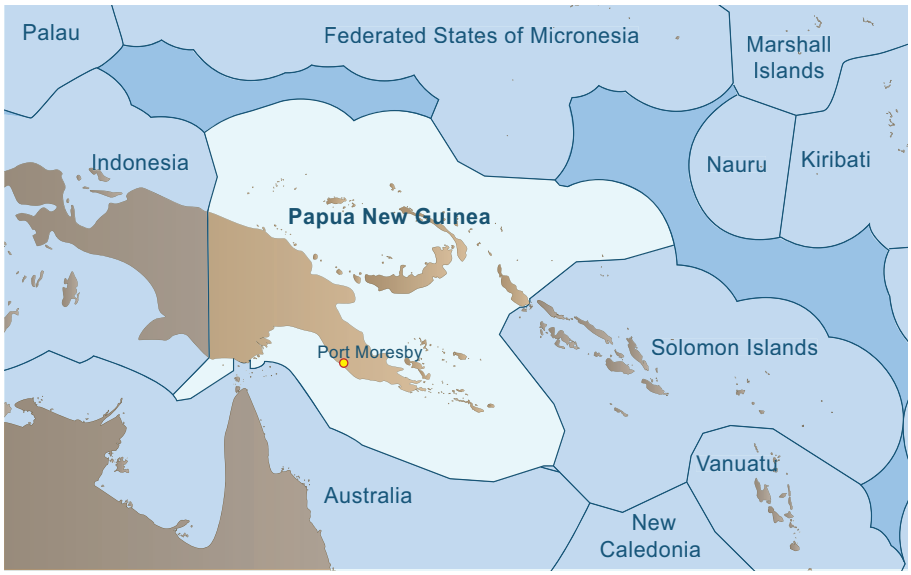
2.14 Papua New Guinea



Key features

Population

Year	2010	2035	2050	2100
Population (x 1000)[a]	6753	10,822	13,271	21,125
Population growth rate[a]	2.1	1.5	1.2	0.6

a = Data from SPC Statistics for Development Programme (www.spc.int/sdp).

EEZ area (km²) 2,446,757

Land area (km²) 462,243

Land as % of EEZ 15.9

Fisheries and aquaculture activities: Oceanic fisheries, coastal fisheries, freshwater and estuarine fisheries, freshwater aquaculture and coastal aquaculture.

Membership of regional fisheries management arrangements: Forum Fisheries Agency; Western and Central Pacific Fisheries Commission; Parties to the Nauru Agreement; South Pacific Tuna and Billfish subcommittee; Melanesian Spearhead Group.

Surface climate and the ocean

Existing features

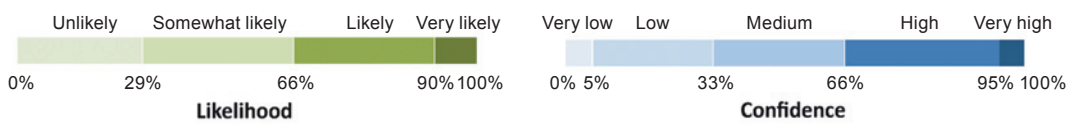
Papua New Guinea (PNG) has a tropical climate {Chapter 2}. Recent air temperatures in Port Moresby have averaged 27.3°C and average rainfall there is > 1100 mm per year (but much higher elsewhere in the country). PNG lies mainly within the Western Pacific Warm Pool Province (Warm Pool) with some southern islands within the Archipelagic Deep Basins Province (ARCH) {Chapter 4, Section 4.3}. The primary influences on the climate and ocean around PNG are the South Pacific Convergence Zone {Chapter 2, Section 2.3.1, Figure 2.4} and South Equatorial Current {Chapter 3, Section 3.2.8, Figure 3.1}.

Projected changes to surface climate

Air temperatures and rainfall in PNG are projected to increase due to climate change under the low (B1) and high (A2) emissions scenarios in 2035 and 2100 {see Chapter 1, Section 1.3 for definition of scenarios} relative to long-term averages {Chapter 2, Section 2.5, Table 2.6}.

Climate feature[a]	1980–1999 average	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Air temperature (°C)	27.3 (Port Moresby)	+0.5 to +1.0	+0.5 to +1.0	+1.0 to +1.5	+2.5 to +3.0
Rainfall (mm)	1122 (Port Moresby)	+5 to +15%	+5 to +20%	+10 to +20%	+10 to +20%
		More extreme wet and dry periods			

* Approximates A2 in 2050; a = for more detailed projections of rainfall and air temperature in the vicinity of Papua New Guinea, see www.cawcr.gov.au/projects/PCCSP.



Projected changes to the ocean

The projected changes to the key features of the tropical Pacific Ocean surrounding PNG relative to the long-term averages are expected to result in increases in sea surface temperature (SST), sea level and ocean acidification. Changes to ocean currents, such as the South Equatorial Current, and the area of the Warm Pool are also expected to occur {Chapter 3, Sections 3.3 and 3.4, Tables 3.1 and 3.2}.

Ocean feature	1980–1999 average	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Sea surface temperature (°C)	28.7[b]	+0.6 to +0.8	+0.7 to +0.8	+1.2 to +1.6	+2.2 to +2.7
Sea level (cm)	+6 since 1960				
IPCC **		+8	+8	+18 to +38	+23 to +51
Empirical models ***		+20 to +30	+20 to +30	+70 to +110	+90 to +140
Ocean pH (units)	8.08	-0.1	-0.1	-0.2	-0.3
Currents	Increase in South Pacific gyre	SEC decreases at equator; EUC becomes shallower; SECC decreases and retracts westward			
Warm Pool area (x 10^6 km^2)[a]	7	+230% (20–26)	+250% (22–27)	+480% (36–46)	+770% (48–65)
Nutrient supply	Decreased slightly	Decrease due to increased stratification and shallower mixed layer			< -20%

* Approximates A2 in 2050; ** projections from the IPCC-AR4; *** projections from recent empirical models {Chapter 3, Section 3.3.8}; a = Warm Pool defined as area with temperature above 29°C; b = average for EEZ derived from the HadISST dataset; SEC = South Equatorial Current; EUC = Equatorial Undercurrent; SECC = South Equatorial Counter Current.

Oceanic fisheries

Recent catch and value

PNG has an important, locally-based, industrial fishery within its exclusive economic zone (EEZ), mainly based on purse-seining for tuna. Recent average catches by this fishery (2004–2008) have exceeded 225,000 tonnes per year, worth > USD 280 million. PNG also licenses foreign purse-seine vessels to fish for tuna in its EEZ. The recent average annual catch by these foreign vessels averaged > 220,000 tonnes between 1999 and 2008, worth > USD 200 million {Chapter 12}. See 'Coastal Fisheries' below for contributions of tuna to nearshore artisanal and small-scale commercial fisheries.

Local oceanic fisheries	Average annual catch (tonnes) 2004–2008	Average annual catch value (USD million)* 2004–2008
Tuna		
Purse-seine	222,260	263.2
Longline	3690	19.1
Other oceanic fish[a]	345	0.3
Total	**226,295**	**282.6**

* Calculated using market value per tonne for 2004–2008; a = billfish catch only, valued at USD 1000 per tonne.

Existing oceanic fish habitat

The Warm Pool is generally poor in nutrients. However, net primary production increases during El Niño events when the depth of the thermocline decreases, bringing more nutrient-rich waters within the photic zone {Chapter 4, Section 4.3.2}. The convergence of the Warm Pool and the Pacific Equatorial Divergence provinces creates prime feeding areas for tuna {Chapters 4 and 8}. Changes in the position of this convergence zone influence the abundance of tuna in the EEZ of PNG {Chapter 8}. The eastward extension of the Warm Pool during El Niño, and westward contraction during La Niña, changes habitat conditions for tuna in the western Pacific.

Projected changes to oceanic fish habitat

Under climate change, the surface area of the Warm Pool is projected to expand {Chapter 4, Table 4.3}. The greater stratification of the water column in the Warm Pool due to higher sea surface temperature {Chapter 3}, and the increased depth of the nutricline {Chapter 4}, are projected to reduce net primary production within the EEZ of PNG. Relocation of the convergence zone between the Warm Pool and PEQD to the east is also expected to increase the distance between the EEZ of PNG and the prime feeding grounds for tuna {Chapter 8}.

Warm Pool feature	Projected change (%)			
	B1 2035	A2 2035	B1 2100*	A2 2100
Surface area[a]	+18	+21	+26	+48
Location	Eastwards			
Net primary production	-7	-5	-9	-9
Zooplankton biomass	-6	-3	-9	-10

* Approximates A2 in 2050; a = area derived from modelling of nutrients and salinity {Chapter 4, Table 4.3}.

Projected changes in oceanic fisheries production

Preliminary modelling suggests that under the B1 and A2 emissions scenarios, catches of skipjack tuna in the EEZ and archipelagic waters of PNG are expected to remain much the same in 2035, relative to the 20-year average (1980–2000). By 2100, catches of skipjack tuna are projected to decrease by ~ 30% under the A2 scenario as these tuna move to the east. Catches of bigeye tuna are projected to follow a similar trend {Chapter 8, Section 8.7}. Modelling for yellowfin tuna and albacore is now in progress. The trends for yellowfin tuna are expected to be similar to those for skipjack tuna, whereas albacore are expected to move poleward.

Projected change in skipjack tuna catch (%)			Projected change in bigeye tuna catch (%)		
B1/A2 2035	B1 2100*	A2 2100	B1/A2 2035	B1 2100*	A2 2100
+3	-11	-30	-4	-13	-28

* Approximates A2 in 2050.

Coastal fisheries

Recent catch and value

The coastal fisheries of PNG are made up of four components: demersal fish (bottom-dwelling fish associated with coral reef, mangrove and seagrass habitats), nearshore pelagic fish (including tuna, Spanish mackerel, rainbow runner, wahoo and mahi-mahi), invertebrates targeted for export, and invertebrates gleaned from intertidal and subtidal areas {Chapter 9, Section 9.2.1}. The total annual catch was estimated to be 35,700 tonnes in 2007, worth USD 62.5 million. The commercial catch was 5700 tonnes. Demersal fish and nearshore pelagic fish are both estimated to make up ~ 40% of the total catch.

Feature	Coastal fisheries category				Total	Total value (USD m)*
	Demersal fish	Nearshore pelagic fish[b]	Targeted invertebrates	Inter/subtidal invertebrates		
Catch (tonnes)*	14,520	13,760	1300	6120	35,700	62.5
Contribution (%)[a]	41	38	4	17	100	

* Estimated total catch and value in 2007 (Gillett 2009)[1]; a = method for calculating disaggregated catch data for each category is outlined in Chapter 9 {Appendix 9.2, Supplementary Table 9.1}; b = catch dominated by non-tuna species.

Existing coastal fish habitat

PNG has very significant areas of coral reefs {Chapter 5}, mangroves, deepwater and intertidal seagrasses, and intertidal sand and mud flats {Chapter 6} that support many important fisheries species.

Habitat	Coral reef[*,a]	Mangrove[b]	Seagrass[b]	Intertidal flat
Area (km^2)	22,200	4640	117	n/a

* Approximate estimate only; a = includes barrier, patch and fringing reefs and reef lagoons {Chapter 5, Table 5.1}; b = values from Chapter 6, Table 6.1; n/a = data not available.

Projected changes to coastal fish habitat

Climate change is expected to add to the existing local threats to coral reefs, mangroves, seagrasses and intertidal flats in PNG, resulting in declines in the quality and area of all habitats {Chapters 5 and 6}.

Habitat feature[a]	Projected change (%)		
	B1/A2 2035	B1 2100*	A2 2100
Coral cover[b]	-25 to -65	-50 to -75	> -90
Mangrove area	-10	-50	-60
Seagrass area	-5 to -20	-5 to -30	-10 to -35

* Approximates A2 in 2050; a = no estimates in reduction of intertidal flats available; b = assumes there is strong management of coral reefs.

Projected changes in coastal fisheries production

All components of coastal fisheries in PNG are projected to show progressive declines in productivity due to both the direct effects (e.g. increased SST) and indirect effects (changes to fish habitats) of climate change {Chapter 9, Section 9.5}.

Coastal fisheries category	Projected change (%)			Main effects
	B1/A2 2035	B1 2100*	A2 2100	
Demersal fish	-2 to -5	-20	-20 to -50	Habitat loss and reduced recruitment (due to increasing SST and reduced currents)
Nearshore pelagic fish[a]	0	-10	-15 to -20	Reduced production of zooplankton in food webs for non-tuna species and changes in distribution of tuna
Targeted invertebrates	-2 to -5	-10	-20	Habitat degradation, and declines in aragonite saturation due to ocean acidification
Inter/subtidal invertebrates	0	-5	-10	Declines in aragonite saturation due to ocean acidification

* Approximates A2 in 2050; a = tuna comprise a part of the nearshore pelagic fishery {Chapter 9, Tables 9.8 and 9.10}.

The overall projected change to coastal fisheries catch reflects the reliance on demersal fish and nearshore pelagic fish. As a result, total catches from coastal fisheries in PNG are projected to decrease slightly under both scenarios in 2035. However, catches are expected to decline by > 10% in 2100 under the B1 scenario and by > 20% under A2.

Coastal fisheries category	Contrib. (%)**	Projected change in productivity (P) and catch (%)					
		B1/A2 2035		B1 2100*		A2 2100	
		P***	Catch	P***	Catch	P***	Catch
Demersal fish	41	-3.5	-1	-20	-8	-35	-14
Nearshore pelagic fish	38	0	0	-10	-4	-17.5	-7
Targeted invertebrates	4	-3.5	-0.1	-10	-0.4	-20	-0.7
Inter/subtidal invertebrates	17	0	0	-5	-0.9	-10	-2
Total catch[a]			**-1.6**		**-13**		**-23**

* Approximates A2 in 2050; ** contribution of each component to total coastal fisheries catch in PNG; *** median projected change in productivity based on range in Chapter 9; a = assumes that proportion of each category remains constant.

Freshwater and estuarine fisheries

Recent catch and value

PNG has significant freshwater and estuarine fisheries {Chapter 10}. The main species caught are barramundi, river herring, Papuan black bass, fork-tailed catfish, saratoga, tilapia, carp, rainbow trout and *Macrobrachium*. These species are harvested by commercial, artisanal, subsistence and recreational fisheries {Chapter 10}. The estimated freshwater fish catch in 2007 was 17,500 tonnes, worth USD 16.6 million[1].

Existing freshwater and estuarine fish habitat

PNG is the largest continental land mass in the region. The larger rivers and lakes in PNG provide a great diversity of freshwater and estuarine fish habitats. The Fly River floodplain covers an area of > 40,000 km^2.

Largest river/Lake	Catchment area (km^2)	River length (km)
Sepik-Ramu	96,000	1126
Fly	76,000	1050
Purari	33,700	470
Murray	647[a]	-
Kutubu	50[a]	-

a = Actual surface area of lake.

Projected changes to freshwater and estuarine fish habitat

The projected increase in rainfall for PNG {Chapter 2, Section 2.5.2} is expected to result in increases in the area and quality of all freshwater fish habitats, particularly later in the century {Chapter 7, Table 7.5}. Sea-level rise is expected to increase the area of estuarine habitat {Chapter 7}.

Projected changes to freshwater and estuarine fish habitat area (%)		
B1/A2 2035	B1 2100*	A2 2100
-5 to +10	-5 to +20	-5 to +20

* Approximates A2 in 2050.

Projected changes in freshwater and estuarine fisheries production

Higher projected rainfall and river flows are expected to result in slightly improved fisheries production from freshwater and estuarine fisheries in PNG by 2035, and increases of up to 7.5% by 2100. River flow increases the availability and quality of habitats, provides cues for fish migration, and enhances reproduction and recruitment {Chapter 10, Section 10.5}.

Projected changes in freshwater and estuarine fish catch (%)		
B1/A2 2035	**B1 2100***	**A2 2100**
0 to +2.5	+7.5	+7.5

* Approximates A2 in 2050.

Aquaculture

Recent and potential production

Pond aquaculture of tilapia and carp is growing rapidly to produce fish for the large inland population of PNG. Recent estimates indicate that > 10,000 small ponds have been constructed. Coastal aquaculture commodities in PNG include shrimp, white pearls produced from the silver- or gold-lipped pearl oyster, seaweed and hatchery-based marine fish (mainly barramundi).

Existing and projected environmental features

Higher rainfall and air temperatures are expected to have positive effects on pond aquaculture and minimal effects on shrimp farming in PNG. However, increasing SST, rainfall and ocean acidification are eventually expected to reduce survival and growth of pearl oyster spat and larval marine fish {Chapter 11}. Production of seaweed is also expected to be affected adversely by higher temperatures and rainfall.

Environmental feature	1980–1999 average	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Air temperature (°C)	27.3[a]	+0.5 to +1.0	+0.5 to +1.0	+1.0 to +1.5	+2.5 to +3.0
Annual rainfall (mm)	1122[a]	+5 to +15%	+5 to +20%	+10 to +20%	+10 to +20%
Sea surface temperature (°C)	28.7	+0.6 to +0.8	+0.7 to +0.8	+1.2 to +1.6	+2.2 to +2.7
Ocean pH (units)	8.08	-0.1	-0.1	-0.2	-0.3

* Approximates A2 in 2050; a = data for Port Moresby.

Projected changes in aquaculture production

The projected effects of climate change on aquaculture in PNG are mixed. Pond aquaculture is expected to be enhanced by increased rainfall, river flows, and warmer temperatures, provided ponds are located where they will not be affected by floods

or storm surge. The commodities grown in coastal waters are likely to be affected adversely by increases in SST, rainfall and ocean acidification {Chapter 11, Table 11.5}. However, shrimp farms in PNG should be able to retain their potential to produce 2000 tonnes per year in the medium term.

Aquaculture commodity	Use	Projected change		
		B1/A2 2035	B1 2100*	A2 2100
Tilapia and carp	Food security	↑ ■ ■	↑ ■ ■	↑ ■ ■
Pearls	Livelihoods	↓ ■ ■	↓ ■ ■	↓ ■ ■
Seaweed	Livelihoods	↓ ■ ■	↓ ■ ■	↓ ■ ■
Shrimp	Livelihoods	↑ ■ ■	↓ ■ ■	↓ ■ ■
Marine fish	Livelihoods	↓ ■ ■	↓ ■ ■	↓ ■ ■

* Approximates A2 in 2050.

Low Medium High
Projected increase

Low Medium High
Projected decrease

Economic and social implications

Economic development and government revenue

Current contributions

The locally-based, industrial surface tuna fishery contributed 2.8% to the gross domestic product (GDP) of PNG in 2007 {Chapter 12}. The longline fishery contributed 0.03% to GDP. When the value of post-harvest processing of tuna in canneries is added to fishing operations, the contribution to GDP increases. Licence fees from foreign vessels (and national vessels) involved in the surface fishery contributed 0.6% to government revenue (GR) in 2007.

Industrial fishery	Contribution to GDP*		Contribution to GR**	
	USD m	GDP (%)	USD m	GR (%)
Surface[a]	161	2.8	15	0.6
Longline	2.7	0.03	0	0

* Information for 2007, when national GDP was USD 5708 million (Gillett 2009)[1]; ** information for 2007, when total GR was USD 2599 million; a = locally-based purse-seine and pole-and-line fleets.

Projected effects of climate change

The projected changes to the contributions to GDP and GR derived from the surface fishery due to the effects of climate change on the distribution and abundance of skipjack tuna are expected to be relatively minor because the PNG economy is large {Chapter 12, Table 12.9}.

Projected changes to GDP (%)**			Projected changes to GR (%)		
B1/A2 2035	B1 2100*	A2 2100	B1/A2 2035	B1 2100*	A2 2100
0 to +0.1	-0.2 to -0.4	-0.4 to -1.2	0	0 to -0.1	-0.1 to -0.2

* Approximates A2 in 2050; ** information for 2007, when total GDP was USD 5708 million and GR was USD 2559 million (Gillet 2009)[1].

Food security

PNG is among the group of PICTs (Group 3) where the estimated sustainable production of fish and invertebrates from coastal and freshwater habitats is unable to supply the national population with the amount of fish needed per person per year for good nutrition[i] {Chapter 12, Section 12.7.1}.

Current contributions of fish to food security

Average national fish consumption in PNG is estimated to be 13 kg per person per year[2], well below the recommended levels for good nutrition. This is primarily due to the fact that much of the large inland population of PNG does not have good access to fish. At present, coastal and freshwater habitats in PNG are estimated to be able to supply only 12 kg of fish per person per year.

Fish consumption per person (kg)			Fish provided by subsistence catch (%)	
National	Rural	Urban	Rural	Urban
13	10	28	64	n/a

n/a = Data not available.

Effects of population growth

PNG will have a rapidly increasing total demand for fish for food security due to the predicted growth of its population. The current estimated shortfall of fish below the recommended level is 23 kg per person per year. This shortfall is expected to increase to 27 kg per person per year in 2035, 29 kg in 2050 and 31 kg in 2100.

Variable	2010	2035	2050	2100
Population (x 1000)	6753	10,822	13,271	21,125
Fish available per person (kg/year)[a]	12	8	6	4
Gap (kg/person/year)[b]	23	27	29	31

a = Based on 3 tonnes of fish per km^2 of coral reef habitat {Chapter 9}; b = relative to recommended consumption of 35 kg per person per year.

Additional effects of climate change

Climate change is expected to cause only relatively minor additional declines in the fish available per person from coastal fisheries. For example, by 2100 under the

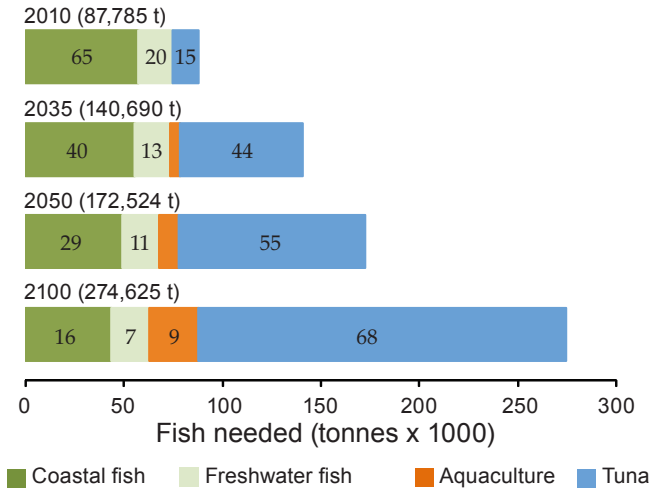
i For most Pacific Island countries and territories, this is based on 35 kg of fish per person per year contributing 50% of dietary protein as recommended by the SPC Public Health Programme, although it is acknowledged that this target is not practical for PNG due to poor access to fish by inland populations (SPC 2008)[25].

A2 emissions scenario, the direct and indirect effects of climate change on coastal fisheries are projected to cause the gap between the fish needed per person for good nutrition, and the fish available from coral reefs, to increase from 31 to 32 kg per person per year.

Filling the gap

Increased access to tuna, and development of small pond aquaculture and freshwater fisheries, all have potential to help supply the shortfall in fish from coastal habitats for food security in PNG. However, this gap will need to be filled mainly by tuna because freshwater fisheries and pond aquaculture are only expected to be able to provide relatively limited quantities of fish. The role of tuna becomes increasingly important in 2050 and 2100. Freshwater fisheries and pond aquaculture will make their greatest contributions in those inland areas where even access to canned tuna is difficult.

The implication is that an increasing proportion of the annual average tuna catch will need to be allocated over time to provide the quantities of fish recommended for good nutrition of PNG's population. The proportions of the total amount of fish needed for food security to be contributed by tuna reach 44% in 2035, 55% in 2050, and 68% in 2100.



Fish (in tonnes) needed for future food security in PNG, and the recommended contributions (%) of fisheries resources and aquaculture production to meet future needs.

These estimates are based on maintaining recent average consumption of 13 kg per person per year instead of the 35 kg per person per year recommended for other Pacific Island countries and territories.

Livelihoods

Current contributions

Large numbers of full-time and part-time jobs have been created through tuna fishing and processing in PNG, although they represent only a low percentage of total employment in the nation due to the large population. Coastal fisheries also provide important opportunities to earn income for coastal communities throughout the country – in representative coastal communities 86% of households are estimated to derive their first or second income from catching and selling fish. Aquaculture has created > 10,000 jobs[4].

Jobs on tuna vessels			Jobs in shore-based tuna processing			Coastal households earning income from fishing (%)			Jobs in aquaculture*
2002	2006	2008	2002	2006	2008	1st	2nd	Both	2007
460	110	440	2707	4000	8550	53	32	86	> 10,000

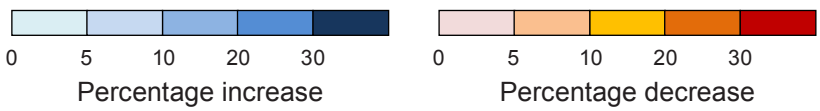
* Mainly represents potential opportunities to earn income from sale of fish produced in freshwater ponds; information derived from Chapter 12, Table 12.6 and the SPC PROCFish Project.

Projected effects of climate change

The effects of climate change on the potential to create more livelihoods based on fisheries and aquaculture are difficult to estimate because there is still scope to derive new jobs from oceanic fisheries, the nearshore component of coastal fisheries, freshwater fisheries, and pond and coastal aquaculture. The A2 emissions scenario is expected to eventually enhance or retard these opportunities as indicated below.

Year	Projected change under A2 scenario					
	Oceanic fisheries**	Coastal fisheries		Freshwater fisheries	Aquaculture	
		Nearshore pelagic fish	Other resources		Ponds	Coastal
Present*	⇧	⇧	⇩	⇧	⇧	⇧
2035	↑	No effect	↓	↑	↑	↓
2050	No effect	↓	↓	↑	↑	↓
2100	↓	↓	↓	↑	↑	↓

* Indicates general direction of new opportunities for livelihoods based on the activity; ** based on projected changes in skipjack tuna catches.



Adaptations and suggested policies

The plans PNG has to derive greater socio-economic benefits from fisheries and aquaculture will depend heavily on interventions to:

1. secure access to the tuna required for canneries and improve the efficiency of locally-based industrial fleets;
2. increase access to tuna to provide the fish needed for food security for both rural and urban communities, and
3. increase the number of livelihoods that can be based on fishing and processing tuna, the nearshore pelagic fish component of coastal fisheries, and aquaculture.

The adaptations and suggested policies to achieve these plans under a changing climate are summarised below (see Section 3 for details).

Economic development and government revenue

Adaptation no. (Section 3.2)	Summary of adaptation	Supporting policy no. (Section 3.3)
E1	Full implementation of sustainable fishing effort schemes	E1, E2, E4–E6
E2	Diversify sources of fish for canneries	E1–E5, E7
E3	Immediate conservation management measures for bigeye tuna	E7, E8
E4	Energy efficiency programmes for industrial tuna fleets	E9
E5	Environmentally-friendly fishing operations	
E6	Gender-sensitive fish processing operations	
E7	Safety at sea	E10
E8	Climate-proof infrastructure	E11
E9	Pan-Pacific tuna management	E2

Food security

Adaptation no. (Section 3.4)	Summary of adaptation	Supporting policy no. (Section 3.5)
F1	Manage and restore vegetation in catchments	F1, F2, F18
F2	Foster the care of coastal fish habitats	F1–F3, F18
F3	Provide for landward migration of coastal fish habitats	F4, F5, F18
F4	Allow for expansion of freshwater habitats	F4, F18
F5	Sustain production of coastal demersal fish and invertebrates	F6, F7, F13, F18
F6	Diversify catches of coastal demersal fish	F6, F13, F18
F7	Manage freshwater and estuarine fisheries to harness opportunities	
F8	Increase access to tuna for urban and rural populations	F8–F13, F18
F9	Develop pond aquaculture to diversify the supply of fish	F13–16, F18
F10	Develop coastal fisheries for small pelagic fish	F13, F17, F18
F11	Improve post-harvest methods	F17, F18

Sustainable livelihoods

Adaptation no. (Section 3.6)	Summary of adaptation	Supporting policy no. (Section 3.7)
L1	Improve technical and business skills of communities	L1, L2
L2	Rebuild populations of sea cucumbers and trochus	L2
L3	Develop coral reef ecotourism ventures	L3
L4	Diversify production of coastal aquaculture commodities	L4, L5
L5	Modify locations and infrastructure for coastal aquaculture	L6