PACIFIC FISHERIES

5.0 FISHERIES IN THE PACIFIC

Fish and fishing are culturally and economically critical for most PICTs and are a mainstay of food security in the region. The importance of the fisheries sector to the region's economy and food security is reflected by its reference in key regional strategies including *The Pacific Plan* and the *Vava'u Declaration on Pacific Fisheries Resources.* (See TOOLS 51 & 52.)

In the Pacific, a great variety of marine organisms are consumed. In Fiji, for example, over 100 species of finfish and 50 species of invertebrates are officially included in the fish market statistics, and many more species are believed to contribute to the diets of people in rural and urban areas of the Pacific. Fish[5] contributes substantially to subsistence and market-based economies and, for some of the smaller PICTs, fishing is their most important renewable resource.

Despite growing reliance on imported food products, subsistence fishing still provides the majority of dietary animal protein in the region, and annual per capita consumption of fish ranges from an estimated 13 kg in Papua New Guinea to more than 110 kg in Tuvalu (Table 5.1). According to forecasts of the fish that will be required in 2030 to meet recommended per capita fish consumption in PICTs (34-37 kg/year), or to maintain current consumption levels, coastal fisheries will be able to meet 2030 demand in only 6 of 22 PICTs. Supply is likely to be either marginal or insufficient in the remaining 16 countries, which include the region's most populous nations of Papua New Guinea, Fiji, Solomon Islands, Samoa and Vanuatu, as shown in Table 5.1. (See TOOL 50.)

Although parameters such as population growth and urbanization have been factored into these forecasts, the impacts of climate change are less well understood and introduce considerable uncertainty in the longer term. In essence, climate change represents a serious and multi-faceted risk to PICT fisheries that is likely to undermine the ongoing sustainability and management of the region's marine resources.

5 Fish is used here to represent both bony fishes and invertebrates.

Table 5.1: **Estimated per capita current fish consumption (see bracketed figures where available, kg/year) and projected capacity of national coastal fisheries resources to fish demand in 2030**

SUSTAINABLE PRODUCTION EXPECTED TO MEET FUTURE NEEDS	SUSTAINABLE PRODUCTION NOT EXPECTED TO MEET FUTURE NEEDS	SUSTAINABLE PRODUCTION ADEQUATE BUT DISTRIBUTION DIFFICULT
Cook Islands (34.9) Marshall Islands New Caledonia (25.6) Palau (33.4) Pitcairn Islands Tokelau	American Samoa Marianas Islands Fiji (20.7) Guam Nauru (55.8) Niue (79.3) PNG (13) Samoa (87.4) Solomon Islands (33) Vanuatu (20.3) Wallis & Fortuna (74.6)	FSM (69.3) French Polynesia (70.3) Kiribati (62.2) Tonga (20.3) Tuvalu (110.7)

Adapted from and Bell *et al.*, 2009 and SPC Policy Brief 1/2008. (See TOOLS 50 & 53.)

This module seeks to provide a simple overview of Pacific fisheries and the likely impacts of climate change, and then sets out some steps that PICT governments, planners and fishing sector stakeholders should consider to address the effects of climate change on the region's fisheries. Importantly, it also directs the reader to further tools available to help formulate climate change policies and adaptation measures.

5.0.1 Traditional coastal fisheries

The majority of fish consumed in the Pacific originates from coastal fisheries, which support a large variety of fish, shellfish, crustaceans and seaweeds that form an integral part of the diet of Pacific people. Apart from areas of mainland Papua New Guinea, virtually all Pacific Islanders live within the coastal zone and rely heavily on the coastal fisheries to supply fish for food. Despite the spread of modern fishing techniques, much of the inshore fishing in the region is still conducted by non-motorized small canoes or by wading and fishing in shallow inshore waters and lagoons. As well as being a source of food, fishing provides important income for many Pacific Island communities.

Fishing in coastal waters involves a wide range of techniques explained below.

Reef gleaning: The collection of marine animals and seaweeds at low tides from reefs and lagoons is an important source of food and livelihood, and a practice commonly undertaken by women and children. Species include sea cucumbers, sea urchins, crabs, shellfish, eels, seaweeds, octopus and finfish. The impact of reef gleaning can be substantial, particularly in highly populated coastlines.

Hooks, lures and lines: Fishing using hooks and lines is practiced throughout the region and range from simple hand-held lines to more elaborate long lines which aim to catch pelagic fish such as tuna and sharks. Lures towed behind boats are also used to catch pelagic species such as mackerel, dolphin-fish and tuna.

Spears: The use of spears is a traditional practice that has been modified in recent years with the advent of underwater flashlights. Species of reef fish that shelter near corals at night have become much easier targets for well-equipped fisherman kitted with modern masks, fins and spear guns.

Nets: There is a wide variety of nets used to catch coastal fish in the Pacific region including monofilament gill and barrier nets, beach seine nets, casting nets and scoop nets to name a few. Given their relatively low price, ease of use and high efficiency, the use of monofilament gill and barrier nets has proliferated in the Pacific. They are now widely used to target a range of fish species including mullet, shark, tuna and mackerel.

Traps: Barrier or fence trapping is one of the oldest forms of communal fishing and is still used commonly throughout the region to catch a variety of finfish.

(See TOOL 54 for further information on coastal fishing techniques)

5.0.2 Commercial fisheries

Offshore fisheries are one of the most important economic bases of many PICTs (see Table 5.2). Tuna, in particular, is a substantial component of both small-scale artisanal and large-scale commercial fisheries. Tuna fishing and transshipment, and access fees for foreign fishing activities represent an extremely valuable source of foreign exchange, especially for American Samoa, Kiribati, Fiji, Guam, the Northern Mariana Islands, the Marshall Islands, and the Federated States of Micronesia. Major fishing operations are also based in the exclusive economic zones (EEZs) of Papua New Guinea, Solomon Islands and Vanuatu.

Large-scale commercial fishing for tuna in the region is typically carried out by foreign fishing fleets originating from China, Indonesia, Japan, Korea, Philippines, Taiwan and USA. Many of these countries use highly effective modern fishing techniques that combine aerial and even satellite technology to find schools of skipjack and yellowfin tuna near the surface. The primary capture method used in the surface fishery is purse-seining, although some pole and line fishing still occurs. Long-lining is used to catch larger yellowfin tuna, bigeye tuna and albacore from deeper water.

Table 5.2: **Estimated combined fish, crustaceans and mollusc capture in FAO Member States in the Pacific region**

PACIFIC COUNTRY	FISH CAPTURE [tonnes/year]
Cook Islands	3 773
FSM	11 630
Fiji	46 891
Kiribati	31 000
Marshalls	42 019
Nauru	39
Niue	203
Palau	967
PNG	274 680
Samoa	3 340
Solomons	39 336
Tonga	2 500
Tuvalu	2 200
Vanuatu	88 075

Source: FAO, 2006

Currently, PICTs do not export a great deal of fishery products derived from their coastal fisheries. However, the export of sea cucumbers (known as *bêche-de-mer* in Melanesia and *trepang* in Micronesia), grouper, giant clam, green snail and other fish species have been important to some economies from time to time. In countries such as Fiji and PNG, there is also a growing trade in shells, corals and ornamental aquarium fish. Most small-scale, export-orientated coastal fishing is carried out by Pacific Islanders who sell their catches to foreign exporters. (See TOOLS 49 to 60.)

5.0.3 Freshwater fisheries

There is a lack of accurate information on the extent and value of freshwater fisheries in the Pacific. While freshwater fisheries do not exist in many smaller PICTs and low-lying atoll countries, they are thought to be contributing significantly to fisheries catches and food security in larger PICTs. In PNG for example, freshwater fish and invertebrate species are thought to provide much of the animal protein in inland areas. The importance of freshwater resources is demonstrated in PNG's Sepik River catchment, where more than 350 000 people live and catch up to 15 different species of freshwater fish for food. A range of local and introduced freshwater species, such as tilapia, eels Macrobrachium, prawns and mussels, are also harvested from lakes and rivers elsewhere in the region.

The freshwater fisheries of PNG are based on a broad range of river channel and floodplain habitats, fed by some of the highest levels of rainfall on Earth. Projected increases of rainfall in the tropics are expected to increase the extent and duration of flooding in PNG. Understanding is fairly limited of how increased flooding, turbidity and higher water temperatures will impact fish themselves and the lowland areas and rivers that support them. It is known, however, that freshwater fisheries throughout the region are based largely on species that migrate between the sea and freshwater. Accordingly, even small rises in sea level, temperature, rainfall and runoff may have impacts on habitats and fisheries in both estuarine and freshwater reaches of river systems. (See TOOL 49.)

5.0.4 Aquaculture in the Pacific

Aquaculture is the world's fastest growing food production system, growing at 7 percent annually. While aquaculture production in the Pacific region is relatively limited, it is considered to have great potential in many PICTs. (See TOOLS 61-65.) Historically the main producers have been New Caledonia, French Polynesia, Kiribati and the Cook Islands. However, highly populated inland areas of PNG probably hold the most potential. The principal types of aquaculture are explained below.

Open systems: Farmed species – such as pearl oysters, giant clams and seaweed – grow on lines or in nets or cages situated in coastal waters. These systems allow free exchange of nutrients, waste products, diseases, parasites and reproductive products between the farmed species and the coastal ecosystem.

Pond culture: Small-pond aquaculture is used in some countries, particularly within Melanesia, for the farming of milkfish and tilapia, and is considered to have considerable potential for expansion in the future. Although some larger, commercial ponds do exist within French Polynesia and Melanesia, they are almost exclusively targeted at shrimp production. The vast majority of pond culture operations in the Pacific region are relatively low-tech and focus on subsistence food production and livelihoods. These small-pond operations usually pose relatively little risk to surrounding ecosystems, but effluent waters and overspill can enter coastal waters, aquifers and adjacent streams, especially during flood events. Nutrient-rich effluent waters can pollute marine and freshwater resources, and introduce pathogens to wild fish populations.

In terms of food security, tilapia is arguably the easiest species to produce in small ponds and is the introduced freshwater fish species with the broadest appeal in the Pacific. (See TOOL 64.) Provided systems can be developed to distribute fingerlings effectively to remote areas, and suitable feeds based on local ingredients can be formulated, small-pond aquaculture has potential to contribute much needed animal protein to inland PNG and on high islands elsewhere in the region. (See TOOLS 61-65.)

5.0.5 Nutrition

Fish is an excellent source of protein and is naturally low in saturated fat and cholesterol. It contains essential dietary vitamins and minerals such as selenium, iodine and calcium. Oily fishes also have high levels of vitamins A and D and are rich in essential omega-3 fatty acids, which are important for growth and development. Omega-3 fatty acids found in fish are believed to have positive effects on the heart and blood vessels, and promote healthy vision and brain development in infants. These healthy fats have been linked to decreasing the risk of delivering a premature, low birthweight baby, and some studies even claim that omega-3 fatty acids may help protect against a range of other diseases including diabetes, cancer, Alzheimer's, depression and other mental disorders.

In addition to the many benefits of vitamins, minerals and omega-3 fatty acids, it is the role that fish plays as a source of dietary animal protein that makes it so important to PICTs. The World Health Organization (WHO) recommends that daily protein intake for good nutrition should be about 0.7 g of protein per kg body weight per day, derived from a variety of sources. In PICTs, where there is a strong tradition of eating fish and a limited range of crops and sources of animal protein, many PICTs will need to consume an average of 34–37 kg per person to meet 50 percent of the recommended protein intake for PICTs. (See TOOL 50)

5.1 THE IMPACTS OF CLIMATE CHANGE ON FISHERIES

While our understanding of how climate change will impact marine environments and fisheries is increasing, there remains an unacceptably high number of gaps in our knowledge given the huge role the world's oceans play in supplying food and maintaining ecosystem services to the planet. Ocean currents circulate massive volumes of cold and warm waters around the planet. The distribution of these waters and the nutrients they carry directly influences food availability for hundreds of millions of people. The currents also affect rainfall, wind patterns and storm behaviour, all of which have far reaching implications for land-based food production and the food and water security of billions of people.

The build-up of greenhouse gases in the Earth's atmosphere is impacting the marine environment in a number of ways. Fishery production losses are anticipated due to a combination of factors that are summarised in Table 5.3 and discussed in further detail below. (See TOOLS 49 to 65.)

5.1.1 Ocean warming and sea-level rise

The accumulation of greenhouse gases in the Earth's atmosphere is leading to an overall increase in average global temperature. The oceans are absorbing much of this heat and have warmed by about 0.7°C over the past century. This warming is causing thermal expansion of the oceans, the same process that sees roofing iron expand as it is heated by the sun during the day. Thermal expansion of the oceans, coupled with melting of glaciers and land-locked ice sheets, has already caused the oceans to rise by about 20 cm over the past century. The oceans are continuing to rise at a rate of about 3 mm/year and are predicted to increase by about 50 to 100cm or more by the end of the century.

Large sea-level rises have the potential to inundate critical fishing infrastructure including wharves, slipways, processing factories and low-lying aquaculture enterprises. They may also drown coral reefs, mangroves, sea grass banks, wetlands and estuaries – ecosystems that form the backbone of coastal fishery habitats and play multiple roles governing the production and distribution of coastal fish species and even deep-water commercial fin-fish species.

Table 5.3: Summarized impacts of climate change on Pacific fisheries and habitats

Ocean warming & sea-level rise	~ Coastal ecosystem inundation/decline ~ Coral bleaching ~ Reduced vertical mixing of nutrients ~ Changing currents & ranges of fisheries species
Ocean acidification	~ Reduced calcification by coral, molluscs and crustaceans ~ Coral reef & marine ecosystem declines
Changing storm and rainfall patterns	~ Increased incidence of drought and/or flooding ~ Increase turbidity of coastal waters ~ Coastal ecosystem destruction & decline
Changing environmental parameters	~ Changes in abundance of invasive pests and diseases

Increases in surface water temperatures can reduce vertical mixing of nutrient-rich cooler waters into the upper levels of the ocean. Such impacts disturb the complex food chains and migratory patterns that support commercial and subsistence fisheries alike. Nutrient distribution patterns are also affected by El Niño-Southern Oscillation (ENSO) events – the major source of inter-annual climate variability in the region. ENSO events strongly influence the production and distribution of phytoplankton and zooplankton within tropical and subtropical waters.

ENSO events are known to impact tuna fishing production, which is a billion dollar industry for the Pacific and the economic backbone of many smaller PICTs. During El Niño conditions, trade winds weaken and warm surface waters extend thousands of kilometres eastwards into the central and eastern Pacific. Skipjack tuna follow the warmer waters and catches increase in the central Pacific and decrease elsewhere. La Niña events are conversely characterized by cooler water conditions and strong trade winds.

A further impact of ocean warming is that of coral bleaching which occurs when coral reefs experience prolonged exposure to unusually warm surface waters. Exposure to waters 1 to 2°C warmer than usual for a period of 3 to 4 weeks can cause corals to expel symbiotic algae (zooxanthellae) that are responsible for their bright colours but more importantly much of their energy. Prolonged or repeated episodes of coral bleaching severely reduces the ability of corals to grow, reproduce and ward off diseases, and may ultimately result in the death of the host colony itself. The rate of global warming is projected to outstrip the capacity of many coral reefs in the Pacific to adapt. Accordingly, coral reefs are expected to lose structural complexity as some species fail to survive. There is real concern that many of the region's coral reefs will ultimately collapse and die as other stressors such as sea level rise, pollution, ocean acidification, increased turbidity and continuing over-exploitation combine to overwhelm these productive coastal ecosystems. (See TOOLS 49-74.)

5.1.2 Ocean acidification

The elevated carbon dioxide levels in the Earth's atmosphere are slowly but surely changing ocean chemistry – a process called ocean acidification. The ocean has absorbed about a third of the human carbon dioxide emissions since around 1750 and it is now more acidic than at any time during the last 650 000 years. Ocean acidification occurs when dissolved carbon dioxide reacts with seawater to form weak carbonic acid. This reduces the availability of the dissolved carbonate that is required by many marine-calcifying organisms, such as corals, shellfish and crustaceans to build their skeletons or shells. There is very real concern that continued emissions of carbon dioxide will drive sufficient gas into the oceans to cause under-saturation of carbonate in ocean waters. Under these conditions, coral reefs and marine animals and plants with carbonate skeletons and shells will struggle to fix sufficient carbonate out of the ocean waters. This will threaten their very survival and the balance of the many complex marine ecosystems that heavily rely on them for ecosystem services such as shelter, reproduction and food.

Global monitoring indicates that the Pacific Ocean has already acidified by 0.1 of a pH unit and is projected to acidify by a further 0.3-0.4 pH units by 2100. This level of acidification will significantly reduce carbonate saturation levels throughout much of the tropical and subtropical Pacific, causing many coral reefs there to collapse as they struggle to fix carbonates. The impacts of coral bleaching and ongoing pollution, mining and destructive fishing practices will further contribute to coral reef degradation in the region. (See TOOLS 66-74.)

5.1.3 Changing rainfall and storm patterns

As tropical oceans warm, it is projected that there will be greater evaporation and moisture availability leading to an intensification of the hydrological cycle, which may lead to increased rainfall in the tropical Pacific between 10°N to 10°S and decreased rainfall in the subtropics. Though the range and even direction of rainfall changes are still poorly understood, scientists do envisage that changes to the hydrological cycle are highly likely and will lead to intensified rainfall for some PICTs and the greater frequency of droughts for others.

Similarly, the 2007 IPCC assessment reports indicate that there is some likelihood that tropical cyclones may become more intense, resulting in heavier rainfall and larger peak wind speeds. (See TOOLS 8 & 9.) While there is presently no scientific consensus on this issue, any intensification, should it eventuate, would clearly place fishing infrastructure and ecosystems at greater risk and make open-sea fishing more hazardous.

Increasing rainfall and associated flooding will also threaten freshwater aquaculture enterprises. These risks would include losing fish from ponds during floods, invasion of ponds by unwanted species and damage to ponds through infilling and breaching of walls. On the other hand, heavier rainfall in low-lying tropical PICTs may provide some benefits in terms of potentially increasing areas suitable for rain-fed pond aquaculture. (See TOOLS 61-65.)

5.1.4 Ecosystem degradation

The aforementioned impacts of climate change are altering environmental conditions at such a rate that many of the region's marine and terrestrial ecosystems – key to fisheries production – will continue to decline and ultimately some may be lost altogether. The region hosts many fragile ecosystems that are vital to the sustainability of the region's fisheries. Coral reefs, mangroves, wetlands, coastal forests, estuaries and sea-grass beds are all highly susceptible to warming waters, changing currents, sea-level rise, ocean acidification and changes in sedimentation from changing rainfall patterns.

Unfortunately many of these ecosystems are already under considerable pressure from coastal land development; pollution of estuaries and lagoons by industrial wastes, fertilizers and pesticides; deforestation of erosion-prone coastal land and mangroves; and over-exploited coastal and deep-sea fisheries. Accordingly, the great concern is that climate change will act as a "threat-multiplier" and exacerbate existing environmental stresses.

While habitat destruction of coastal and marine ecosystems such as mangroves and corals reefs has obvious implications for fisheries, other effects of climate change may be more subtle but equally detrimental to the region's fisheries. Warming waters are likely to force slow migration of some fish species to cooler waters either further to the north or south of the equator. Less adaptable species that live around reefs will find their ecological niches shrinking and possibley disappearing all together. As environmental conditions change, ecosystems may become vulnerable to outbreaks of marine invasive species and diseases. Changing currents may also impact the dispersal of fish larvae and the connectivity among neighbouring fish populations in different areas.

While not all fish species will decline with climate change – some species may actually flourish as their ecological niches expand – there is growing concern that the overall impacts of climate change on Pacific fisheries and the region's food security will be negative. This is partially due to the region's strong reliance on vulnerable coastal fisheries but is also a reflection of the limited adaptive capacity of small and isolated PICTs to change fishing practices and modes of production. (See TOOLS 49-65.)

5.2 ADAPTING TO THE IMPACTS OF CLIMATE CHANGE

This section provides some keys steps that PICT governments, communities and/or individuals may consider to reduce the present and pending impact of climate change on Pacific fisheries. They range from high-level policy steps to smaller practical steps that may be undertaken by communities and individuals.

Given the large degree of uncertainty associated with how fish populations, habitats and migratory patterns will change with time, the steps provided below take a regional and non-prescriptive approach that focuses on sound environmental management and diversifying fish production practices in the Pacific. The list of steps is not exhaustive but is rather designed to prompt ideas, discussion and action, and draw the reader's attention to further tools and resources provided at the end of the module.

5.2.1 Addressing planning and climate change mainstreaming

The role of PICT governments and regional institutions will be critical in helping the region build stronger, more diversified and climate-resilient Pacific fisheries. It will require national fisheries agencies, FAO, and regional agencies such as the Secretariat of the Pacific Community (SPC), and the Forum Fisheries Association (FFA) to focus more resources on research, capacity building and education initiatives in the areas of coastal fisheries and aquaculture. To date, much of the effort has focused on high-value migratory commercial species – principally tuna.

A more diversified fisheries production base will essentially spread the risk of climate change and hopefully help identify those practices or production modes that are favoured, or at least, not as strongly affected by climate change. Other environment-focused regional organizations such as the Secretariat of the Pacific Regional Environment Programme (SPREP), NGOs and UN agencies also have a critical role to play in developing strategies and programmes, and promoting the protection of terrestrial and marine ecosystems that are integral to sustaining fish production in the Pacific.

Careful planning and the revision of existing fisheries policies to factor in the impacts of climate change and to diversify production vehicles will be critical to building a more resilient fishing sector. The following steps are focused on climate change "mainstreaming" activities that are designed to ensure that the impacts and causes of climate change are fully considered in all government policies and development initiatives.

- **Step 31 –** Stakeholders and communities should call for, and support, PICT governments to mainstream climate change adaptation and mitigation efforts and food security into national development strategies, fisheries sector plans and policies. Care should be taken to ensure the following.
  - Existing and newly developed fisheries plans and policies take a conservative, precautionary approach to managing marine resources and that they are responsive to the uncertainties of climate change and future food security needs.
  - The plans draw on the principals of ecosystem-based fisheries management which factor in the broader effects of fishing on the environment, as well as its impacts on other sectors, such as tourism, and the importance of marine conservation and integrated coastal management.
  - PICT governments should develop fishery management plans for coastal fisheries and, where appropriate, for aquaculture. These plans should be developed in a highly consultative way, incorporate indigenous technical knowledge and promote community-based fisheries management or co-management approaches. They should also complement customary marine tenure systems.
  - PICT governments should look to eliminate subsidies that may encourage over fishing and excess fishing capacity. Fuel-efficient fishing and aquaculture practices should be promoted.
  - PICT governments should look to develop and apply environmental impact assessment procedures to all activities and processes that may have an impact on marine ecosystems, including fishery, aquaculture and seafood processing projects.

- **Step 32 -** To secure sustainable levels of fish for food security in PICTs, national fisheries agencies with the support of regional and multilateral organizations will need to promote fisheries polices that improve access to fish for rural communities and growing urban populations. The key ways to do this are the following.
  - Manage coral reef fisheries to maximize their sustainable yields to ensure that the gap emerging between the fish that reefs can supply and the fish needed for food by growing human popualtions is no greater than it needs to be.

photo: ©Tim Pickering

Left: the installation of low-cost Fishing Aggregating Devices (FADs) have been shown to improve inshore tuna catches and reduce the need for subsistence fishers to venture far offshore in often inadequately equipped, small boats. Right: Mozambique tilapia pond constructed by Mr Fred Manu at Manakwai Village in North Malaita, Solomon Islands.

- ~ Reallocate a proportion of national tuna catches for domestic consumption to meet food security needs. This may include the sale of low export value tuna (e.g. undersized fish and by-catch from commercial fishing fleets) on PICT domestic markets to strengthen food security for rapidly growing urban populations.
- ~ Establish low-cost, inshore fish aggregating devices (FADs) and develop small-pond and larger aquaculture operations. The allocation of land and waters resources for aquaculture should be factored into land-use plans.

~ **Step 33 –** Governments should ensure that fisheries and aquaculture are blended into national climate change adaption strategies. Failure to do so may see aquatic systems, fisheries and aquaculture potentially suffer as the result of adaptation measures applied by other sectors, such as the increased use of dams for water capture and hydropower, or the construction of artificial coastal defensives.

~ **Step 34 –** Governments, regional agencies and development partners should work collaboratively to strengthen human and institutional capacity to identify climate change risks to Pacific fisheries and to develop, implement and monitor appropriate adaptive measures. (See TOOLS 49-83.)

5.2.2 Combating information gaps

Much of the global climate change research conducted to date on fisheries and marine ecosystems has focused on tuna (big-eye, albacore, skipjack and yellowfin) and on coral reefs. There has been comparatively little research conducted on the impacts of climate change on Pacific coastal fisheries, and the coastal ecosystems that support them.

Here are some steps that could help to ensure that we have up-to-date and best practice information available to fishing stakeholders and decision-makers in the Pacific region.

- **Step 35 –** Awareness among stakeholders of the probable impacts of climate change on fisheries, and marine and coastal ecosystems is required at all levels. Relevant stakeholders should also be made aware of the adaptive steps (and underlying strategies) available to maintain and enhance fisheries production in the Pacific region.

- **Step 36 –** PICTs need to call for and support climate change-focused research that both models the effects of climate change on Pacific fisheries and also seeks to identify practical village-level solutions to adapting to climate change. The research gaps are numerous but some key ones have been identified. (See TOOL 1.)
  - Increase high-quality observations of oceanographic conditions and surface weather for PICTS. Such observations will help shed light on how rapidly these systems are changing and how these changes will impact marine ecosystems and fisheries.
  - Downscale climate change and oceanographic modeling to "island-scale" resolution to facilitate a more accurate assessment of the local sensitivity and vulnerability of PICTs to changing ocean and climate conditions.
  - Prepare inventories of vegetated coastal habitats, including their connectivity to coral reefs, and environmental thresholds for growth and survival, to help identify links to fisheries productivity.

- Improve baseline information on the size and composition of coastal and inland fishery landings across the region, in order to assess climate change impacts and the success of adaptation measures.
- Improve modeling of the responses of key tuna species to climate change to identify and understand the projected fishing effort and interactions among tuna species. These models also should include descriptions and long-term observations of the relationships between tuna populations and the abundance of plankton and micronekton upon which tuna sometimes feed.
- Guide efforts towards identifying locations suitable for the establishment of low-cost inshore FADs.
- Improve the management of freshwater fisheries and facilitate the expansion of pond aquaculture in PICTs. This requires research and modeling to assess*: (i)the habitat and freshwater flow requirements, and connectivity needed to sustain river and estuary-based fisheries; (ii) projected changes in the area and availability of floodplain habitats for fisheries production and pond aquaculture; and (iii) how climate change may increase the incidence of pathogens for important aquaculture species.*
- Undertake research and development to adapt and improve fishing practices, equipment and baits to reduce by-catch and to improve targeting of desirable fish species.

~ **Step 37 -** To ensure climate change-focused fisheries research is successful, it should be strongly targeted at resource conservation but must also address the food security and livelihoods requirements of fishers. Where practicable, research should draw upon the skills and expertise of subsistence fishers and other key fisheries stakeholders at all stages of the research process.

~ **Step 38 -** A regional approach to the sharing of climate change adaptation initiatives and lessons learned is critically important to building Pacific expertise on fisheries that can be shared among neighbouring countries. (See TOOLS 11-22 & 49-83.)

5.2.3 Adaptations for tuna fisheries

Warming ocean temperatures and changes to currents and food chains in the open ocean are projected to affect the location and abundance of tuna in the Pacific. Preliminary research indicates that the concentrations of skipjack and big-eye tuna are likely to shift further eastward in the Pacific under climate change. The shift of tuna stocks eastward may represent a windfall to smaller resource-poor countries such as Kiribati, Tuvalu and Tokelau in the central Pacific. Conversely, Melanesian countries and the Federated States of Micronesia and Nauru may lose valuable revenue from falling catches, and lower licence fees from distant water fishing nations to fish in their Exclusive Economic Zones. Reduced catches may also affect the profitability of national canneries and processing plants.

The impacts of climate change on long-lining operations is less well understood but there is some evidence to suggest that stocks of yellowfin and albacore tuna may also gradually shift eastwards away from traditional fishing grounds. While little can be done to control the future migratory patterns of tuna, there are some practical steps that nations can take to build the resilience of national tuna industries and to strengthen food security.

~ **Step 39 –** **PICTs should strictly adhere to international treaties and conventions aimed at sustaining tuna stocks. PICTs should also seek and bide by the advice generated by regional agencies that are tailored towards sustaining regional tuna stocks.**

~ **Step 40 –** **New and existing shore-based fishing infrastructure, such as canneries and wharves, should be assessed and, where necessary, upgraded to withstand greater intensity cyclones and rising sea levels. Upgrading work should factor in projected changes to tuna migratory patterns and associated processing demand. Some boats will also need to be replaced or upgraded to meet changing occupational safety requirements in an ocean that may experience more extreme weather events and intensified storm activity.**

~ **Step 41 – The establishment of low-cost inshore FADs in rural areas would serve to improve tuna catches for rural populations and reduce the need for subsistence fishers to venture far offshore in search of tuna in often inadequately equipped, small boats.**

~ **Step 42 – The domestication of tuna fisheries may provide some PICTs with an opportunity to increase the long-term sustainability of their tuna resources, while improving national food security and providing local jobs.**

~ **Step 43 – Methods to increase the shelf life of tuna caught on inshore FADs should be developed and disseminated to subsistence fishers. Focus must be given to handling, hygiene and cold-chain storage practices, and the development of low-cost preservation methods such as drying and smoking.** (See TOOLS 49-60.)

5.2.4 Adaptation for coastal fisheries

Climate change is projected to cause significant changes to the availability and relative abundance of the fish and invertebrates that currently support coastal fisheries in the Pacific. The loss of structural and biological complexity on coral reefs will have profound effects on the types of fish and invertebrates associated with them. For example, fish species that depend on live coral for food, and on the intricate variety of shelter created by structurally complex reefs for their survival, are eventually likely to disappear. Effects of climate change on coastal fisheries associated with coral reefs may not be immediately apparent, but result in slow, long-term declines in yields as resilience and productivity are gradually eroded.

The decline of coral reefs is not the only factor that will affect coastal fisheries resources. Depending on the location of PICTs, projected increases in air and sea surface temperatures, sea level, cyclone intensity and turbidity of coastal waters due to higher rainfall can be expected to affect the growth and survival of mangroves, sea grasses, wetlands and the nature of intertidal and sub-tidal sand and mudflat areas. Although the role that these habitats play in supporting fisheries production in the Pacific is poorly understood compared to that of coral reefs, there is evidence that these ecosystems provide important nurseries for juvenile fish and important breeding and feeding grounds for a wide range of coastal fish species.

Given the vital role that coastal fisheries play in subsistence life throughout the Pacific (See TOOL 50), one of the greatest impacts that climate change is likely to have is on food security. If future production of fish from coral reefs and the other coastal habitats decreases, or is comprised of fish not readily accepted as food by local communities, the emerging gap in the fish needed for food security will increase.

The following steps provide some recommendations to help sustain coastal fisheries in the bow-wave of climate change.

~ **Step 44 – In addition to addressing the present and pending impacts of climate change, PICT governments and communities must also urgently address the ongoing impacts of: *mining; deforestation; ocean-based disposal of domestic and human wastes; poorly planned coastal development; and the over exploitation and abuse of Pacific fisheries through destructive and unsustainable fishing practices, such as the use of explosives and poisons.* Examples of these unsustainable activities can be found throughout the region and their impacts must not be thrown into the "climate change basket" which appoints blame elsewhere. To date, addressing these threats under the banner of climate change has been marred by lack of international action.**

~ **Step 45 – The strengthening of simple community-based measures aimed at sustaining coastal fisheries is critical. These measures may include the establishment of marine reserves; the protection of vulnerable species and/or spawning fish; village-enforced short- and long-term harvesting restrictions; setting species-specific minimum size-limits; regulation and banning of some forms of fishing methods, such as spearfishing at night, spearing crayfish, and the use of poisons and explosives. Failure to act locally will ultimately lead to overfishing and destabilized ecosystems vulnerable to environmental change, diseases and pests.**

~ **Step 46** – Community-based sustainable fisheries measures should be coupled with national fishing regulations. These higher-level measures should reinforce community-based fisheries management in a way that prevents overfishing, promotes community ownership and management of marine resources, and provides a safety net where devolving management to the local level encounters difficulty. They must also strongly consider and complement customary marine tenure systems that prevail throughout most PICTs.

~ **Step 47** – National fisheries agencies should look to work with communities to undertake baseline surveys and to establish simple indicator-based monitoring systems to ensure that fish harvesting rates are sustainable. Examples of simple indicators may include: density of target species per unit area of habitat; body mass; and catch per unit of effort.

~ **Step 48** – Where practicable, PICT governments should consider the allocation of dedicated fishing grounds for rural communities and promote rights-based fishing as opposed to a "free for all" fishing approach. This may serve to improve local governance and sustainable management of marine resources and reduce resource exploitation by "outsiders". In many PICTs, such an approach may involve supporting and re-establishing customary marine tenure systems.

photo: ©James Ngwaerobo

photo: ©SPC

Aquaculture is thought to hold strong potential for improving food security partilcularly in the Melanesian Countries. Species such as Nile tilapia (pictured) grow rapidly and can provide an important source of protein for inland populations.

- **Step 49 – PICTs and regional organizations should promote the importance of maintaining healthy and self-replenishing fisheries to fishing communities. Such work should stress the need to manage fisheries sustainably, and the interconnectedness of the marine and terrestrial ecosystems that support them. This concept of co-dependence draws strongly upon the principals of ecosystem-based fisheries management.**

- **Step 50 – The role of tidal flats, wetlands, coastal forestry and mangroves in supporting fisheries resources is often grossly undervalued. These ecosystems play multiple and important roles in sustaining coastal fisheries and food security. Governments and communities must act to protect these fragile ecosystems against deforestation, land reclamation and other destructive development initiatives.**
  - **Mangroves, coastal forests and wetlands act as important buffers between the land and sea. They help prevent silt-laden and polluted surface waters from reaching fragile marine environments and, conversely, protect land resources against the ravages of wave action, cyclones, storm surges and rising sea levels.**
  - **Coastal vegetation combats climate change by trapping carbon dioxide which can remain locked away in the cellulose of plants for many decades or even hundreds of years.**

5.2.5 Adaptation for aquaculture and freshwater fisheries

The impacts of climate change are predicted to impact aquaculture and freshwater fisheries in a multitude of ways. For example, many low-lying areas and flood plains that are suited for aquaculture will become increasingly impacted by rising sea levels, storm surges and rain-induced flooding as the impacts of climate change take hold in the Pacific region. Increased flooding will impact aquaculture operations by dispersing brood stock, eroding and infilling ponds, and damaging adjacent pumps and infrastructure.

Likewise, increased flooding and associated erosion and silting of rivers, streams and lakes will adversely impact freshwater fisheries. Effective land-use planning will be critical to help in identifying areas suited for aquaculture and to help protect forests

Figure 5.4: **Mangroves and coastal forests play an important role in protecting fisheries and coral reefs from the damaging effects of sedimentation and pollution. In this picture, silt from steep, erosion-prone land has been washed into the ocean. Effective land-use planning and the retention of forested zones between the land and the sea could have helped avoid this ongoing damage to the nearby coral reef.** (See TOOLS 49-83.) (Vava'u 2009)

photo: ©R. Sands

and water resources and fish habitats within vulnerable catchments. Drought also may impact some PICTs with obvious consequences to both freshwater fisheries and aquaculture operations.

Open aquaculture systems that are based in coastal waters will also need to consider the increased risks to infrastructure associated with possible increases in storm and cyclone intensity in some PICTs. Change in salinity levels and water temperature is also likely to affect the viability of farming some species of seaweed such as kappahycus or *cottonii*. In the case of kappahycus, higher water temperatures combined with lowered salinity (from increased rainfall) may trigger outbreaks of epiphytic filamentous algae (EFA) and *ice-ice* disease in some PICTs. Both of these diseases can substantively reduce kappahycus production.

Unregulated mining of sands, corals and rocks from beaches is a common practice throughout the Pacific region. Indescriminant mining can increase erosion, siltation and degradation of coastal ecosystems that form vital nurseries and habitats for a wide variety of fish species.

While many scientists predict that climate change will have an overall negative impact on Pacific aquaculture operations, not all impacts will be harmful. In contrast to the projected declines for PICT agriculture, climate change may open new opportunities for aquaculture as seas encroach on coastal lands, as more dams and impoundments are constructed in river basins to buffer the effects of changing rainfall patterns and droughts and to harness hydropower, and as urban waste demands more innovative disposal. With land-based aquaculture there may also be more scope to engineer solutions to climate change impacts, particularly in larger scale commercial operations, where water temperatures and water quality can be altered through filtration and reticulation systems. Presented below is a series of steps aimed at protecting Pacific island ecosystems and the freshwater fisheries and aquaculture operations they host.

~ **Step 51 –** While it is unrealistic to think that climate change-induced coastal erosion in PICTs can be totally prevented, it is important to reduce human activities that further contribute to coastal erosion processes. Activities such as the mining of corals and sand, the development of coastal infrastructure, and the deforestation and degradation of coastal forests, mangroves and wetlands must be closely regulated.

~ **Step 52 –** Land-based aquaculture initiatives should be located carefully to reduce the risk of flooding and/or inundation. It may be possible to climate-proof existing aquaculture infrastructure by installing effective drainage systems, reforesting catchments and by upgrading ponds and buildings to withstand higher intensity storms and heavier rainfall.

~ **Step 53 –** In subtropical and atoll countries that may become increasingly impacted by drought, the installation and/or up-scaling of water capture and storage facilities may be necessary to maintain or develop aquaculture productions levels and processing capacity.

~ **Step 54 –** Aquaculture operations should incorporate effective aquatic biosecurity practices and regulations to avoid the introduction of alien and invasive species, diseases, parasites or other unwanted species along with imported broodstock. They also must avoid poor husbandry practices, such as overstocking, which can cause diseases or parasitic infections that have the potential to devastate production and infect wild fish populations.

~ **Step 55 –** Aquaculture operations that source juvenile brood stock from the wild, and fish and other marine organisms for production feed must ensure that their practices do not overfish or degrade natural fisheries and the broader environment. (See TOOLS 49-65.)