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EXECUTIVE SUMMARY

SMALL-SCALE FISHERIES IN A WARMING OCEAN: EXPLORING ADAPTATION TO CLIMATE CHANGE

Imprint

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EXECUTIVE SUMMARY: TOWARDS ADAPTATION TO CLIMATE CHANGE IN SMALL-SCALE FISHERIES

Climate change is already having a serious impact on the global ocean, and it's going to get considerably worse in future. As marine ecosystems are transformed, the fisheries that depend on them will not remain viable unless they adapt to the changing conditions of a heating world.

Action is needed right now. Small-scale fisheries are by far the ocean's largest employer, providing more livelihoods than industrial fisheries, oil and gas, shipping and tourism combined. They're responsible for about half the world's seafood landings and play a critical role in food security and nutrition, especially for those living in poverty. Small-scale fisheries in developing nations are the most vulnerable to the effects of climate change, and there's an urgent need to help fisher communities put their operations on a sustainable footing for the coming decades.

This report summarises a recent initiative from WWF's Fish Forward 2 campaign, aimed at doing exactly that. This study combines cutting-edge climate risk modelling with grassroots engagement with local communities to understand what a warming ocean means for small-scale fisheries, and to identify key strategies for adapting to the new reality.

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BACKGROUND:
FISHERIES IN A HEATING OCEAN

90%

OF THE HEAT

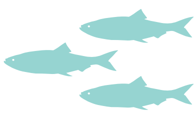
GENERATED IN THE OCEAN SINCE THE 19TH CENTURY IS THROUGH CO_2 PRODUCED BY HUMAN ACTIVITY

Since the 19th century, the ocean has absorbed about 28% of the CO_2 produced by human activity and more than 90% of the heat this has generated. By the end of the century ocean acidity will be increasing at a rate 10 times faster than any other acidification event in the last 55 million years.

Marine species are reacting to ocean warming by moving towards colder, deeper waters, shifting their range further offshore or towards the poles. While this will bring more fish into polar waters, tropical zones are likely to see reduced biodiversity and a number of local extinctions as they become too hot to support key species. However, not all species are moving at the same speed, and prey/predator relationships are changing.

A warmer surface also increases stratification (layering) in the ocean, reducing nutrient exchange and disrupting foodwebs from phytoplankton upwards through the trophic levels.

Acidification has physiological impacts on marine organisms – corals, plankton etc – which rely on stable chemical conditions to build calcium-based shells and other structures. Lower oxygen levels affect the survival, reproduction and growth of many marine species.



LOWER OXYGEN LEVELS

AFFECT THE SURVIVAL, REPRODUCTION AND GROWTH OF MANY MARINE SPECIES

The IPCC expects extreme events – in particular marine heatwaves – to become more intense, longer and more frequent. This will have a major impact on coastal ecosystems and habitats, causing high mortality in some species with effects amplified along food chains and into fishery resources

The cumulative effects of these changes are particularly devastating for coral reefs, which are home to 25% of all marine life. Some 50% of reefs have been destroyed since pre-industrial times, and even in strong climate mitigation scenarios the IPBES expects that only 1% will survive until 2050. More than a quarter of the world's small-scale fishers currently depend on them for their livelihoods.

In a business-as-usual mitigation scenario, climate change factors are expected to reduce fish biomass by between 30 to 40% in some tropical regions by 2100. Countries in these zones are highly dependent on fisheries, but lack social and financial resources to adapt and prepare for the future.

THE PROJECT:
THREE COUNTRIES, THREE STAGES

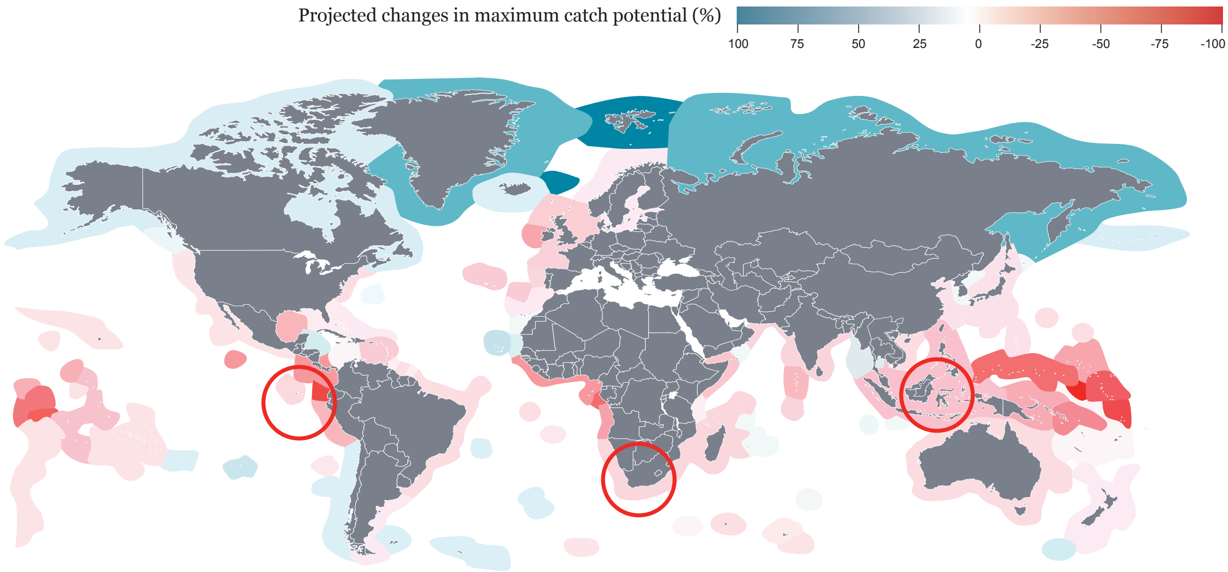


Figure 1 – Projected changes in maximum fisheries catch potential (%) by the end of the century for selected ocean regions under high greenhouse gas emission scenarios. Red circles indicate study areas. (FAO 2018)

There's a human dimension to these changes too. Less fish means fishers have to spend more time at sea and bring home less money, increasing poverty in already deprived communities. Our aim was to find out more.

By integrating fine-grained scientific forecasting models with the experience and insights of local fishers on three continents, the project provides a new and important perspective on the climate crisis and small-scale fisheries. Work focused on three developing countries – Ecuador, South Africa and the Philippines – where small-scale fisheries play a key socio-economic role, and where the effects of climate change will be particularly strongly felt.

Our forecasting modelled a range of projected climate change impacts on fish stocks in each country's exclusive economic zones (EEZs), mapping regional temperature projections from IPCC warming scenarios and other related risk factors against the exposure, vulnerability and adaptability indexes of key commercial species. This allowed us to estimate the extent to which regional stock levels (and therefore catches and livelihoods) are likely to be affected as oceanic conditions change and fish move to stay within their preferred temperature range.

The next part of the project moved on from modelled risk projections to practical local experience. Our researchers visited fisher communities in all three countries, to investigate how far and in what ways they perceive that climate change is already affecting their livelihoods. In a series of workshops with fishers and other stakeholders, we explored their experiences of fishing in a changing climate and discussed possible adaptation strategies, both in terms of small-scale fishing activity and fisheries management more broadly. Our discussion of the workshops begins on page 13.

PART 1: PROJECTIONS

Changes in ocean parameters

For each country we assessed how far ocean temperature, oxygen and acidity are likely to change by 2100 under a business-as-usual climate scenario.

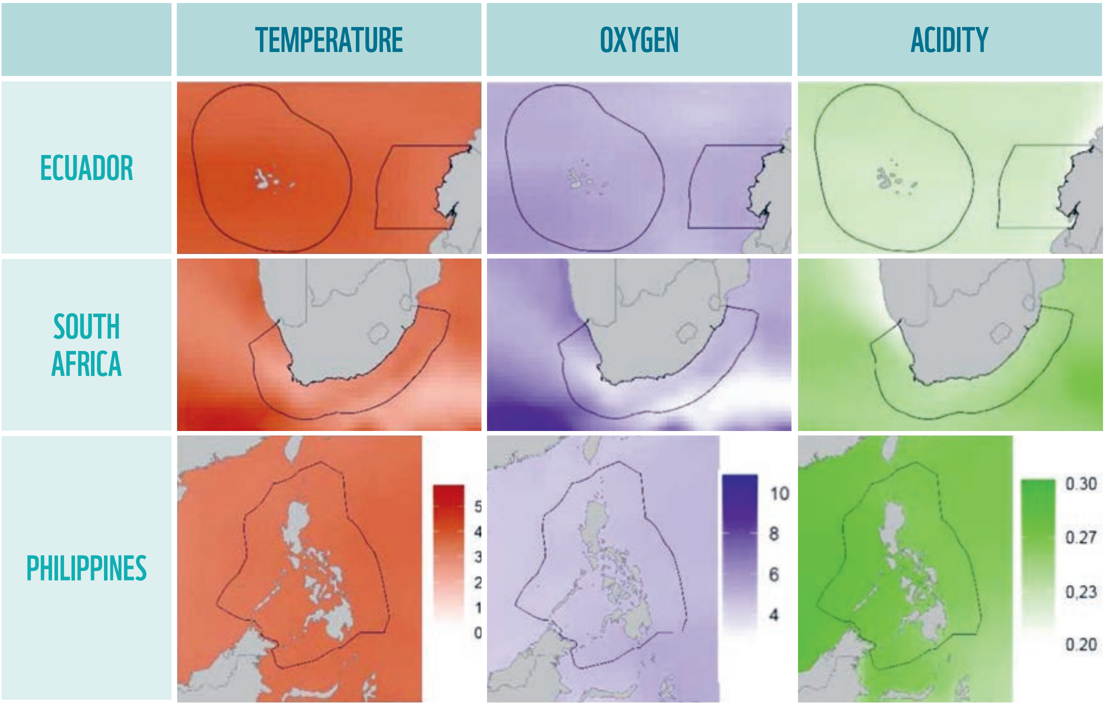


Figure 2 – Expected change by 2100 in temperature (in °C), oxygen (concentration lost, in %) and acidity (decrease in pH), for the three case studies under the business-as-usual scenario (RCP 8.5)

2°C+
TEMPERATURE INCREASES EXPECTED

Temperature increases of more than 2°C are expected everywhere, with oxygen concentration decreasing by at least 2.5% and up to 10%, and pH by 0.2 to 0.25 unit. The changes are greatest in the Philippines, while South Africa shows the highest regional variability. Ecuador is set for the largest increase in temperature.

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Exposure index

The magnitude of these changes can be assessed by comparing them to past conditions – the higher the relative change, the greater the probability that species targeted by fishers have never before experienced such variability in their environment.

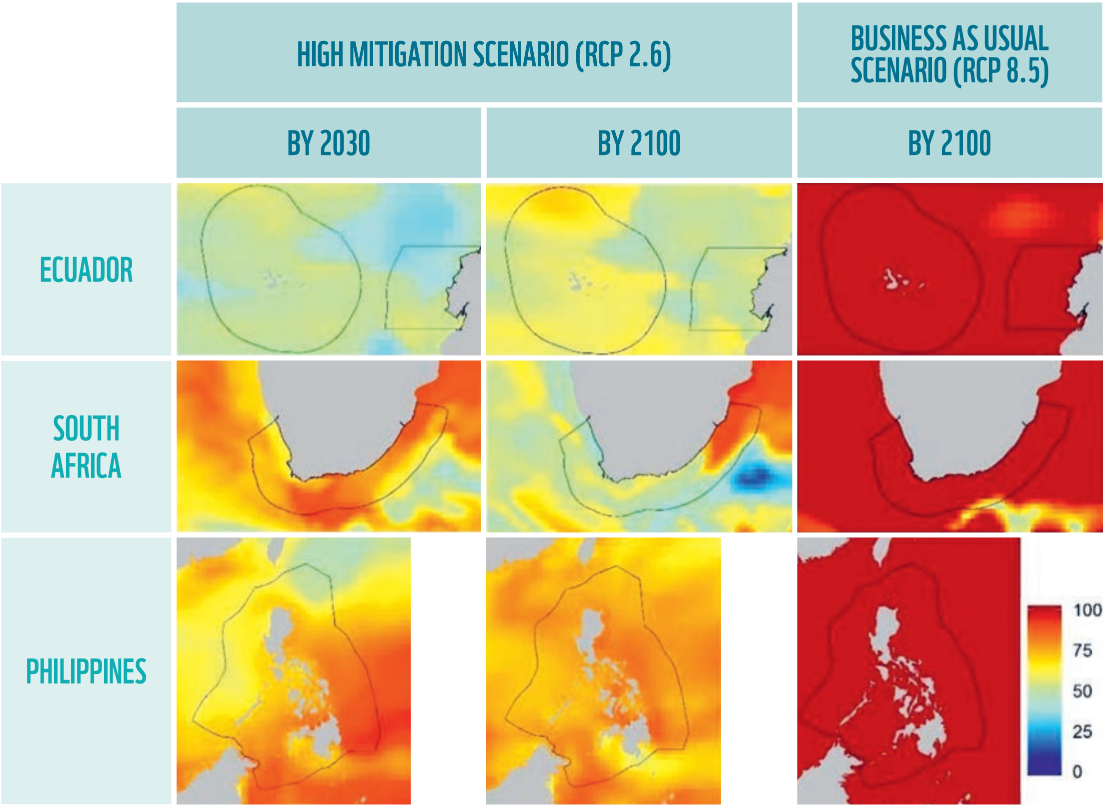


Figure 3 – Exposure index (expressed as the probability that environmental parameters will be outside the range observed in the past 59 years) in the three case studies and for three projections of climate change (NB. projections of RCP 8.5 by 2030 would be close to those of RCP 2.6)

In all three case studies, a business-as-usual scenario suggests that by 2100 marine species will have to live in an environment they have never encountered in the past. Stronger mitigation scenarios reduce this ‘exposure index’, but even by 2030 the probability of encountering unexperienced environments is still above 50% within each EEZ.

Key species: vulnerability

To determine the risk of climate impacts on key fishery species in each case study we assessed their vulnerability to change (i.e. their relative temperature sensitivity and adaptive capacity), the potential regional extent of such changes, and the species' individual degrees of exposure (depending on their regional distribution). The greater a species' vulnerability, combined with its density in environments subject to the largest changes, the higher the risk of climate impacts.

COUNTRY	SPECIES	VULNERABILITY	RISK OF CLIMATE IMPACT
ECUADOR (SMALL-SCALE FISHERY)	Common dolphinfish	61	77
	Chub mackerel	30	67
	Pacific thread herring	44	72
	Sailfin grouper	NA	NA
SOUTH AFRICA (LINE FISHERY)	Geelbek croaker	84	78
	Carpenter seabream	80	70
	Yellowtail amberjack	50	59
	Snoek	44	58
	Silver kob	NA	NA
	Slinger seabream	NA	NA
PHILIPPINES (TUNA HANDLINE FISHERY)	Indo-Pacific blue marlin	85	87
	Wahoo	68	80
	Common dolphinfish	61	77
	Skipjack tuna	39	71
	Yellowfin tuna	39	69
	Swordfish	39	71
	Frigate tuna	29	69

Figure 4 – Vulnerability to and risk of climate impact index of key case study species (yellow: index <50), medium (orange: 50 to 75), and high (red: >75)

Even for species with low vulnerability the risk of climate impacts is medium to high in all cases, because of the very high exposure index of the regions we studied. All of these fisheries must be considered at risk, with a significant part of their current catch made up of species which are likely to be severely affected by climate change.

Changes in catch composition in all three areas are inevitable as species move with the changing ocean conditions. An additional challenge will be to avoid over-exploitation of the remaining fishery resources.

Biomass change

By calculating changes in ecosystem biomass as it moves up trophic levels from primary producers to top predators under different climate change scenarios, we have an indication of the likely impact on species within those trophic levels. Assuming there is no change in fishing patterns, this also shows how catch potential is affected for each assessed species.

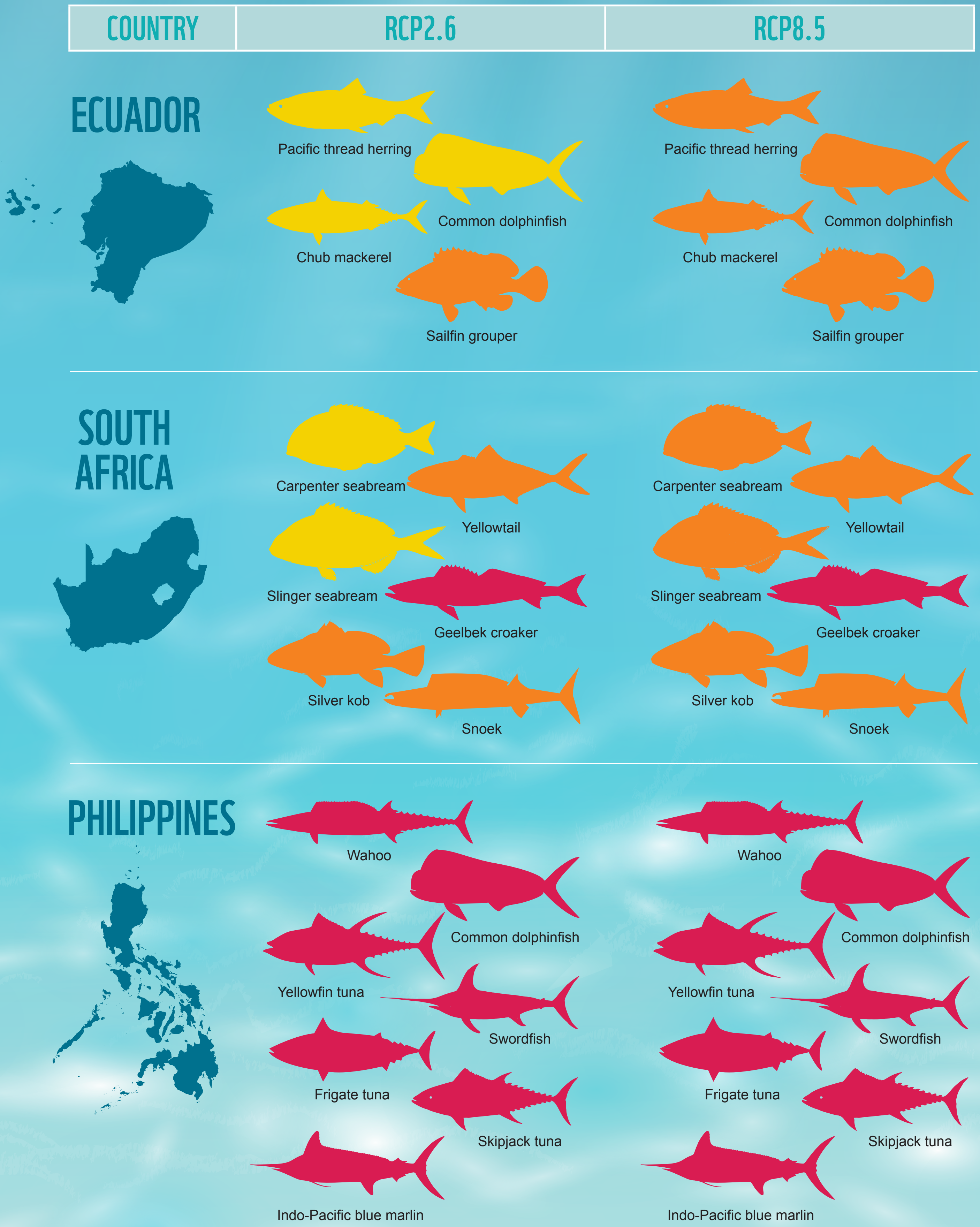
COUNTRY	SPECIES	TROPHIC LEVEL	CHANGE IN BIOMASS (%) 2030 RCP 2.6	CHANGE IN BIOMASS (%) 2030 RCP 8.5	CHANGE IN BIOMASS (%) 2100 RCP 2.6	CHANGE IN BIOMASS (%) 2100 RCP8.5
ECUADOR (SMALL-SCALE FISHERY)	Pacific thread herring	2.9 ± 0.2	-5.9	-8.1	-6.0	-11.4
	Chub mackerel	3.4 ± 0.2	-6.5	-8.9	-6.7	-12.5
	Common dolphinfish	4.4 ± 0.2	-7.6	-10.2	-7.7	-14.1
	Sailfin grouper	4.5 ± 0.2	-8.3	-10.8	-8.0	-15.6
SOUTH AFRICA (LINE FISHERY)	Carpenter seabream; Slinger seabream	3.5 ± 0.2	-7.9	-7.9	-6.9	-8.4
	Snoek	3.6 ± 0.2	-8.3	-8.2	-7.2	-9.0
	Silver kob; Yellowtail	4.2 ± 0.2	-10.4	-10.4	-9.0	-12.0
	Geelbek croaker	4.5 ± 0.2	-11.4	-11.4	-9.8	-13.3
PHILIPPINES (TUNA HANDLINE FISHERY)	Wahoo	4.3 ± 0.2	-11.4	-12.4	-10.5	-19.1
	Yellowfin tuna; Frigate tuna; Skipjack tuna	4.4 ± 0.2	-11.5	-12.7	-10.5	-19.5
	Common dolphinfish; Swordfish; Indo-Pacific blue marlin	4.5 ± 0.2	-11.6	-12.6	-10.6	-19.3

Figure 5 – Changes expected in the total biomass of key fishery species by 2030 and 2100 under different RCP scenarios

Generally speaking, the higher the trophic level of a species, the worse the impact it will suffer from climate change. In all cases – regardless of the fishery, the mitigation scenario or the year – our results show that biomass of the species targeted by the assessed fisheries will decrease. Without climate mitigation, the decrease is above 8% for all assessed species by 2030; and even with strong mitigation the smallest decrease is 5.9%. By 2100, a business-as-usual approach would see biomass reductions of almost 20% across the entire Philippines fishery. An illustration of 2030 biomass change is shown on the following page.

BIOMASS CHANGE (%): LOW MEDIUM HIGH

BIOMASS CHANGE IN 2030 WITHIN TROPHIC LEVELS IN THREE COUNTRIES



SUMMARY: WHAT SCIENCE-BASED MODELLING SHOWS US

All the indicators in the modelling exercise clearly show that climate change will have a significant negative impact on most of the species targeted by the small-scale fisheries we assessed. Extensive changes in ocean parameters point to a decrease in biomass levels of up to 20%.

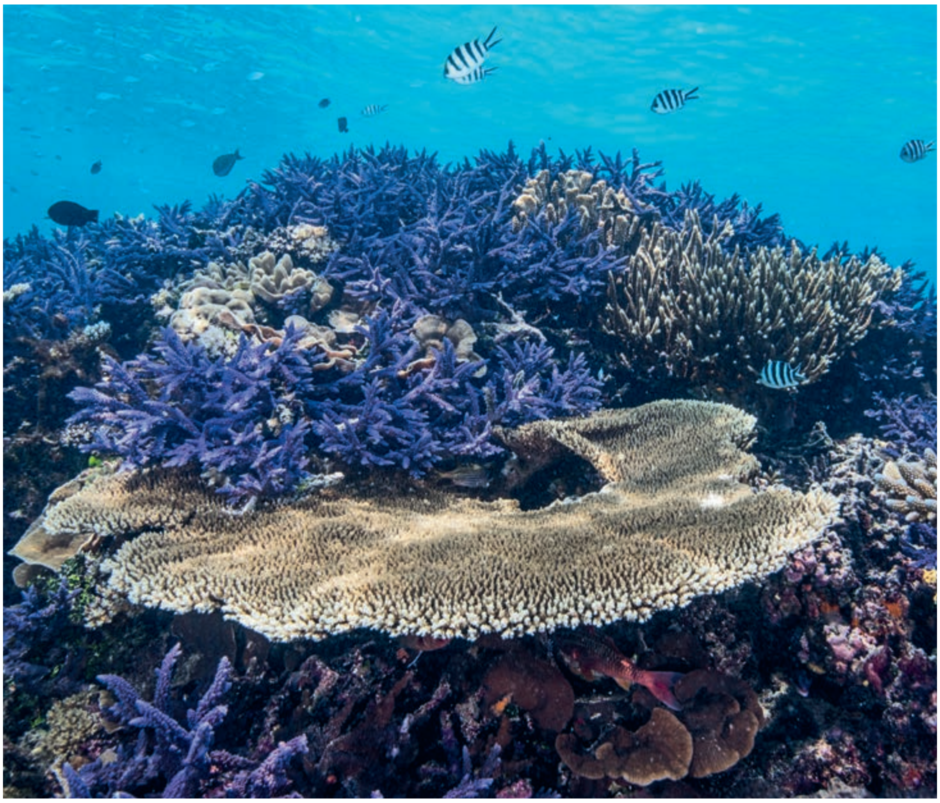
20%

DECREASE IN BIOMASS LEVELS AS A RESULT OF EXTENSIVE CHANGES IN OCEAN PARAMETERS

Projected impacts vary between species. The case study fisheries target a range of species with diverse ecological life traits, including at different trophic levels: along with catch quantity, catch composition is also sure to change in future.

Strong mitigation efforts will go some way to lessening the damage, but even in the most optimistic scenarios the situation is very serious, and urgent action is needed to meet the coming ecological challenges.

The sustainability of small-scale fishing activity in each of these regions depends on the ability to adapt fast. That's where the local fishers come in: the next section brings them into the picture.



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PART 2: WORKSHOPS THE VIEW FROM THE WATER

We held workshops with fishers and other stakeholders in each country. From start to finish it was abundantly clear that local knowledge is a valuable source of information to guide fisheries management towards greater sustainability, and it's essential to involve the fishers themselves in decisions about their future.

"I AM VERY WORRIED. IT AFFECTS MY ECONOMY AND THEREFORE THE WELLBEING OF MY FAMILY"

FISHER, ISABELA ISLAND, ECUADOR

We collected data on the changes fishers had observed over the previous 10 years, in three categories: climatic conditions, impacts on ecology and marine resources, and fishing practices. The same themes frequently recurred across all three countries.

- The most frequent sign of climate change observed by fishers is the **increase in sea water temperature.** Other stakeholders mentioned **increased extreme events,** like high tides and strong winds.
- All countries mentioned a **decrease in fish availability,** either through **reduced abundance** or **changed distribution** (e.g. South African snoek). Fishers in the Philippines and Ecuador reported **smaller fish.**
- Changes in species seasonality and life cycles required **new fishing practices.** Decreasing catches are pushing fishers **further offshore** in the Philippines and South Africa; and in Ecuador fishers reported **reduced quality of life** due to the climate-related fish shortage.

"I AM NOT WORRIED. WE CAN'T CHANGE FATE"

FISHER, LAGONOY GULF, PHILIPPINES

In all three countries, most of the stakeholders said they are very worried about climate change. However, there is a marked variability in how prepared they feel to respond.

In the Philippines the vast majority say they are ready to adapt, pointing out that they are used to adapting to change and extreme events, while arguing that there's no reason to worry about something that can't be controlled. For the Ecuadorians, by contrast, this is exactly why it's so worrying, and two-thirds say they are not yet prepared for adaptation.

As for the fisheries themselves, stakeholders nevertheless felt that Ecuador had good adaptive capacity thanks to the empirical and traditional knowledge of its fishers. This however was not the case for South Africa, where notable differences in opinions between fishers, managers and scientists could pose an obstacle to effective adaptation efforts.

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ADAPTATION MEASURES

With all participants acknowledging that the effects of climate change are already visible in their fisheries, we then discussed what to do about it – and here it was immediately clear that local ecological knowledge and multi-stakeholder co-management will be key to adapting to a sustainable future for the small-scale sector.

"WE ARE NOT READY AND WE ARE WORRIED"

FISHER, SAN CRISTÓBAL ISLAND, ECUADOR

Improving livelihoods

There are two aspects to adaptation. Changes in fishing practices and fishery management in direct response to climate change are needed, but the first goal must be to reduce poverty and raise basic living conditions in small-scale fisher communities across the world. Improved fisher livelihoods – particularly in the light of the projected falls in future catches – will underpin resilient communities with the resources and capacity to adapt for the long term.

"THE FISHING SECTOR IS NOT READY, BUT WE, THE FISHERS, HAVE ALWAYS BEEN GOOD OBSERVERS AND WILL DISCOVER IN TIME THE MECHANISM TO OVERCOME CLIMATE CHANGE EFFECTS"

FISHER, ISABELA ISLAND, ECUADOR

Key to improving livelihoods is to maximise the value of what the fishers bring home – not by catching more fish but by increasing the quality of landings, processing them more efficiently, and avoiding middle-man fees by creating direct channels to market.

Education, too, is key, as it underpins empowerment and social mobility. Gender equality comes into play here, with proper recognition and reward for the invaluable roles women play in small-scale fisheries – particularly in fish sales – an important priority.

Investments in everything from ice-making machines to seafood marketing campaigns, resource conservation and micro-finance initiatives provide measurable benefits for coastal communities, who are then better able to steward their marine resources and maximise their resilience in a warming ocean.

"WE MUST ADAPT, EVOLVE, CHANGE AND CREATE A NEW CULTURE IN THE FACE OF CLIMATE CHANGE BECAUSE IT AFFECTS PRODUCTIVITY IN THE FISHERY AND AFFECTS OUR OWN LIVES"

FISHER, SANTA CRUZ ISLAND, ECUADOR

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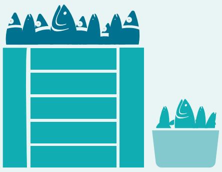
Fisheries management

Stakeholders in all our workshops agreed that adapting fisheries management to climate change is a central challenge. Local fishers and others suggested many different ways of addressing the issue, and again many of the same themes recurred in all three countries.

Broadly speaking, proposed adaptation measures fell under the following headings:

Enforce effective monitoring, control and surveillance

Ultimately, sustainability comes down to optimal resource management – if fishery regulations are absent or ignored, controlling what goes on there is impossible, and conservation plans are doomed to fail. Permits, seasonal closures, total allowable catches, protected areas – all can contribute to sustainable management. Control agencies and surveillance should be reinforced with inspectors given the training and tools they need, and the fishers themselves should be educated on the importance of compliance.

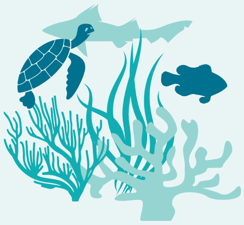


Adaptive management

By definition, climate change implies a situation that is constantly evolving, and fisheries management needs to keep pace to ensure adaptive measures remain appropriate and effective. Alternative management approaches should always be considered, for example changing from effort limits to catch limits to adjust exploitation rates when catch potential is unstable.

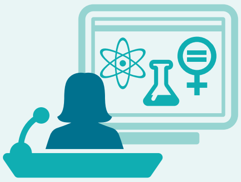
Co-management

Fishers rightly place great importance on participatory management structures, which could be implemented via multi-stakeholder management committees at fishery and regional levels. As well as making the active support of local fishers much more likely, such structures benefit from their unique knowledge and observations of what's really going on in the water – this perspective is an invaluable complement to the fine-grained scientific projections and analysis which make up the first part of this study.



Precautionary targets and an ecosystem-based approach

The increase in variability and risk that come with a changing climate is a strong argument for the adoption of precautionary management targets that support broader ecosystem resilience. This means minimising the impact of fishing on marine biodiversity, habitats, food webs etc, beyond the usual targets based on single-species approaches (e.g. maximum sustainable yield). Mandating minimum landing sizes and larger meshes, for example, is known to be an efficient way of reducing fishing's impact on fish stocks.



Develop research on fisheries adaptation

Alternative scenario planning that integrates knowledge from all stakeholders is needed – and the range of potential outcomes to plan for must integrate social factors as well as climatic and fishery science. This is another area where the role of women should be highlighted, as a driver of efficiency and sustainability.

MITIGATION MEASURES: REDUCING SECTOR GREENHOUSE GAS EMISSIONS

"LIMITING GHG EMISSIONS IS CURRENTLY THE ONLY OPTION TO MITIGATE OCEAN WARMING, ACIDIFICATION, DEOXYGENATION, SEA-LEVEL RISE, IMPACTS OF EXTREME WEATHER EVENTS AND DESTRUCTION OF PARTICULARLY SENSITIVE ECOSYSTEMS, SUCH AS CORAL REEFS"

COP25 – OCEAN AND CLIMATE PLATFORM POLICY RECOMMENDATIONS

While the main aim of this project was to identify adaptation measures for small-scale fisheries, the projections clearly underline the fundamental importance of mitigating future temperature rise as far as possible. The continuing viability of many fisheries worldwide – plus the livelihoods they provide and the food security they offer – depends on the global community successfully making ambitious cuts in emissions. A business-as-usual approach to mitigation will spell disaster for millions.

Although marine fisheries contributed just 0.6% of global emissions in 2018, and small-scale fisheries tend to be much more fuel-efficient than their industrial peers, workshop participants were keen to discuss how to further minimise their CO_2 footprint during fishing operations. Suggested improvements included:

- Reducing fishing vessel speed
- Replacing towed fishing gears which burn a lot of fuel with passive gears which don't
- Increasing fuel and vessel efficiency (however, any increase in fishing power should be carefully managed to ensure fishing effort remains within sustainable limits).

"STRATEGIES TO ADDRESS CLIMATE CHANGE MUST FIRST CARE FOR PEOPLE FIRST AND FOREMOST THROUGH EDUCATION AND BY BUILDING EQUITY. WITH THIS EDUCATION, WE CAN GUARANTEE CONSERVATION AND WE CAN FIGHT CLIMATE CHANGE"

FISHER, SAN CRISTÓBAL ISLAND, ECUADOR

Beyond the question of direct emissions, the CO_2 balance of the marine ecosystems where fisheries operate is significant. Seagrass beds, mangrove forests and healthy fish stocks are important carbon sinks, and fishers commented on their degradation and the need for protection. Strategies to protect and restore coastal and ocean ecosystems should be promoted, favouring nature-based solutions. Healthy ecosystems also moderate flooding and reduce the impacts of sea level rise and extreme weather events.

© James Morgan / WWF

CONCLUSION: ADAPTATION IS URGENT

Our study shows that the time for talking is over. The food security and livelihoods of many millions of the poorest people in the world hang in the balance.

Internationally, the global community must galvanise its efforts to cut carbon emissions. If countries fail to fulfil their pledges under the Paris Agreement, our projections indicate that changes in ocean ecosystems in many parts of the world will become so severe that small-scale fisheries and the communities they support will be unable to adapt.

Even the most optimistic emissions reduction scenarios are likely to see population numbers of some target fish species falling far below current levels, while other species move offshore away from the coastal areas they've sustained for generations – and that's without accounting for any of the other anthropogenic factors that are degrading marine species and habitats across the global ocean. When these too are taken into account, it's clear that small-scale fishers across the developing world face enormous and unprecedented challenges in the years to come.

Consequently, the urgency of adaptation is clear. But while global engagement on climate mitigation is crucial, it will not be anywhere near enough on its own. As well as cutting carbon emissions, the international community needs to provide real support to small-scale fishing communities to help them proactively adapt to the changes we see taking place. Our study shows some of the ways in which this can be taken forwards, thanks in part to the first-hand knowledge and experience shared by small-scale fishers in our workshops.

Participants in all three countries highlighted the importance of rehabilitating marine and coastal ecosystems, as well as calling for better and more effective monitoring and control of fishing activity. Traceable supply chains should support sustainability. Modern technology and efficient gear would increase knowledge and reduce overall pressure on marine resources; while improving the quality of the catch would add value to fish products, increasing relative returns on a diminishing harvest and maintaining fishing's financial viability. Market access needs to be made more equitable. Equally important is to raise safety levels at sea for the fishers, who will have to work further offshore and stay out for longer as species distribution changes in a warming ocean.

Engagement with fishing communities is of paramount importance. Participative management – where users are directly involved in decisions on how to manage the resources they depend on – is known to increase the resilience of coastal communities. As well as contributing invaluable local ecological knowledge to management strategies, an engaged community is much more likely to feel a sense of ownership, complying with fishery regulations and increasing the likelihood of long-term sustainable outcomes.

Our study leaves no doubt of the scale of the effort that will be needed to achieve these long-term sustainable outcomes in the world's small-scale fisheries, but it does show there are ways of getting there. Work must begin immediately.

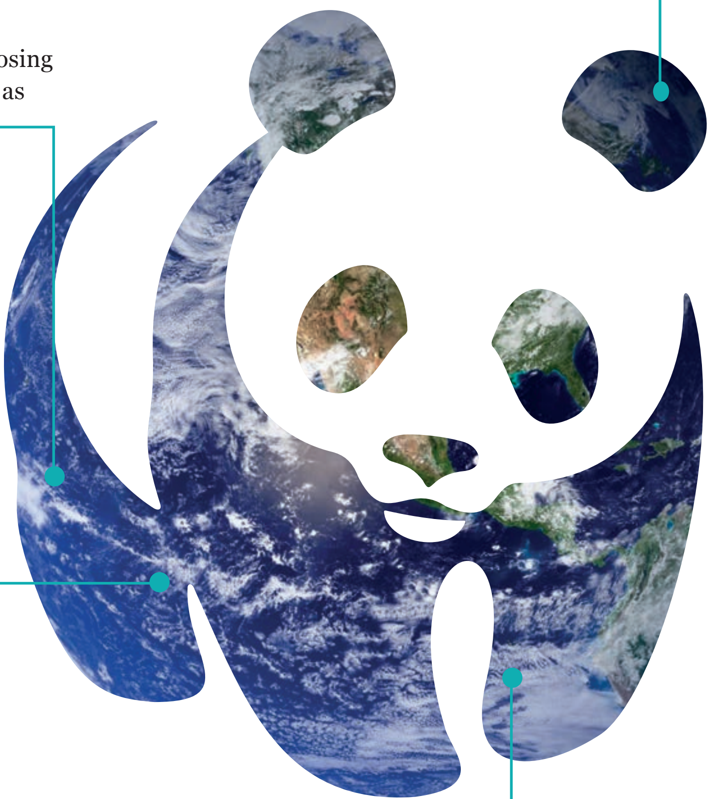
THE CLIMATE CRISIS IN A WARMING OCEAN IN NUMBERS

50%

As the ocean warms developing countries face a 50% potential reduction in annual catches

70%

Small island states and developing countries risk losing up to 70% of their revenue as their catches diminish



3MM PER YEAR

Sea level rise 25cm over last 140 years, but 3mm per year since the 1990s

10 TIMES FASTER

Warming oceans are changing oceans: #climatechange pushes aquatic animals to migrate about 10 times faster than their terrestrial counterparts

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