SPC
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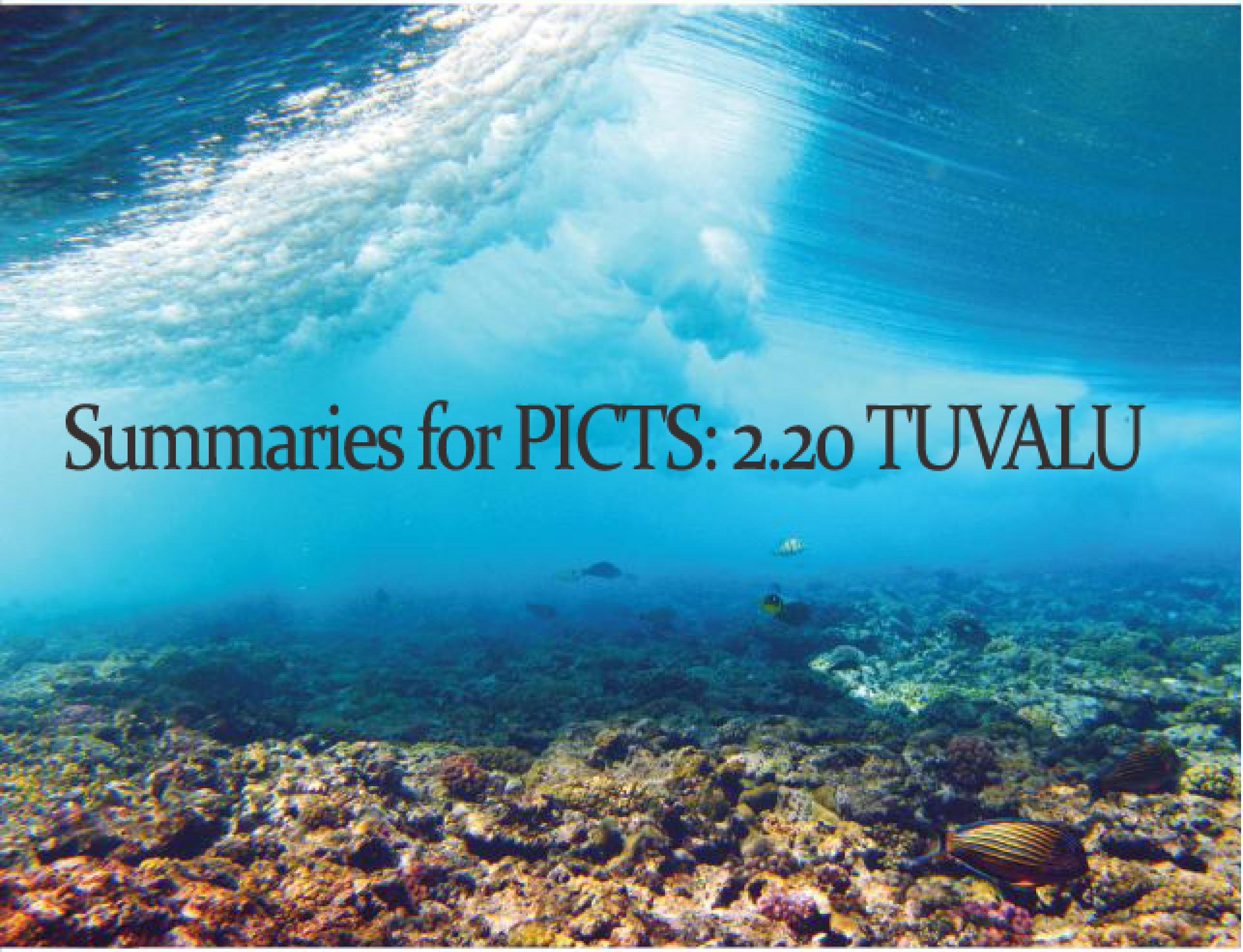
Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change

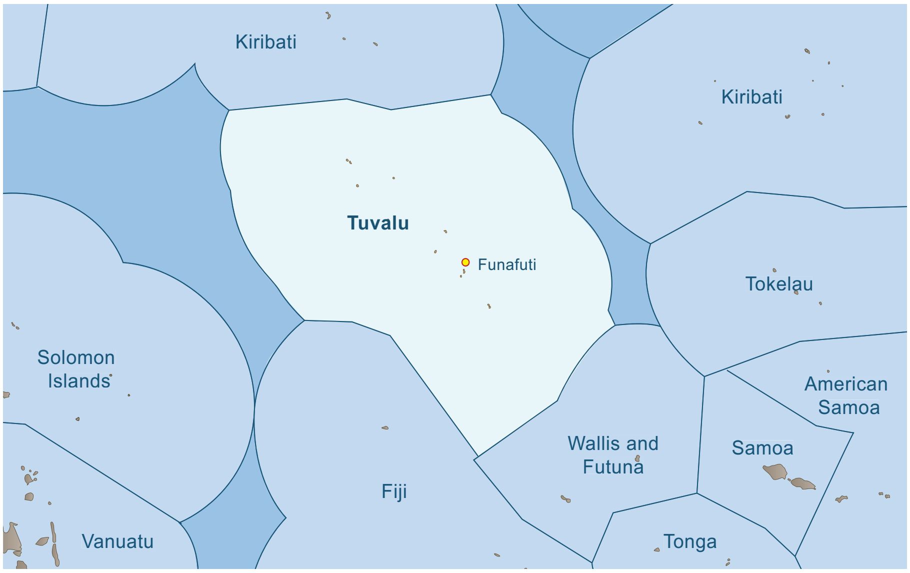


Summaries for PICTS: 2.20 TUVALU

Summary for Pacific Island Countries and Territories

2011

2.20 Tuvalu



Key features

Population

Year	2010	2035	2050	2100
Population (x 1000)[a]	11	13	14	19
Population growth rate[a]	0.5	0.6	0.6	0.8

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

EEZ area (km²) 719,174

Land area (km²) 26

Land as % of EEZ 0.004

Fisheries and aquaculture activities: Oceanic fisheries and coastal fisheries.

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.

Surface climate and the ocean

Existing features

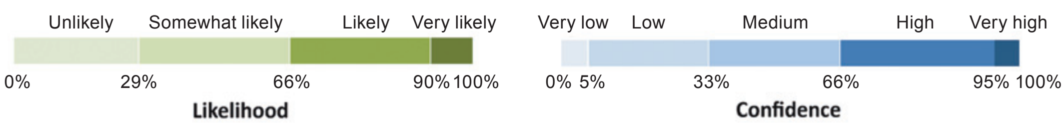
Tuvalu has a tropical climate {Chapter 2}. Recent air temperatures in Funafuti have averaged 28.2°C and average rainfall is > 3660 mm per year. Tuvalu lies within the Pacific Equatorial Divergence Province (PEQD) {Chapter 4, Figure 4.6}. The PEQD Province is generated by the effects of the earth's rotation on the South Equatorial Current, which results in significant upwelling of nutrients {Figure 4.3}. These conditions create the richest surface waters in the region.

Projected changes to surface climate

Air temperatures and rainfall in Tuvalu 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)	28.2 (Funafuti)	+0.5 to +1.0	+0.5 to +1.0	+1.0 to +1.5	+2.5 to +3.0
Rainfall (mm)	3666 (Funafuti)	+5 to +15%	+5 to +20%	+10 to +20%	+10 to +20%
		More extreme wet and dry periods			
Cyclones (no. per year)	0.8	➢ Total number of tropical cyclones may decrease ➢ Cyclones are likely to be more intense			

* Approximates A2 in 2050; a = for more detailed projections of rainfall, air temperature and cyclones in the vicinity of Tuvalu, 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 Tuvalu 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 and location of the PEQD Province, 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)	29.4[a]	+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			
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 = 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

Tuvalu has a very small local fishery for tuna within its exclusive economic zone (EEZ). Recent annual average catches (2004–2008) by this fishery were ~ 16 tonnes per year, worth > USD 36,000. Tuvalu also licenses foreign fleets to fish for tuna in its EEZ. These fleets made average annual catches in the surface fishery of 26,380 tonnes between 1999 and 2008, worth USD 22.6 million. See 'Coastal Fisheries' below for contributions of tuna to nearshore artisanal fisheries.

Local oceanic fisheries	Average annual catch (tonnes) 2004–2008	Average annual catch value (USD)* 2004–2008
Tuna		
Troll	16	36,656
Total	**16**	**36,656**

* Calculated using market value per tonne for 2004–2008.

Existing oceanic fish habitat

The PEQD Province is characterised by high-salinity, nutrient-rich waters, and an abundance of phytoplankton {Chapter 4, Figure 4.7}. However, primary production in PEQD is limited by low iron concentrations {Chapter 4, Figure 4.9}. The convergence of PEQD and the Western Pacific Warm Pool creates prime feeding areas for tuna {Chapters 4 and 8}. Changes in the position of this convergence zone due to the El Niño-Southern Oscillation have a major influence on the abundance of tuna in the EEZ of Tuvalu {Chapter 8}.

Projected changes to oceanic fish habitat

Under climate change, the surface area of the PEQD Province is projected to contract and the convergence zone with the Warm Pool is expected to move eastward. However, there are likely to be only minor changes in the key components of the food web for tuna (e.g. net primary production and zooplankton biomass) in PEQD {Chapter 4, Table 4.3}.

PEQD feature	Projected change (%)			
	B1 2035	A2 2035	B1 2100*	A2 2100
Surface area[a]	-20	-27	-30	-50
Location	Eastwards			
Net primary production	0	0	+2	+4
Zooplankton biomass	-2	-2	-3	-6

* 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 of Tuvalu are expected to increase significantly in 2035 and 2100, relative to the 20-year average (1980–2000). Catches of bigeye tuna are projected to increase slightly under both scenarios in 2035 and under B1 in 2100, and decrease under A2 in 2100 {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
+37	+41	+25	+3	+2	-6

* Approximates A2 in 2050.

Coastal fisheries

Recent catch and value

The coastal fisheries of Tuvalu are made up mainly of three components: demersal fish (bottom-dwelling fish associated with coral reef, mangrove and seagrass habitats), nearshore pelagic fish (including tuna, rainbow runner, wahoo and mahi-mahi), and invertebrates gleaned from intertidal and subtidal areas {Chapter 9, Section 9.2.1}. The total annual catch was estimated to be 1215 tonnes in 2007, worth > USD 2.8 million. The commercial catch was 226 tonnes. Demersal fish are estimated to make up ~ 70% 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)*	837	326	0	52	1215	2.8
Contribution (%)[a]	69	27	0	4	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 comprised equally of tuna and non-tuna species.

Existing coastal fish habitat

Tuvalu has > 3000 km^2 of coral reef to support coastal fisheries species, but only a very small area of mangrove habitat. There is little or no seagrass habitat in Tuvalu. The area of intertidal sand flats within lagoons has not been measured.

Habitat	Coral reef[a]	Mangrove[b]	Seagrass[b]	Intertidal flat
Area (km^2)	3175	0.4	0	n/a

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, and intertidal flats in Tuvalu, 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[c]	-10	-30	-60

* Approximates A2 in 2050; a = no estimates in reduction of intertidal flats available; b = assumes there is strong management of coral reefs; c = indicative estimates from Samoa {Chapter 6}.

Projected changes in coastal fisheries production

Fisheries for demersal fish and intertidal and subtidal invertebrates in Tuvalu 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}. On the other hand, the nearshore pelagic fishery component of coastal fisheries is projected to increase in productivity due to the redistribution of tuna to the east {Chapter 8}.

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]	+15 to +20	+20	+10	Changes in distribution of tuna
Inter/subtidal invertebrates	0	-5	-10	Declines in aragonite saturation due to ocean acidification

* Approximates A2 in 2050; a = tuna comprise ~ 50% of the nearshore pelagic fishery {Chapter 9, Tables 9.8 and 9.10}.

The overall projected change to coastal fisheries catch reflects the strong reliance on demersal fish balanced somewhat by the projected increase in productivity of nearshore pelagic fish. As a result, total catches from coastal fisheries in Tuvalu are projected to increase slightly under both scenarios in 2035 but decline under both scenarios in 2100, particularly under A2 in 2100.

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	69	-3.5	-2	-20	-14	-35	-24
Nearshore pelagic fish	27	+17.5	+5	+20	+5	+10	+3
Inter/subtidal invertebrates	4	0	0	-5	-0.2	-10	-0.4
Total catch[a]			**+2**		**-9**		**-22**

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

Freshwater and estuarine fisheries

Tuvalu has no freshwater or estuarine fisheries.

Aquaculture

Trials to assess the potential for farming milkfish are underway in Tuvalu.

Existing and projected environmental features

The projected increases in air temperature and rainfall are expected to enhance the conditions for growing milkfish in Tuvalu.

Environmental feature	1980–1999 average[a]	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Air temperature (°C)	28.2	+0.5 to +1.0	+0.5 to +1.0	+1.0 to +1.5	+2.5 to +3.0
Annual rainfall (mm)	3666	+5 to +15%	+5 to +20%	+10 to +20%	+10 to +20%

* Approximates A2 in 2050; a = data for Funafuti.

Projected changes in aquaculture production

Enterprises farming milkfish in Tuvalu are expected to be favoured by higher air temperatures and increased rainfall {Chapter 11}.

Aquaculture commodity	Use	Projected change		
		B1/A2 2035	B1 2100*	A2 2100
Tilapia	Food security			

* Approximates A2 in 2050.

Economic and social implications

Economic development and government revenue

Current contributions

Licence fees from foreign vessels involved in the surface fishery have recently contributed 11% to government revenue (GR). The small locally-based tuna fishery does not contribute to the gross domestic product of Tuvalu {Chapter 12}.

Industrial fishery	Contribution to GR*	
	USD m	GR (%)
Surface	3.4	11

* Information for 2007, when total GR was USD 31 million.

Projected effects of climate change

The preliminary modelling of the projected effects of climate change on the distribution and abundance of skipjack tuna indicate that there could be significant increases in the contributions of licence fees from foreign fishing vessels to government revenue {Chapter 12}. For example contributions in 2035 are projected to increase by 4–9%, i.e. from ~ 11% to 15–20%.

Projected changes to GR (%)		
B1/A2 2035	B1 2100*	A2 2100
+4 to +9	+4 to +10	+2 to +6

* Approximates A2 in 2050.

Food security

Tuvalu is among the group of PICTs (Group 2) where the estimated sustainable production of fish and invertebrates from coastal habitats has the potential to supply the national population with the 35 kg of fish per person per year recommended for good nutrition[i]. However, it may be difficult to distribute the catch due to the distances between fishing areas and population centres {Chapter 12, Section 12.7.1}.

Current contributions of fish to food security

Average national fish consumption in Tuvalu is estimated to be 110 kg per person per year, well above the recommended levels for good nutrition[2]. In rural areas most of this fish comes from subsistence fishing and fish provides > 75% of dietary animal protein. At present, coral reefs in Tuvalu are estimated to have the potential to supply > 850 kg of fish per person per year.

i Based on fish contributing 50% of dietary protein as recommended by the SPC Public Health Programme (SPC 2008)[25].

Fish consumption per person (kg)			Animal protein from fish (%)		Fish provided by subsistence catch (%)	
National	Rural	Urban	Rural	Urban	Rural	Urban
110	147	69	77	41	86	56

Effects of population growth

Assuming that the catch can be distributed effectively, coral reefs in Tuvalu are presently estimated to supply a surplus of > 800 kg of fish per person per year above the basic recommended level of 35 kg. The predicated population growth in Tuvalu will increase the total demand for fish for food security. However, coastal fisheries are expected to easily meet the demand for the traditionally high levels of fish consumption for the remainder of the century, provided the potential catch can be distributed effectively.

Variable	2010	2035	2050	2100
Population (x 1000)	11	13	14	19
Fish available per person (kg/year)[a]	858	744	700	514
Surplus (kg/person/year)[b]	823	709	665	479

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

The large area of coral reefs relative to future population size in Tuvalu is still expected to supply the fish needed for the traditionally high levels of consumption, even if production of demersal fish declines by up to 50% under the A2 emissions scenario by 2100 {Chapter 12}.

Livelihoods

Current contributions

Full-time and part-time jobs have been created through tuna fishing and processing in Tuvalu. Coastal fisheries also provide important opportunities to earn income for coastal communities, with almost 50% of households in representative coastal areas deriving their first or second income from catching and selling fish.

Jobs on tuna vessels			Jobs in shore-based tuna processing			Coastal households earning income from fishing (%)		
2002	2006	2008	2002	2006	2008	1st	2nd	Both
59	20	65	36	10	10	24	24	48

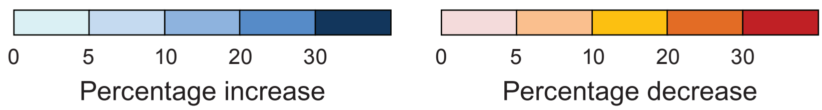
Information derived from Chapter 12, Table 12.6 and the SPC PROCFish Project.

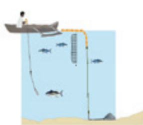
Projected effects of climate change

The effects of climate change on the potential to create more livelihoods based on fisheries are difficult to estimate because there is still scope to derive new jobs from oceanic and coastal fisheries. However, 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	
		Nearshore pelagic fish	Other resources
Present*	⇧	⇧	⇩
2035	↑	↑	↓
2050	↑	↑	↓
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 Tuvalu has to derive greater socio-economic benefits from fisheries and aquaculture will depend heavily on interventions to:

1. maximise access to tuna for economic development;
2. manage coastal fish habitats and fish stocks to ensure that they continue to supply fish for food security; and
3. increase the number of livelihoods that can be based on fishing and tourism.

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
E3	Immediate conservation management measures for bigeye tuna	E8
E7	Safety at sea	E10
E9	Pan-Pacific tuna management	E2

Food security

Adaptation no. (Section 3.4)	Summary of adaptation	Supporting policy no. (Section 3.5)
F2	Foster the care of coastal fish habitats	F1–F3, F18
F5	Sustain production of coastal demersal fish and invertebrates	F6, F7, F13, F18
F6	Diversify catches of coastal demersal fish	F6, F13, F18
F8	Increase access to tuna for urban and rural populations	F8–F13, 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