Food and Agriculture Organization of the United Nations

FAO INNOVATION FOR BLUE TRANSFORMATION

El Niño impacts and policies for the fisheries sector

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PREPARATION OF DOCUMENT

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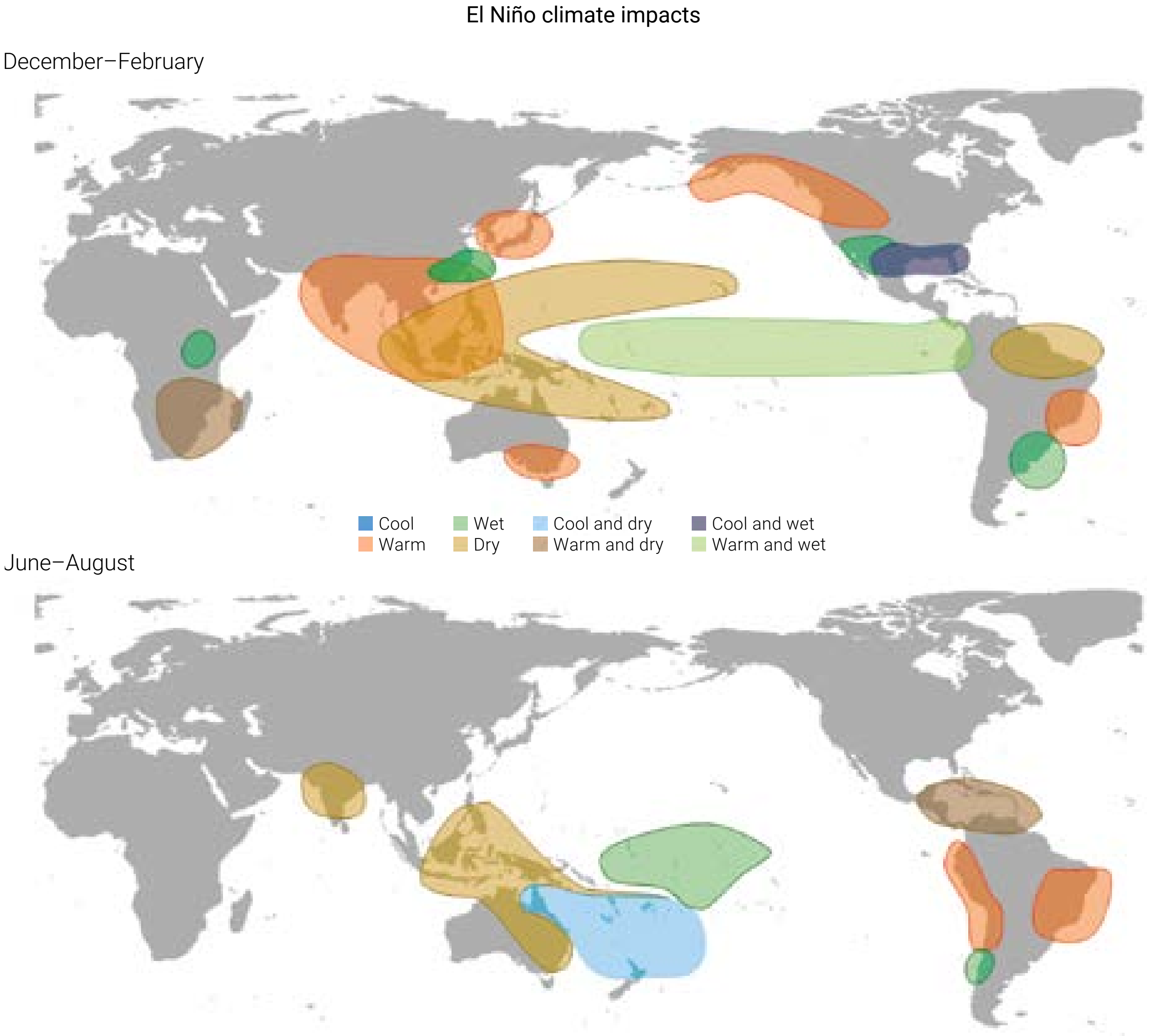
What is El Niño?

The El Niño Southern Oscillation (ENSO) is a natural climate phenomenon, in which surface waters in the central and eastern Equatorial Pacific fluctuate between warmer and colder conditions, causing changes in weather patterns around the world and driving extreme weather events including drought, flooding and storms. ENSO includes both El Niño and La Niña phases. The warm (El Niño) and cold (La Niña) phases of ENSO alternate, causing opposite extremes in affected countries.

Figure 1. Typical global climate impacts of an El Niño event in the austral summer (December to February) and winter (June to August)



Source: Bertrand, A., Lengaigne, M., Takahashi, K., Avadí, A., Poulain, F. and Harrod, C. 2020. *El Niño Southern Oscillation (ENSO) effects on fisheries and aquaculture.* FAO Fisheries and Aquaculture Technical Paper No. 660. Rome, FAO. https://doi.org/10.4060/ca8348en

BOX 1
EL NIÑO: FACTS & FIGURES

- The **El Niño Southern Oscillation** (ENSO) is a **natural climate phenomenon** and includes **both warm** (**El Niño**) and **cold** (**La Niña**) phases.
- El Niño is a natural climate event during which **surface waters** of the central and eastern Pacific Ocean **become warmer than usual**, resulting in changes in global weather patterns.
- El Niño events occur **every 2 to 7 years** and typically last for 9 to 12 months.
- The slow onset pattern of El Niño events implies **it can often be predicted** months ahead which means that **anticipatory actions, policies and emergency responses can usually be prepared** well in advance.
- The 2023/24 El Niño, which reached a peak at the end of 2023 and concluded in May 2024, followed immediately after a La Niña phase of more than 2 years, which had brought the opposite extremes to the affected countries.

Source: FAO. (forthcoming). *El Niño impacts on the fisheries sector and adaptation and response measures*. Rome.

An El Niño event is characterized by elevated sea surface temperatures in the central and eastern equatorial Pacific Ocean, while La Niña is associated with lower temperatures in the same area. Conditions between these two extreme phases are referred to as being neutral. El Niño events occur more frequently and have more severe impacts than the cooler La Niña events. These variations are closely linked to variations in the Southern Oscillation (fluctuations in the atmospheric pressure over the tropical Pacific Ocean).

On average, ENSO events occur approximately every 3 years with impacts on geography, ecosystems and human societies (Figure 1). The timing and intensity of events, and their impacts, vary considerably.

Stronger El Niño events cause considerable losses in the countries most affected, directly because of local weather extremes and indirectly through impacts on, for example, agriculture and fisheries. The global costs of a strong El Niño event have been estimated at between tens of billions to trillions of US dollars per event (Liu *et al*., 2023). The 2015/2016 El Niño event impacted more than 60 million people globally and led to 23 countries having to ask for humanitarian aid (FAO, 2023).

El Niño is usually a slow onset event and can often be predicted months ahead of the event, which means that anticipatory actions, policies and emergency responses can usually be prepared well in advance. However, El Niño events are diverse, each with its own unique impacts. While its occurrence can be predicted in advance, it is not always possible to predict which type of El Niño event will occur.

No two El Niño events are the same and at least three different types have been identified: Extreme; Eastern Pacific; and Central Pacific El Niño. The magnitude of warming varies depending on the type of El Niño, and the impacts of events on fisheries and aquaculture vary among regions and in the level of intensity.

Practical and achievable coping measures for fisheries include the strengthening and maintenance of monitoring and early warning systems, ensuring the participation of stakeholders in the decision-making process, implementing flexible and adaptive management strategies, and improving scientific knowledge on the effects of El Niño on fishery resources and livelihoods along the aquatic food chain.

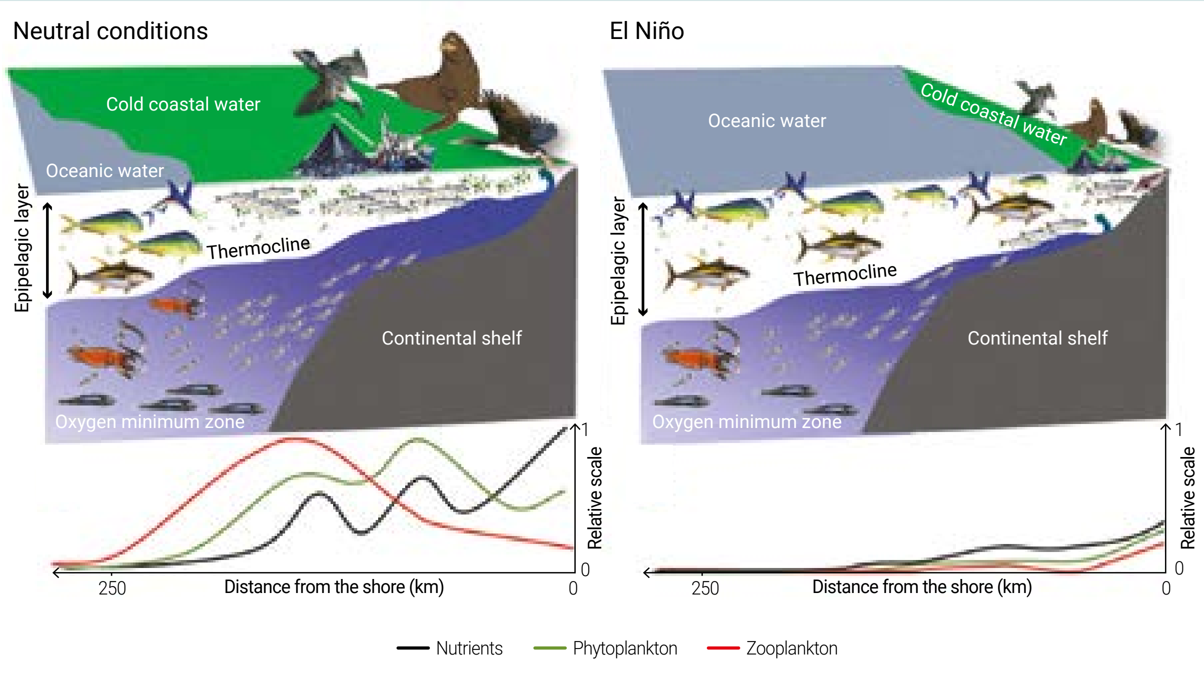
BOX 2

A CONCEPTUAL MODEL OF CHANGES IN THE PELAGIC ECOSYSTEM OF THE SOUTHEAST PACIFIC CAUSED BY EL NIÑO EVENTS

In "neutral" years (not El Niño/La Niña), there is a shallow thermocline in the southeast Pacific and a good supply of nutrients from wind-driven upwelling. The coastal ecosystem extends far from the shore and has high primary production, which supports high biomass (including fish). Further offshore, the oceanic ecosystem has a low level of nutrients and therefore low primary production, with less food available for oceanic fish species such as tunas and dolphinfish.

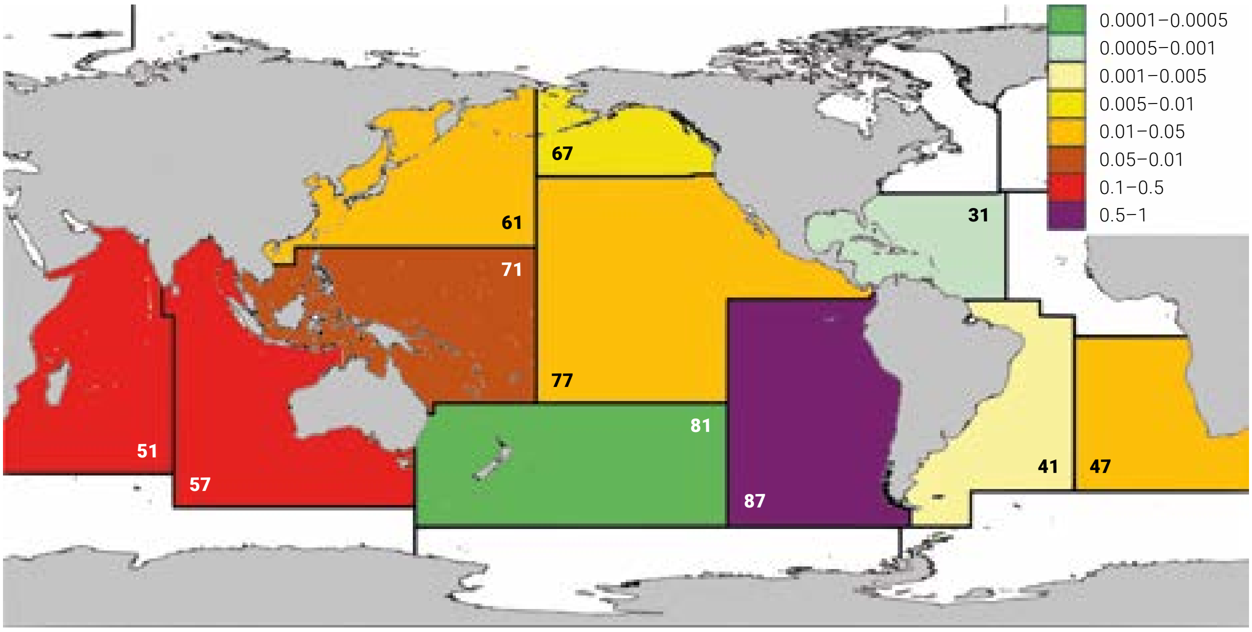
In years experiencing extreme El Niño, the coastal area of high production in the southeast Pacific is drastically reduced and the lower productivity oceanic ecosystem intrudes close to the coastline. The California Current system, extending from the west coast of Mexico to southern Canada, undergoes similar changes in response to El Niño.

Conceptual model of inshore–offshore pelagic ecosystem changes associated with El Niño



Source: Bertrand, A., Lengaigne, M., Takahashi, K., Avadí, A., Poulain, F. and Harrod, C. 2020. *El Niño Southern Oscillation (ENSO) effects on fisheries and aquaculture*. FAO Fisheries and Aquaculture Technical Paper No. 660. Rome, FAO. https://doi.org/10.4060/ca8348en

Figure 2. El Niño-related risk for marine fisheries by FAO Major Fishing Areas (MFA), shaded according to the estimated risk value (on a logarithmic scale) with higher values representing higher risk values (numbers included in the boxes correspond to the particular numbers of each FAO MFA)



Note: For this assessment the risk value incorporates: Hazard (product of the event's intensity and probability of occurrence); Exposure (proportion of fisheries showing significant reduction in catch during an event); and Vulnerability (combined reduction in catches of affected species). Hazard is the combined likelihood of both an El Niño occurring and its noticeable physical expression at a certain region. The assessment (FAO, forthcoming) shows that of the 27 FAO Major Fishing Areas (MFA), 11 have significant physical El Niño manifestations: three in the Atlantic, two in the Indian, and six in the Pacific. Hazard was therefore computed only for those 11 MFAs. Exposure is based on the FAO catch statistics (FAO, 2020), as the proportion of fisheries at each MFA that show significant reductions in productivity during the locally manifested El Niño events. Catch data was extracted from the FAO database (FAO, 2020) for each MFA, considering all the annual production time series of fisheries (ISSCAAP groups) having at least 25 years of valid data during the 1950 to 2021 period. The number of fisheries considered within each area ranges between 69 and 196, representing a production (in million tonnes per year) of between 0.4 and 19.9. Despite the differences in hazard, the exposure estimation is strikingly similar among MFAs, between 7.2 and 22.1 (average 14.3%). The vulnerability was estimated as the added catch reduction (in million metric tonnes) of all the affected species for each MFA (FAO, forthcoming).

Source: FAO. (forthcoming). *El Niño impacts on the fisheries sector and adaptation and response measures*. Rome.

Impacts of El Niño on marine fisheries

The warming of the surface layer and the deepening of the central and eastern equatorial Pacific thermocline during El Niño events result in less upwelling of nutrient rich water and therefore lower primary production, which can lead to a reduction in the availability of prey for fish and other marine species. Some tropical marine species respond to the warming events by moving into cooler waters (Box 2). These changes are most pronounced in the equatorial Pacific region but can also occur along the western coasts of North and South America as warm ocean anomalies are transmitted to higher latitudes by coastal waves.

An El Niño event has been estimated to result in a decline in yield from global fisheries and aquaculture of between 1 and 3.5 percent, depending on the intensity of the event (Bertrand *et al.*, 2020). Global marine landings have been estimated to decline by an average of 3.2 million tonnes per year during extreme El Niño years and by an average of 0.7 million tonnes during an Eastern Pacific El Niño. In contrast, landings increase on average during La Niña years and remain stable during a Central Pacific El Niño and neutral years (Bertrand *et al.*, 2020).

Strong to extreme Eastern Pacific El Niño events from 1950 to 2023 affected ocean conditions and marine fisheries in 11 out of the 22 FAO Major Fishing Areas (MFAs) (FAO, forthcoming). The highest impacts were experienced in the Southeast Pacific, followed by the Indian Ocean and the Western and Eastern Central Pacific (Figure 2).

PACIFIC OCEAN

The Humbolt Current system, extending from southern Chile to northern Peru in the Southeast Pacific (MFA 87), is the oceanic region most affected by El Niño (FAO, forthcoming). Effects are much stronger in the northern parts of this area than in the southern parts. Strong Eastern Pacific and extreme El Niño events create warmer ocean temperatures and heavy rains, which influence the abundance and production of marine species in different ways. Some coastal species do well under the warmer conditions, for example, lobster (*Panulirus gracilis)* and (*P. penicillatus*), octopus (*Octopus mimus)* and tuna species, while others suffer, such as some crab species and Peruvian anchoveta (*Engraulis ringens)*. Heavy rain can lead to strong river flows and floods, which can damage infrastructure used by small-scale fisheries.

During El Niño events over the last seven decades, catches of the most affected species in the Southeast Pacific (MFA 87) were reduced by 0.28 million metric tonnes on average per year, mainly as a result of lower Peruvian anchoveta catches (FAO, forthcoming). Catches were also reduced during El Niño events by approximately 0.045 million metric tons per year in the Western Central Pacific (MFA 71). El Niño has generally milder impacts in the Eastern Central Pacific (MFA 77), but within this area, extreme El Niño events can also affect the whole California Current system, which extends from the top of Vancouver Island southwards to the central Baja California peninsula. However, catches were only reduced by an average of about 0.01 million tonnes in this area during El Niño events and reductions have also been small in the Northwest Pacific (MFA 61), Northeast Pacific (MFA 67), and Southwest Pacific (MFA 81) (FAO, forthcoming).

INDIAN OCEAN

The Pacific and Indian Oceans are connected via the atmosphere and through the passages in the Indonesian Archipelago called the Indonesian Throughflow. Nearly 70 percent of the El Niño events taking place between 1950 and 2023 had detectable impacts in the Indian Ocean (MFA 51 and 57) and the risk levels associated with El Niño events are estimated to be moderate (FAO, forthcoming). Significant reductions in catches during these events were recorded in several fisheries, including for Indian oil sardine (*Sardinella longiceps*), skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*) and southern bluefin tuna (*Thunnus maccoyii*), and Penaeus shrimps (*Penaeus* spp.) (FAO, forthcoming).

Coral reefs, mangroves and seagrass beds provide important habitats for many coastal fish species and help to support fisheries. These habitats are already under threat from various impacts of climate change and human activity, and the threats are exacerbated by El Niño events. Coral reefs in the West Indian Ocean are still recovering from the severe 1997/98 El Niño but their recovery was setback by repeated El Niño events including 2016, amid human pressures and other threats (Bertrand *et al*., 2020).

ATLANTIC OCEAN

El Niño events cause warming of the tropical North Atlantic in spring (April to June in the northern hemisphere), after the peak of the event. El Niño also has impacts on the equatorial Atlantic. Overall, however, the influence of El Niño events on the Atlantic (MFA 31 and 34) is relatively low (Figure 2) (FAO, forthcoming). Nevertheless, there are indications of some impacts. For example, in the Southwest Atlantic (MFA 41), low shrimp catches are related to floods associated with El Niño events, while high catches are related to La Niña (drought) events.

In the Benguela upwelling ecosystem of the Southeast Atlantic (MFA 47), it has been reported that catches of anchovy (*Engraulis encrasicolus)* tend to increase several months after El Niño events, while those of sardine (*Sardinops sagax)* tend to increase after La Niña events, with a similar lag. However, Bertrand *et al*. (2020) report that there has been no robust evidence of El Niño events having impacts on the fisheries in this area.

El Niño also has impacts on freshwater fisheries (see Box 3) and aquaculture (Box 4) through, for example, changes in precipitation rates and water temperature and impacts of extreme weather events.

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BOX 3

IMPACTS OF EL NIÑO ON FRESHWATER FISHERIES

A comprehensive evaluation of the impacts of ENSO events on freshwater fisheries has not yet been undertaken, but they have the potential to affect inland ecosystems, including freshwater systems that sustain locally important fisheries.

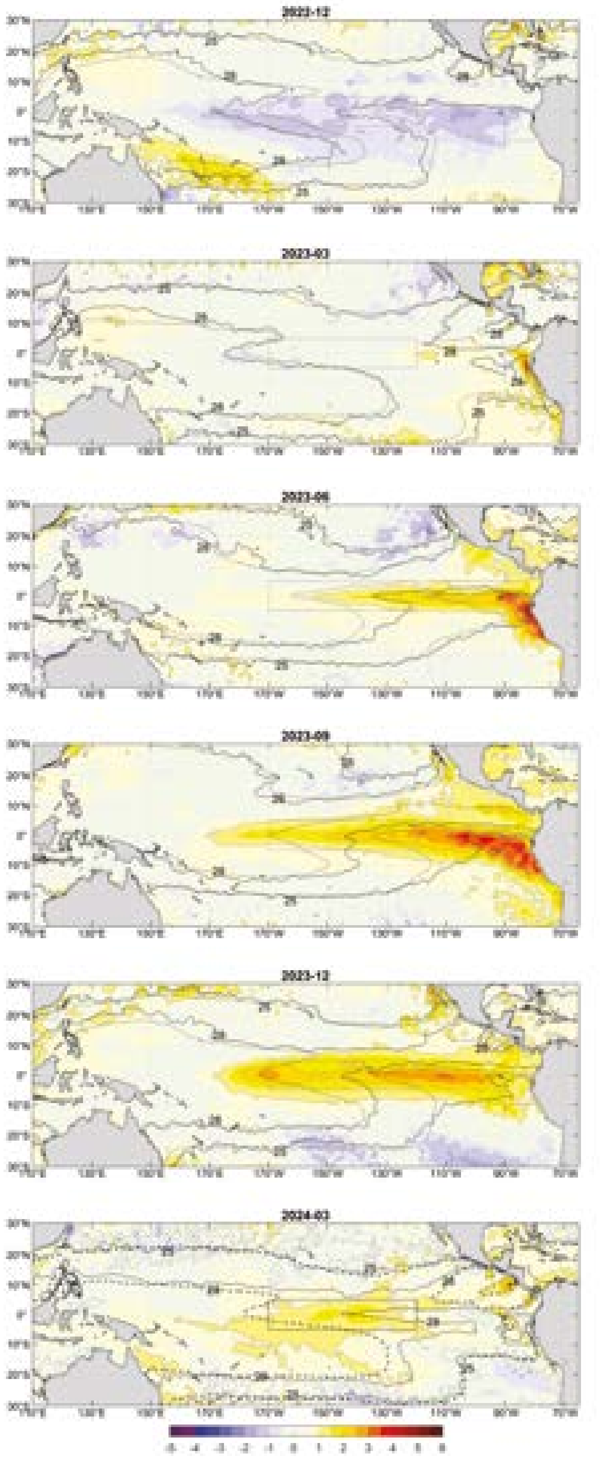
The western Pacific, India, and southern Africa are likely to experience conditions that are drier than average during El Niño events, while the Middle East, central and southern America, the central and eastern Pacific, India, and other smaller regions experience wetter-than-usual conditions. During Eastern Pacific El Niño years, the coasts of Chile, Ecuador, and Peru frequently experienced unprecedented precipitation. On the contrary, El Niño has the potential to induce profound droughts in regions of southern Asia, Australia, and Indonesia. These fluctuations have impacts on the properties of freshwater systems (for example water levels, pollutant concentrations, oxygen availability).

Low water levels in reservoirs, lakes, and rivers restrict the fish habitat and degrade the conditions for spawning and feeding. Restricted habitat increases the concentration of fish and their vulnerability to exploitation. Conversely, heavy precipitation and flooding can result in pollution of rivers and lakes and sediment discharge, degrading fish habitats and impairing freshwater and anadromous fish populations.

Elevated freshwater temperatures from El Niño events can also impact on various ecological processes, affecting the availability of oxygen, rates of primary production, abundance of parasites and pathogens, and the physical condition of fauna. Species of fish susceptible to fluctuations in temperature may encounter diminished rates of survival.

Source: The International Research Institute for Climate and Society. 2024. *ENSO Resources.* [Accessed on 24 June 2024]. Available at https://iri.columbia.edu/wp-content/uploads/2023/05/ELNINO-RAINFALL-2023.pdf

Figure 3. Monthly SST anomaly maps in the Tropical Pacific (Dec-2022, Mar-2023, June-2023, Sept-2023, Dec-2023, and Mar-2024)



Notes: Line contours depict the isotherms of 28 °C and 25 °C, associated to the eastern edge of the warm pool and the Eastern cold tongue, respectively; dotted lines are the climatological positions of both isotherms.
Refer to the disclaimer on the copyright page for the names and boundaries used in this map.

Source: FAO. (forthcoming). *El Niño impacts on the fisheries sector and adaptation and response measures*. Rome.

BOX 4

IMPACTS OF EL NIÑO ON AQUACULTURE PRODUCTION

El Niño effects on ocean and weather patterns can alter the quantity and quality of plankton and other food sources in culture systems that rely on the environment, and can result in temperatures, salinities, and dissolved oxygen concentrations deviating from the optimal levels for cultured species. That can affect growth rates and increase the susceptibility of cultured organism to diseases and pathogens. Increased runoff from above average rainfall can carry pollutants to the aquaculture facilities, while below normal rainfall can limit the availability of water for culture facilities.

Extreme weather can damage aquaculture facilities. In Peru, for example, extreme El Niño events can result in enormous die-offs of cultured sea scallops, which provides over 25 000 direct and indirect jobs, due to torrential rains and water warming.

A primary concern for many aquaculture enterprises is the availability of wild-caught feed. The aquaculture industry consumes more than 70 percent of the world's fishmeal production, although aquaculture feeds constitute only 4 percent in total industrial feed production. A significant proportion of fishmeal originates from Peruvian anchoveta and other small marine pelagic fish (and increasingly, fish waste and by-products). These can be directly affected by El Niño (see Case Study 1). ENSO is believed to be partially responsible for a 26.5 percent decline in global fishmeal production between 2000 and 2018, which led to a more than three-fold increase in fishmeal prices from 2000 to 2018.

Suitable adaptation strategies can help to make the aquaculture sector more resilient to El Niño effects. For example, reducing the reliance on wild caught feed and enhancing the quality of feed provided can lessen the susceptibility of some enterprises to environmental stress. Selective breeding to develop strains more tolerant of temperature variability and extremes; use of infrastructure able to withstand extreme weather; and the development and enhancement early warning systems and predictive capacity can all assist in adapting to these effects.

Sources: Jannathulla, R., Rajaram, V., Kalanjiam, R., Ambasankar, K., Muralidhar, M., Syama Dayal, J. 2019. Fishmeal availability in the scenarios of climate change: Inevitability of fishmeal replacement in aquafeeds and approaches for the utilization of plant protein sources. *Aquaculture Research*. 50: 3493–3506. https://doi.org/10.1111/are.14324
Romagnoni, G., Kluger, L.C., Tam, J., Wolff, M. 2022. Adaptations to Climate Variability in Fisheries and Aquaculture Social-Ecological Systems in the Northern Humboldt Current Ecosystem: Challenges and Solutions. In: Misiune, I., Depellegrin, D., Egarter Vigl, L. (eds) *Human-Nature Interactions*. Springer, Cham. https://doi.org/10.1007/978-3-031-01980-7_30

The 2023/24 El Niño event

The 2023/24 El Niño event started in early 2023 in the eastern Pacific and largely disappeared by May 2024 when conditions returned to neutral across the equatorial Pacific (FAO, forthcoming). While it was not considered an extreme El Niño it still had major impacts on oceanic conditions and the ecology of a wide area of the Pacific.

The development of the event, an Eastern Pacific El Niño (Figure 3) can be summarised as follows (reference to "panels" refers to the respective panels in that figure, counting from the top):

i. Before the start of the 2023/24 event, La Niña conditions in the tropical Pacific Ocean had prevailed for more than two years, with a gap of four months of neutral conditions in mid-2021. During La Niña, increased coastal and equatorial upwelling in the eastern Pacific had pushed the western Pacific 'warm pool' boundary far to the west of its usual location (1st panel);
ii. Weakening of the South Pacific high-pressure cell by the end of 2022 and well into 2023 resulted in reduced upwelling, and therefore reduced production, along the Peruvian coast, and the depth of the thermocline increased from March to July 2023 (2nd and 3rd panels);
iii. Warmer sea surface temperatures in the east moved increasingly westward and northwards, leading to El Niño conditions in the equatorial central Pacific from May, and warmer than usual sea surface temperatures in the tropical northeast Pacific during summer 2023 (3rd and 4th panels);
iv. Above normal sea surface temperatures close to the Peruvian coast, with a substantial impact on fish stocks and fisheries, reached a peak in July, before starting to decrease slowly. However, anomalous temperatures continued to increase to the north and west of this area, reaching high to very high levels in November and December 2023 in the central Pacific (4th and 5th panels);
v. As a result of these changes, the eastern boundary of the warm pool in the equatorial belt, with surface temperatures between 28 and 29°C, moved about 2 700 nautical miles to the east between February and July 2023 and largely remained there until the end of the year (4th and 5th panels);
vi. The event was drawing to a close by March 2024 (6th panel) and conditions returned to neutral by May.

Associated with these changes, the productive mixed surface water layer remained thicker than normal in the eastern Pacific until early 2024, while in the western Pacific it became progressively thinner and shallower from October 2023 onwards. These changes affected the supply of nutrients to the upper layers and the distribution and condition of some fish stocks. The Southeast Pacific experienced a reduction in coastal habitat and the thick mixed surface water layer led to reduced upwelling of nutrient-rich water into the surface zone, and a reduction in primary production (Figure 2). As a result, anchoveta moved closer to the coast and to deeper water. At the same time, the incursion of oceanic waters closer to the Peruvian coast resulted in higher abundances of tropical and transboundary warm water species.

In the eastern Pacific, El Niño conditions finished in March 2024, and in the Central Pacific, the intensity of El Niño weakened during the first quarter of 2024, returning to neutral conditions during spring. Warm sea surface anomalies are expected to persist in the Northeastern Pacific until end-2024. The impacts of these changes on some species and fisheries are discussed in case studies 1 to 4.

Other components of ecosystems are also affected. For example, El Niño conditions raised the probability of coral bleaching on both sides of the Pacific in the first half of 2024, which would also impact species dependent on coral reefs. In addition, changes in precipitation and sea surface temperature can lead to increased salinity in seas around the Philippines and reduced salinity in Malaysian and Indonesian waters, with likely impacts on coastal marine aquaculture in the western Pacific. Those impacts could continue to be felt for some time after the current El Niño event has ended. Tropical cyclones, exacerbated by El Niño conditions, are another potential threat to ecosystems and fisheries, potentially impacting lives and damaging fishing assets and infrastructure as well as affecting safety at sea.

CASE STUDY 1

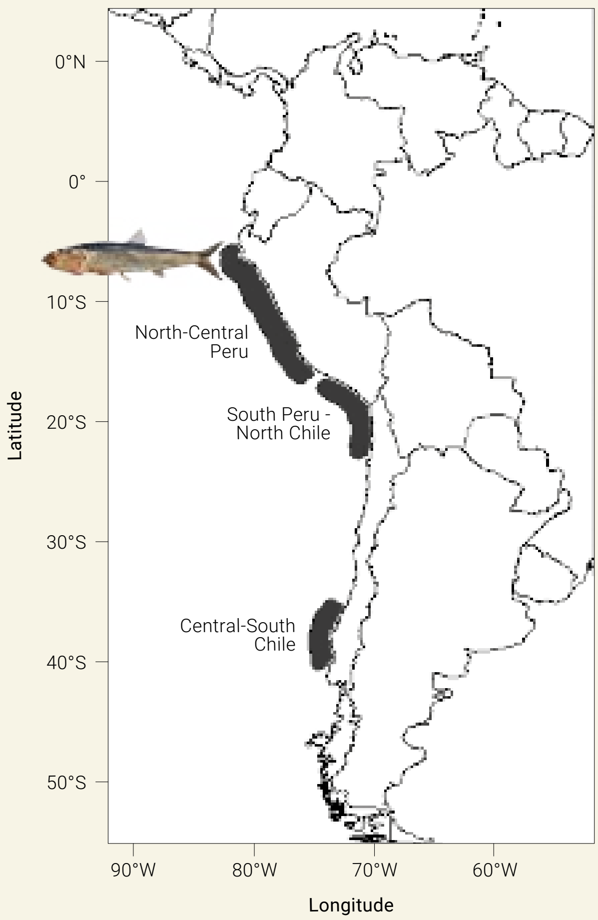
Peruvian anchoveta (*Engraulis ringens*)

The Peruvian anchoveta is a small pelagic fish found in the coastal waters off Chile and Peru. In addition to supporting the world's largest single-species fishery, it is an important prey species for fish, sea birds and marine mammals. Its population dynamics are heavily influenced by environmental conditions, from interannual to multidecadal time scales. The total catch of the species in 2022 was nearly 4.9 million tonnes, of which 4.12 million tonnes was caught by Peru and 0.74 million tonnes by Chile. Most of the catch is converted to fish meal and fish oil for export. Fish meal and fish oil accounted for around 3.9 percent of the total value of Peruvian exports over the last decade and directly employed more than 53 000 people.

The 2023/24 El Niño event had major impacts on the stock and fisheries. The rapid onset of conditions in the eastern Pacific in the summer of 2023 led to a decrease in reproduction of anchoveta and, as waters warmed, the anchoveta moved closer to the coast and into deeper waters. As a result of these abnormal conditions, the management authorities did not open the fishery during the first fishing season of that year. Later in the year, the sea surface temperatures anomalies eased, and the southeast trade winds strengthened. Anchoveta spawned in spring, as they do under normal conditions, but the condition of adults was below the norm and the distribution of fish was still not back to normal.

The management authorities opened the fishery for the second fishing season in October 2023, but closed it early in January 2024, before the full allowable catch limit had been reached. The industrial anchoveta landings in Peru were reported to be only 1.99 million tons in 2023, the lowest since 1999. As a result of low landings and lower condition of anchoveta in 2023, the value of fish meal and oil exported by Peru was only 1.141 billion USD the lowest in the previous 20 years. By the first quarter of 2024, a rapid transition from El Niño to neutral conditions along with coastal cooling was recorded off Peru, and a recovery of the biomass and distribution was noticed, associated with strong recruitment of juveniles. The quota for the first fishing season was set at 2.475 million tonnes and, given the projections towards La Niña conditions during 2024, shallowing of the thermocline and increasing productivity will likely benefit the Peruvian anchoveta stocks and the second fishing season in the year.

Figure 4. Fishing areas for the Peruvian anchoveta (*Engraulis ringens*), and an adult individual



Note: Refer to the disclaimer on the copyright page for the names and boundaries used in this map.

Source: FAO. (forthcoming). *El Niño impacts on the fisheries sector and adaptation and response measures*. Rome.

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CASE STUDY 2

Tuna fisheries in the Pacific

More than half of the global production of tuna takes place in the Western Central Pacific Ocean (WCPO) and tuna fishing is an important source of income and employment for several Pacific islands, countries and territories (PICTs). Benefits are derived through direct involvement of their national fishing fleets and by receiving licensing fees paid to the countries by foreign fleets fishing in their exclusive economic zones. The PICTs most engaged in tuna fishing include Papua New Guinea, Kiribati, Nauru, Federated State of Micronesia and the Marshall Islands, Tuvalu and Palau (Figure 4). Most of the catch consists of four tuna species: skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), bigeye (*T. obesus*), and albacore (*T. alalunga*).

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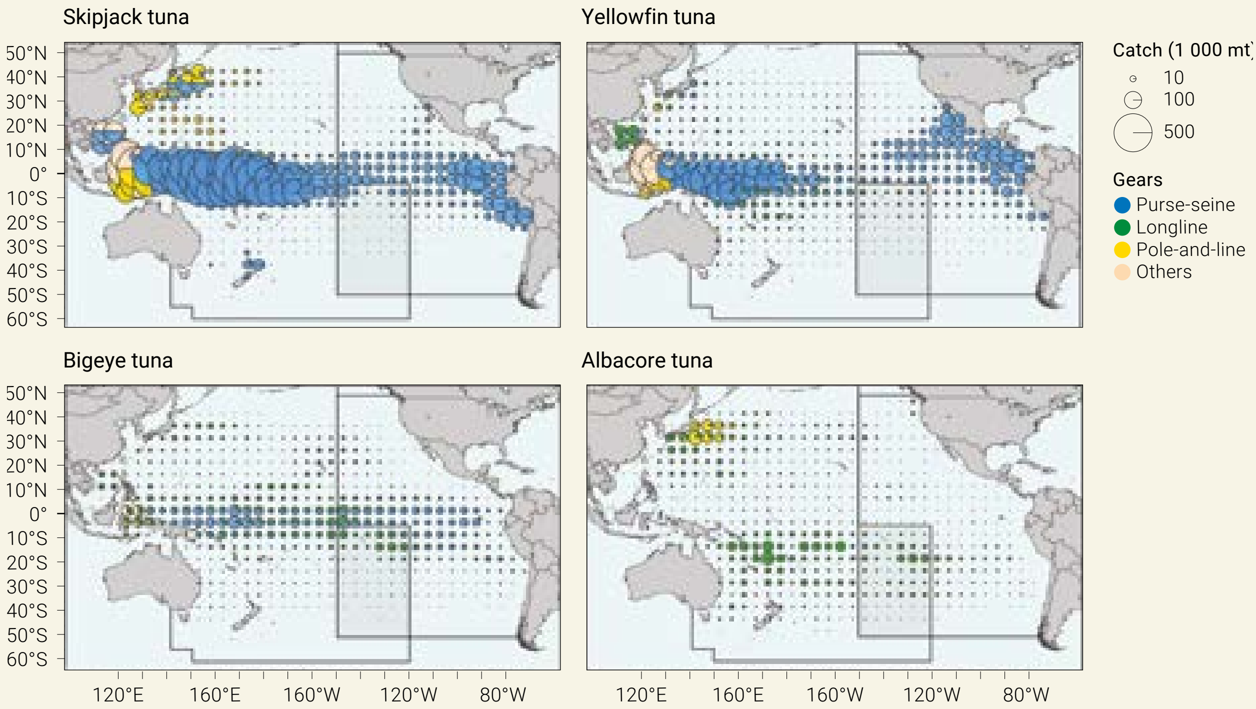
Figure 5. Distribution and magnitude of total catches for skipjack, yellowfin, bigeye and albacore tunas in the Pacific Ocean between 2009 and 2018 by 5° square and fishing gear



Note: The hatched area represents the overlap in management area between the convention areas of the Western and Central Pacific Fisheries Commission (WCPFC; west) and Inter-American Tropical Tuna Commission (IATTC; east). The light blue shaded area represents the Pacific Islands and Territories region. Refer to the disclaimer on the copyright page for the names and boundaries used in this map.

Source: FAO. (forthcoming). *El Niño impacts on the fisheries sector and adaptation and response measures*. Rome.

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El Niño events cause substantial changes in habitat conditions for tuna in the region. The expansion of the warm pool of water during an El Niño event in the central and eastern Pacific and thinning in the western areas result in a shift to the east in the distribution of skipjack tuna and increase the catchability of yellowfin and big eye tuna and albacore in the west. These changes are accompanied by spatial changes in the availability of the different species to the fishery and, therefore, changes in catch per unit effort.

The impacts of the 2023/2024 El Niño event on tuna and the tuna fisheries followed these patterns in general for skipjack and yellowfin catches. For the eastern Kiribati islands and other exclusive economic zones near the eastern boundary of the equatorial Western Central Pacific, a temporary increase in the catchability of skipjack was recorded up to the end of 2023 and tended to revert to the western PICTs in the first few months of 2024, when El Niño was declining. By contrast, the available information indicated a substantial decline in the yellowfin catch in the second half of 2023, which could have been caused by decreased catchability in the east of the region. Little change was seen in bigeye catches.

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CASE STUDY 3

Elkhorn seamoss aquaculture in the Philippines

Elkhorn sea moss (*Kappaphycus alvarezii*) (ESM), is a fast growing red seaweed native to the Indo-Pacific and typically found in depths from 1 to 17 metres. It is cultivated in several countries in southeast Asia as well as in some other tropical countries. ESM accounts for over 90 percent of the production of seaweed cultivated in the Philippines, which produced more than 85 percent of total global production. It is used for human consumption and to produce carrageenan, which is used as a food additive and in the pharmaceutical industry. Approximately 200 000 households farm ESM in the country, employing more than 400 000 men and women.

During an El Niño event, monthly rainfall in the Philippines decreases, leading to increasing salinity, drought, and warmer sea surface temperatures. Extreme temperatures during El Niño events are reported to increase the susceptibility of seaweeds to pathogens and to ice-ice disease, an infection by pathogenic bacteria. High temperatures also increase the risk of infestations by algal epiphytes: huge infestations in Camarines Norte, Philippines, in the early 2000s were attributed to El Niño-driven high temperatures. Higher rainfall during La Niña conditions could lead to reduced salinity of the coastal waters, which also increases the probability of ice-ice outbreaks.

In addition, tropical cyclones occur more frequently in the northwestern Pacific during El Niño than during La Niña events, but cyclone intensity can be exceptionally strong during La Niña events. Tropical cyclones can destroy entire seaweed farms.

El Niño conditions in 2023 did not adversely affect seaweed production but sea surface temperatures around the Philippines were higher than usual from December 2023 and rainfall was lower. Those conditions are not conducive to good ESM growth and carrageenan yields, and there is also an increased risk of ice-ice outbreaks and epiphytic infestation on the seaweed.

Source: Authors' own elaboration.


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CASE STUDY 4

Coastal shrimp fisheries in Ecuador

Shrimp fisheries in Ecuador occur over much of the Pacific coast. The climate consists of a dry, cold season from June to November and a rainy, warm season from December to May, but El Niño conditions typically result in higher temperatures and rainfall than average, and the converse under La Niña conditions.

The most important shrimp resources in Ecuador are reported to be the whiteleg shrimp (*Penaeus vannamei*), the pomada shrimp (*Xiphopenaeus riveti*) and the yellowleg shrimp (*Penaeus californiensis*). Their lifecycle typically involves spawning offshore, the eggs remaining in the water column for about three weeks before being transported inshore and migrating into estuaries, where they remain for three to four months before migrating offshore to complete the cycle.

The shrimp fishery in Ecuador consists of two types of trawl vessels (langostineras and pomaderas), and there is also an artisanal fishery that operates in estuarine areas, particularly in the Gulf of Guayaquil and in Esmeraldas, mainly targeting juvenile shrimps for the aquaculture industry. At present, the fishery is made up of an industrial trawl fleet of 40 boats, which provides livelihoods for 2 500 families, and an artisanal fishery consisting of at least 617 artisanal fishers supporting about 3 000 families. Landings were close to 12 900 tonnes in 2021.

Historical data indicate an estimated 30 percent rise in average shrimp landings during El Niño years (warmer and wetter weather along the Ecuador coast) and reduced landings in La Niña years (drier and cooler conditions). However, El Niño events in recent years have had limited impacts on rainfall, and the very strong 2015/16 El Niño in the eastern Pacific had little impact on it. Pressures from human activities and management may therefore have had a greater impact on variability in shrimp landings than El Niño events and other climatic factors in recent years. However, the limited information available makes it difficult to determine the extent of ENSO influence on biomass of shrimp populations and fisheries.

Source: Authors' own elaboration.

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Policy options

ENSO events have major impacts on people, agriculture, fisheries and sustainable development, and the frequency and severity of these events are increasing under the influence of climate change. However, El Niño and La Niña are slow onset events and can be predicted months in advance, which provides some time for preparation and adaptation to upcoming events. Effective policies and strategies should be put in place to facilitate preparation for these events, and measures included in suitable existing policies such as those ones on climate change, fisheries and aquaculture or sustainable development.

i. The specific policy requirements to encourage and facilitate preparation and adaptation to ENSO events in marine fisheries will depend on the political, environmental, social and economic circumstances of each country and region, but there are common elements that are likely to apply in many cases:
ii. The impacts of ENSO events are felt across environmental, social and economic dimensions and policies should address all three through integrated approaches.
iii. Communities and other stakeholders impacted most strongly should be closely involved in policy formulation and implementation. As El Niño events typically have the greatest impacts on the most vulnerable, policies should give particular attention to them, helping them to safeguard their livelihoods and strengthening their resilience to such events.
iv. Policies should allow for flexibility and adaptability in determining fishing seasons and fishing closures to ensure sufficient recovery time and long-term sustainability.
v. Policies should allow for flexibility in allocating tradable fishing rights to ensure adaptability in response to stocks shifting across international borders.
vi. Policies should integrate the provision of emergency assistance with sustainable development by incorporating risk and vulnerability assessment into planning for development, and by linking provisions for emergency assistance with longer-term development goals.

vii. Policies should ensure the provision of timely and reliable early warning information that provides people with sufficient time to make decisions to protect their livelihoods and assets and, if required, to relocate to avoid life-threatening conditions.

viii. Policies should include measures to facilitate anticipatory actions, for example, measures to help fishers protect their boats ahead of storms, and provision of embankments as protection against flooding or sea surges.

ix. Ensuring the provision of early response in cases where El Niño conditions devastate fishing communities and aquaculture enterprises is also an important requirement, together with provision of support and compensation as needed. The establishment of insurance schemes could be an important component of this.

x. Further monitoring and research into the diversity of El Niño events and their impacts, the frequency of extreme events (for example marine heatwaves), and the effects of global warming on these events is needed in order to strengthen science-based adaptive management policies and actions.

xi. Policies should address general improvements in coastal and fishery habitats that can help to mitigate impacts and increase resilience, for example through rehabilitation and protection of marine habitats such as mangroves, seagrasses and coral reefs, implementation of marine protected areas as appropriate, and effective integrated coastal zone management and marine spatial planning.

xii. ENSO events can have some positive impacts, and policies should allow for and facilitate flexibility and the adaptive capacity of stakeholders to respond to positive opportunities, such as increased availability of some fishery resources and allow for the development of new products and markets.

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