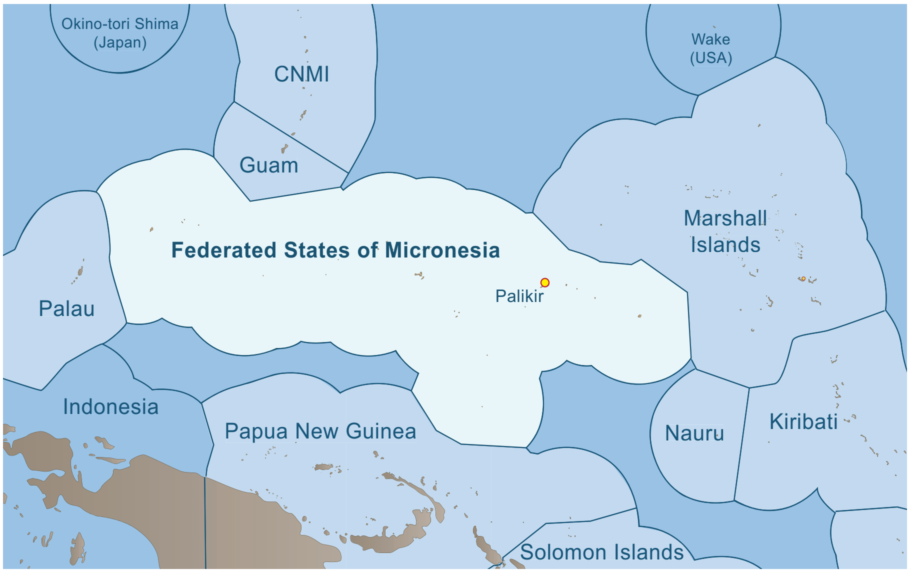
2.3 Federated States of Micronesia



Key features

Population

Year	2010	2035	2050	2100
Population (x 1000)[a]	102	105	109	109
Population growth rate[a]	-0.4	0.4	0.1	0

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

EEZ area (km²) 2,939,300

Land area (km²) 700

Land as % of EEZ 0.024

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

Membership of regional fisheries management arrangements: Forum Fisheries Agency; Western and Central Pacific Fisheries Commission; Parties to the Nauru Agreement.

Surface climate and the ocean

Existing features

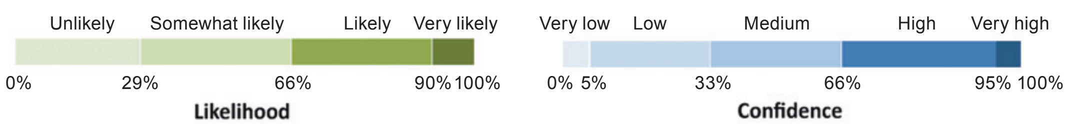
Federated States of Micronesia (FSM) has a tropical climate {Chapter 2}. Recent air temperatures in Pohnpei have averaged 27.3°C and average rainfall is ~ 4600 mm per year. FSM lies mainly within the Western Pacific Warm Pool Province (Warm Pool) {Chapter 4, Figure 4.6}. The primary influence on surface climate in the Warm Pool is the El Niño-Southern Oscillation (ENSO), which also affects the surrounding ocean. Under normal conditions the net primary production (NPP) in this part of the ocean is low due to the deep thermocline. However, NPP increases during El-Niño episodes because the thermocline becomes shallower.

Projected changes to surface climate

Air temperatures and rainfall in FSM 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 (Pohnpei)	+0.5 to +1.0	+0.5 to +1.0	+1.0 to +1.5	+2.5 to +3.0
Rainfall (mm)	4588 (Pohnpei)	+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 FSM, 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 FSM 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 (increases in the North Pacific gyre) and reductions in nutrient supply 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)	29.1[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 North Pacific gyre	Continued increase in strength of North Pacific gyre			
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.

Oceanic fisheries

Recent catch and value

The local industrial surface fishery for tuna operates inside and outside the exclusive economic zone (EEZ) of FSM. Average annual catches by this fishery are 19,500 tonnes per year, worth > USD 23 million. The locally-based longline fishery catches > 900 tonnes of tuna per year, worth ~ USD 5 million. FSM also licenses foreign purse-seine vessels to fish for tuna within its EEZ. Between 1999 and 2008, these foreign vessels made an average total annual catch of > 152,000 tonnes, worth USD 126 million. Foreign longline fleets also landed average catches of > 5500 tonnes, worth USD 26 million. Significant quantities of tuna are also landed in FSM for transhipping to canneries in Asia {Chapter 12}. See 'Coastal Fisheries' below for contributions of tuna to nearshore small-scale commercial fisheries.

Local oceanic fisheries	Average annual catch (tonnes) 2004–2008	Average annual catch value (USD million)* 2004–2008
Tuna		
Purse-seine	19,544	23.1
Longline	938	4.9
Other oceanic fish[a]	136	0.1
Total	**20,618**	**28.1**

* 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, although 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 between the Warm Pool and the Pacific Equatorial Divergence (PEQD) provinces creates prime feeding areas for tuna {Chapters 4 and 8}. The westward contraction of the Warm Pool during La Niña episodes increases the abundance of tuna near the EEZ of FSM.

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 FSM. Relocation of the convergence zone between the Warm Pool and PEQD to the east is also expected to increase the distance between FSM's EEZ 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 of FSM are expected to increase by 14% in 2035, relative to the 20-year average (1980–2000). However, by 2100 under the B1 scenario (A2 in 2050), the increase in skipjack tuna catch is only likely to be small, and is expected to decrease considerably under A2 in 2100. Catches of bigeye tuna are projected to decrease under both scenarios in 2035 and 2100 {Chapter 8, Section 8.7}. Modelling for yellowfin tuna is now in progress. The trends for yellowfin tuna are expected to be similar to those for skipjack tuna.

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
+14	+5	-16	-3	-11	-32

* Approximates A2 in 2050.

Coastal fisheries

Recent catch and value

The coastal fisheries of FSM are made up of four categories: demersal fish (bottom-dwelling fish associated with coral reef, mangrove and seagrass habitats), nearshore pelagic fish (including tuna, 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 12,600 tonnes in 2007, worth > USD 23.0 million. The commercial catch was 2800 tonnes. Demersal fish are estimated to make up 50% 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)*	6290	3560	30	2720	12,600	23.3
Contribution (%)[a]	50	28	< 1	22	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 currently comprised equally of tuna and non-tuna species.

Existing coastal fish habitat

FSM has very significant areas (> 15,000 km^2) of coral reef, as well as mangroves and seagrasses that support many coastal fisheries species {Chapters 5 and 6}. The areas of intertidal sand and mud flats have not been measured.

Habitat	Coral reef[a]	Mangrove[b]	Seagrass[b]	Intertidal flat
Area (km^2)	15,074	86	44	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, seagrasses and intertidal flats in FSM, 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 -10	-5 to -25	-10 to -30

* 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 FSM 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 contribute to the nearshore pelagic fishery {Chapter 9, Tables 9.8 and 9.10}.

The overall projected change to coastal fisheries catch reflects the expected decrease in the productivity of all coastal fisheries categories. As a result, total catches from coastal fisheries in FSM are projected to decrease slightly under both scenarios in 2035, and to decline substantially under both scenarios 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	50	-3.5	-2	-20	-10	-35	-17.5
Nearshore pelagic fish	28	0	0	-10	-3	-17.5	-5
Targeted invertebrates	< 1	-3.5	-0.007	-10	-0.2	-20	-0.4
Inter/subtidal invertebrates	22	0	0	-5	-1	-10	-2
Total catch[a]			**-2**		**-14**		**-25**

* Approximates A2 in 2050; ** contribution of each component to total coastal fisheries catch in FSM; *** 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

The main freshwater and estuarine species caught in FSM are eels, tilapia and *Macrobrachium*. These species are mostly taken by subsistence fishing from rivers and lakes. The estimated annual freshwater fish catch in 2007 was 1 tonne, worth USD 8000 {Chapter 10}.

Existing freshwater and estuarine fish habitat

The largest river in FSM, Nanpil Kiepw, is only 10 km in length and has a limited range of freshwater and estuarine fish habitats {Chapter 7, Table 7.1}.

Island	Largest river	Catchment area (km^2)	River length (km)
Pohnpei	Nanpil Kiepw	7.8	10

Projected changes to freshwater and estuarine fish habitat

The projected increase in rainfall for FSM {Chapter 2, Section 2.5.2} is expected to result in increases in the area and quality of freshwater fish habitats {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 +5	-5 to +10	-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 production from freshwater and estuarine fisheries in FSM. 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	0	+7.5

* Approximates A2 in 2050.

Aquaculture

Recent and potential production

The main aquaculture commodities in FSM are produced for livelihoods from coastal waters. These commodities include black pearls and marine ornamentals, such as cultured coral and giant clams. Hatchery production of sea cucumbers (sandfish) is also underway in FSM.

Existing and projected environmental features

Increasing SST, rainfall and ocean acidification are expected to reduce the suitability of coastal waters for culturing pearls, ornamental products and sea cucumbers {Chapter 11}.

Environmental feature	1980–1999 average	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Annual rainfall (mm)	4588[a]	+5 to +15%	+5 to +20%	+10 to +20%	+10 to +20%
Sea surface temperature (°C)	29.1	+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 Pohnpei.

Projected changes in aquaculture production

The coastal aquaculture commodities produced in FSM are likely to be affected adversely by climate change {Chapter 11, Table 11.5}.

Aquaculture commodity	Use	Projected change		
		B1/A2 2035	B1 2100*	A2 2100
Pearls	Livelihoods			
Marine ornamentals	Livelihoods			
Sea cucumbers	Livelihoods			

* Approximates A2 in 2050.

Low Medium High

Projected decrease

Economic and social implications

Economic development and government revenue

Current contributions

The local surface tuna fishery contributed 3.3% to the GDP of FSM in 2007, and the longline fishery provided a further 0.7% of GDP {Chapter 12}. Licence fees from foreign (and national) vessels involved in the surface fishery contributed > 10% to government revenue (GR), and fees from longline fleets contributed a further 1.3% of GR.

Industrial fishery	Contribution to GDP*		Contribution to GR**	
	USD m	GDP (%)	USD m	GR (%)
Surface	7.8	3.3[a]	14.8	10.2[b]
Longline	1.7	0.7	2.2	1.3

* Information for 2007, when national GDP was USD 237 million (Gillett 2009)[1]; ** information for 2007, when total GR was USD 145 million; a = locally-based purse-seine fleets; b = includes fees from both foreign and domestic fleets.

Projected effects of climate change

The projected changes to GDP due to the effects of climate change on the distribution and abundance of skipjack tuna {Chapter 8, Table 8.4} could increase contributions from the catches of this species to GDP from ~ 3% to ~ 4% in 2035 and reduce these contributions to 2% in 2100 {Chapter 12}. The projected changes to government revenue could increase from 10% to up to 12% in 2035, but fall to 8% by 2100 under the A2 scenario.

Projected changes to GDP (%)			Projected changes to GR (%)		
B1/A2 2035	B1 2100*	A2 2100	B1/A2 2035	B1 2100*	A2 2100
0 to +1	0	0 to -1	+1 to +2	0 to +1	-1 to -2

* Approximates A2 in 2050.

Food security

FSM 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 FSM is estimated to be 69 kg per person per year, significantly above the 35 kg per person per year recommended for good nutrition {Chapter 12}. The majority of this fish is provided by subsistence fishing.

Fish consumption per person (kg)			Animal protein from fish (%)		Fish provided by subsistence catch (%)	
National	Rural	Urban	Rural	Urban	Rural	Urban
69	77	67	80	83	77	73

Effects of population growth

The population in FSM is projected to remain relatively stable over this century and coastal fisheries are expected to easily supply the fish needed for food security. Large surpluses of fish are expected to continue to be available in 2035, 2050 and 2100.

Variable	2010	2035	2050	2100
Population (x 1000)	102	105	109	109
Fish available per person (kg/year)[a]	442	429	414	414
Surplus (kg/person/year)[b]	407	394	379	379

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 effects of climate change on coastal fisheries are likely to cause only minor reductions in the significant surplus of fish available for food. Even with the projected decreases in production of demersal fish of up to 50% by 2100 under the A2 emissions scenario, the large area of coral reef relative to population size will continue to supply sufficient coastal fish for food security {Chapter 12, Table 12.12}. Projected increases in tuna catch by the nearshore fishery are expected to further increase access to fish until 2050 under the A2 emissions scenario.

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

Livelihoods

Current contributions

Full-time and part-time jobs have been created through tuna fishing and processing in FSM, although they represent only a low percentage of total employment in the nation. Coastal fisheries also provide important opportunities to earn income for coastal communities throughout the country, with > 50% of households in representative coastal communities deriving their first or second incomes by catching and selling fish. Relatively few people are employed in aquaculture[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
89	36	25	131	24	140	48	5	52	20

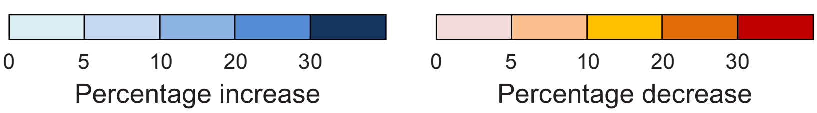
* Ponia (2010)[4]; information derived from Chapter 12, Table 12.6 and the SPC PROCFish Project.

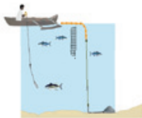
Projected effects of climate change

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 and the nearshore component of coastal fisheries. However, the A2 emissions scenario is expected to eventually enhance or retard these opportunities as indicated below.

Year	Projected change			
	Oceanic fisheries**	Coastal fisheries		Aquaculture (coastal)
		Nearshore pelagic fish	Other resources	
Present*	↑	↑	↓	↑
2035	↑	No effect	↓	↓
2050	↑	↓	↓	↓
2100	↓	↓	↓	↓

* Indicates general direction of new opportunities for livelihoods based on the activity; ** based on projected changes in skipjack tuna catches; freshwater and estuarine fisheries not included due to their mainly subsistence role.





Adaptations and suggested policies

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

1. maximise access to tuna, and the efficiency of local industrial fishing operations, to increase the contributions from oceanic fisheries resources to economic development and government revenue;
2. manage coastal fish habitats and fish stocks to maintain the good supply of fish for food security; and
3. increase the number of livelihoods that can be sustained by fishing, tourism and coastal 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

<table>
<tr><th>Adaptation no. (Section 3.2)</th><th>Summary of adaptation</th><th>Supporting policy no. (Section 3.3)</th></tr>
<tr><td>E1</td><td>Full implementation of sustainable fishing effort schemes</td><td>E1, E2, E4–E6</td></tr>
<tr><td>E3</td><td>Immediate conservation management measures for bigeye tuna</td><td>E8</td></tr>
<tr><td>E4</td><td>Energy efficiency programmes for industrial tuna fleets</td><td rowspan="2">E9</td></tr>
<tr><td>E5</td><td>Environmentally-friendly fishing operations</td></tr>
<tr><td>E7</td><td>Safety at sea</td><td>E10</td></tr>
<tr><td>E8</td><td>Climate-proof infrastructure</td><td>E11</td></tr>
<tr><td>E9</td><td>Pan-Pacific tuna management</td><td>E2</td></tr>
</table>

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
F8	Increase access to tuna for urban and rural populations	F8–F13, 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