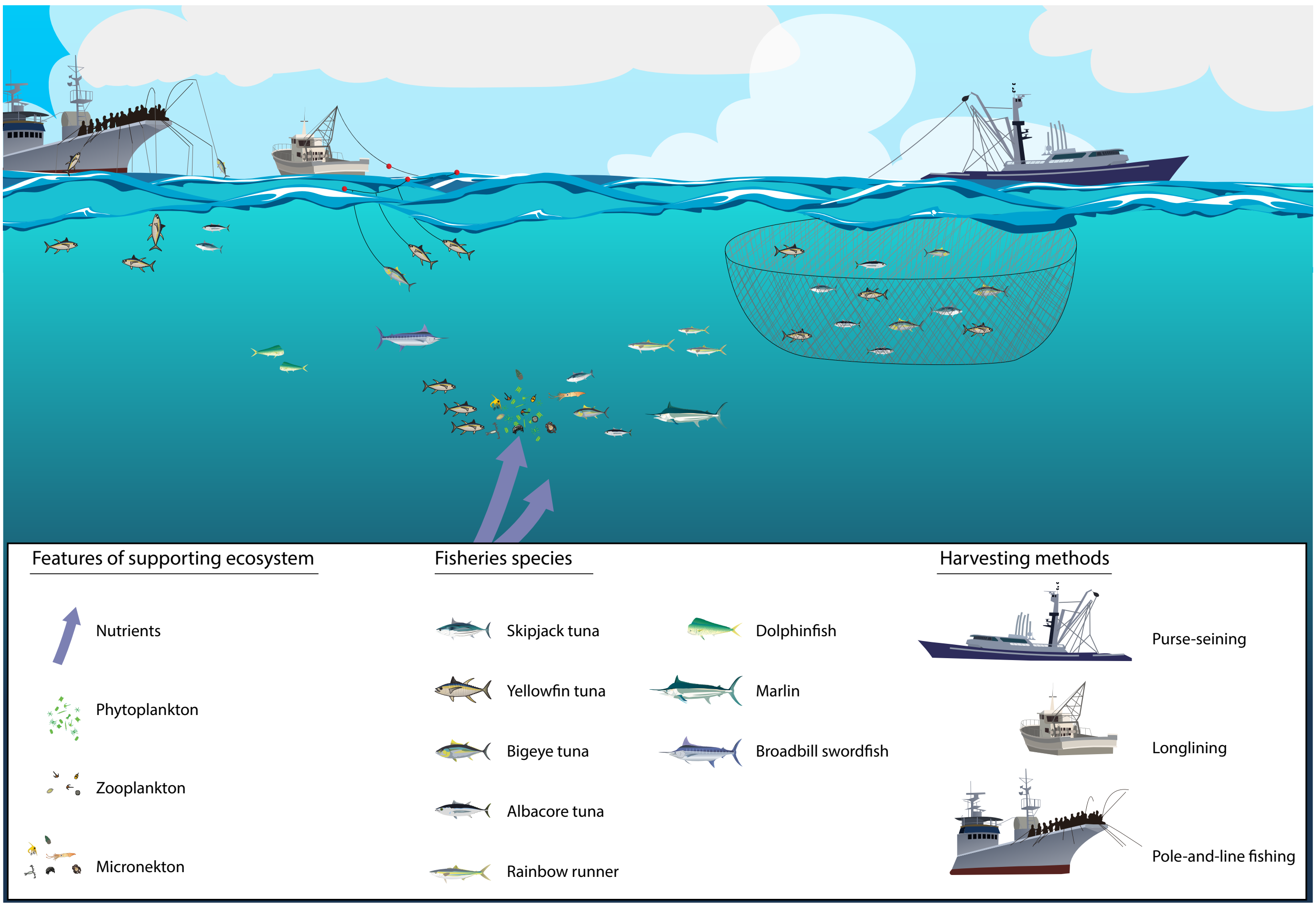
Recent modelling of the distribution of yellowfin tuna larvae under intermediate and high pCO_2 scenarios suggests the largest reductions in density (up to 20% compared to the reference scenario) will occur in the eastern Pacific Ocean. Smaller, although potentially significant, reductions in yellowfin tuna larval density are expected in the exclusive economic zones of Pacific Island countries and territories in the central Pacific, including northern French Polynesia, and the Phoenix and Line Islands of Kiribati (Fig. 1).

Policy considerations

Increased mortality of early life stages of pelagic fishes – whether directly through decreased fitness, or indirectly due to food web effects – will affect fish stocks through altered recruitment to the spawning population. To reduce the effects of OA on valuable tuna fisheries and other pelagic species in the Pacific Islands region, and the reliance of these resources for food security and livelihoods, policy and governance that explicitly includes the impacts of OA needs to be developed. The scombination of OA with other impacts of GHG emissions requires its consideration within the broader development of the impacts of GHG emissions and climate change on ocean ecosystems.

While the reduction of GHG emissions is the most effective method of stabilising atmospheric concentrations of CO_2, geoengineering opportunities such as ocean fertilisation have also been proposed to assist with sequestering CO_2 away from the atmosphere. Any policy to guide the use of such technologies should consider the interconnectedness of atmospheric-derived ocean stressors. Technologies that enhance the absorption of CO_2 in ocean systems, are likely to exacerbate OA.

For example, ocean fertilisation enhances the marine biological carbon pump by adding nutrients that are naturally limited, which when added, increase production and the draw-down of CO_2 from surface waters to deep waters. It is likely, however, that this will simply transfer issues of OA from surface waters to deeper waters. Policy development for this technology will need to provide guidance on how to evaluate the overall benefit to, or impact on, ecosystem services.



Main species caught in pelagic fisheries in the Pacific Islands region, with features of their supporting ecosystem, and the main methods used to harvest them.

Scale of application will be an important policy consideration for geoengineering opportunities. Both ocean fertilisation and ocean alkalinisation, whereby alkaline substances are added to seawater, have the potential to neutralise OA impacts at small scales such as coral reefs, but are unlikely to be logistically feasible at the scale of oceanic habitats.

With mitigation options such as geoengineering largely untried, and with potential unintended negative consequences, adaptation is a priority for OA governance and policy for oceanic habitats in the tropical Pacific Ocean.

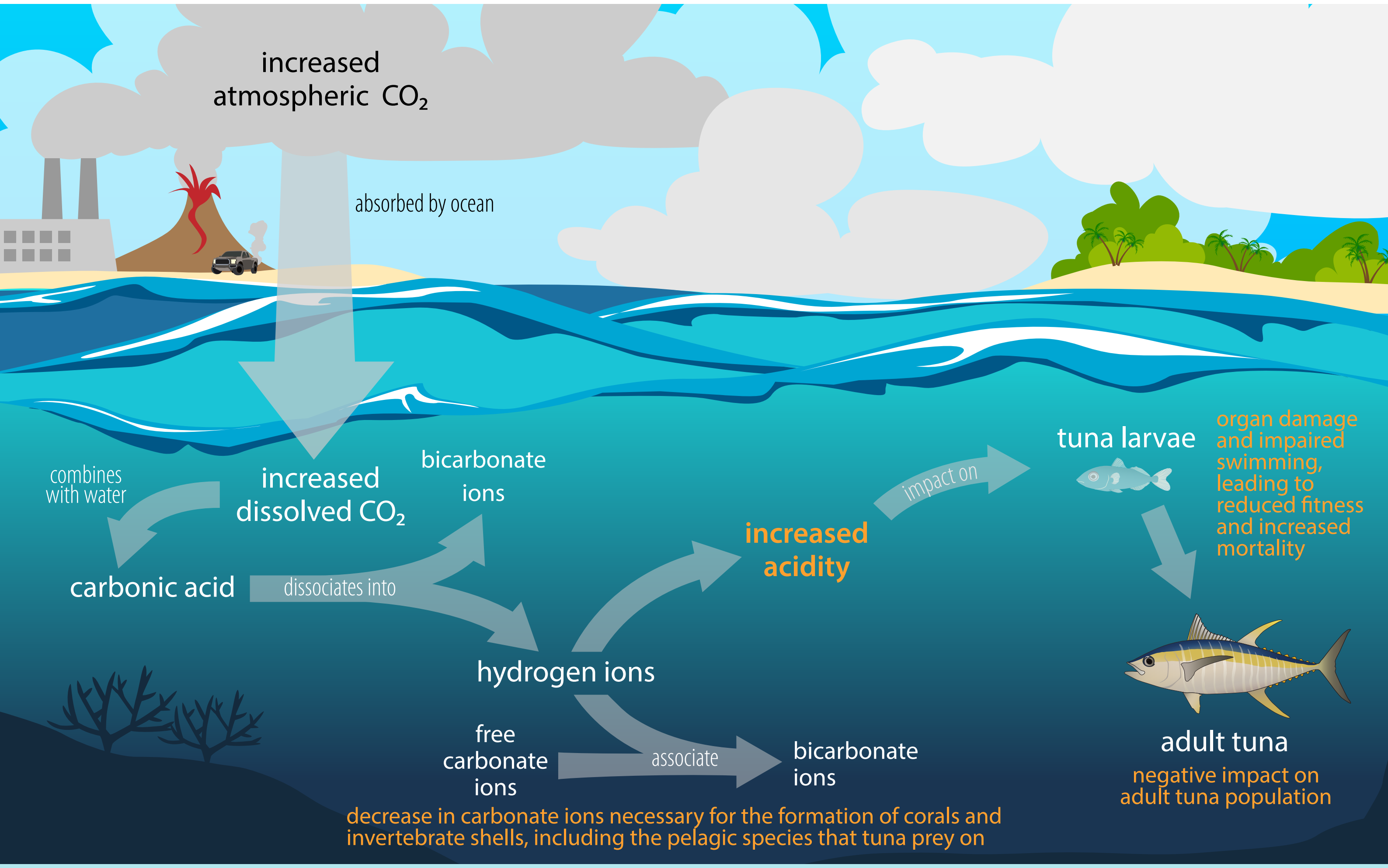
Adaptations for pelagic fisheries in the Pacific Ocean include:

- Maintaining natural adaptive capacity by protecting and enhancing fish stock abundance. Maximising genetic diversity within stocks increases the opportunity for genetic variation and/or the inheritance of phenotypic traits, which decrease vulnerabilities to OA.
- Recognising that seasonal and decadal fluctuations in OA will create a mosaic of suitable habitat that will increase patchiness in fisheries. Protection of particularly vulnerable areas from overexploitation, and identifying and protecting areas that are less exposed or less sensitive to OA that provide refugia, should become part of fisheries management.
- Establishing monitoring and advanced warning systems to allow fishing enterprises to respond appropriately to regional and decadal changes in pH levels. Exit strategies may need to be developed and reskilling undertaken in some circumstances.
- Recognition that fisheries management may need to adjust access arrangements to ensure stock abundances remain sufficiently high to maintain resilience to increasing natural mortalities.
- Include the implications of OA, and climate change more broadly, in future management objectives of the Western and Central Pacific Fisheries Commission, and strengthen precautionary approaches to fisheries management.

To reduce the uncertainty of the effects of OA on pelagic fishes and ecosystems, policy should guide future research investments that focus on:

- The synergistic effects of changes in ocean chemistry and ecosystem productivity on species of importance to the Pacific Islands region, the food webs that support these species, and associated ecosystem dynamics.
- The adaptive capacity of species to reduce their vulnerability to OA and the synergistic impacts of changes in ocean chemistry.
- The structure of tuna stocks (i.e. the number of self-replenishing populations of each species present in the Pacific Ocean), and responses of each stock to increased OA.
- Building regional capability in OA science and its implications for fisheries management.

For more information or technical assistance,
contact SPC's Oceanic Fisheries Programme (ofpinfo@spc.int)



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