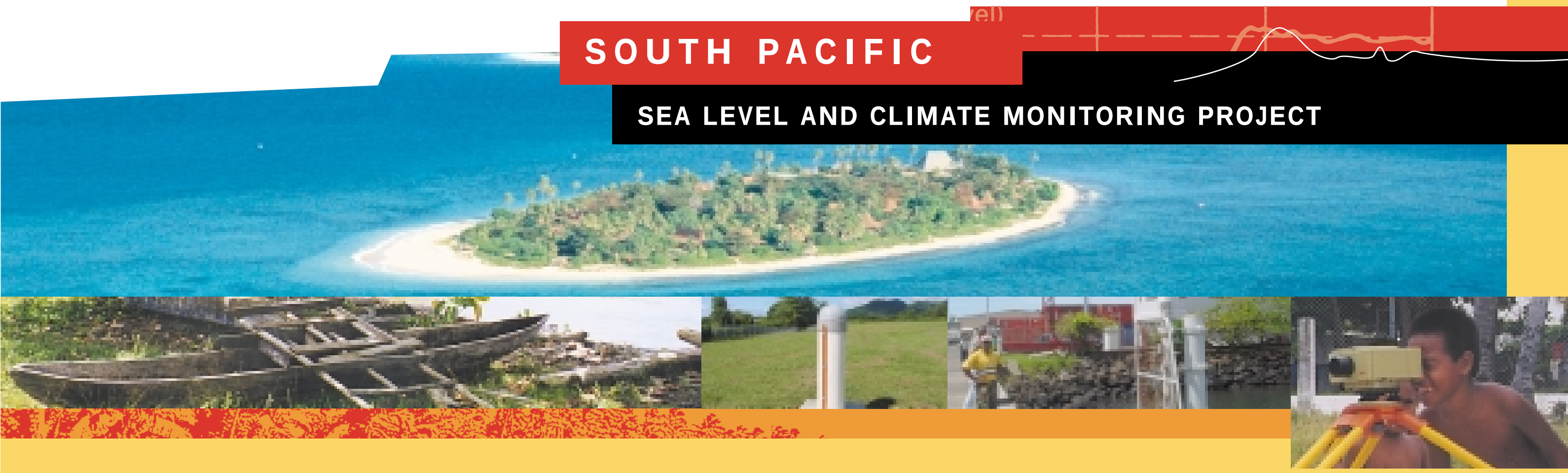


SOUTH PACIFIC

SEA LEVEL AND CLIMATE MONITORING PROJECT

A Project supported by the Australian Government

OCEAN VARIABILITY AND FISHING

Ocean variability is to marine life what atmospheric variability or weather is to life on the land.

On land, variations in rainfall, sunshine and temperature can affect the quantity and quality of crops, the times of harvesting and the returns. Using past records of rainfall, primary producers plan their farming operations to cope as best they can with these variations.

It is no different in the marine environment, except that making and recording observations—enhanced significantly in the past decade with satellite technology—is relatively new.

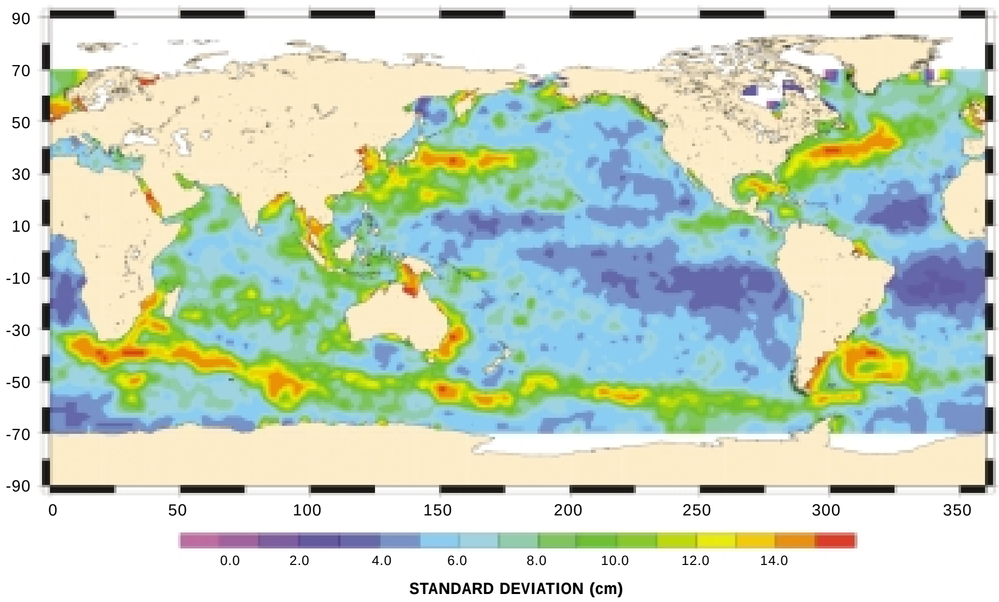
Scientists have broad hints of how environmental variability affects marine species, but are confident that marine life is as sensitive to ocean variability as life on land is to terrestrial climate.

Unlike the atmosphere, the ocean changes at a much slower rate and a rule of thumb is that a day in the atmosphere is equivalent to a week in the ocean. There is some exciting new oceans research centred on ocean 'weather' prediction and analysis, and forecasting of day-to-day variations in ocean currents, ocean eddies and temperatures.

OCEAN VARIABLES

Winds move across the earth's surface towards the west near the equator (trade winds) and towards the east in the temperate mid-latitudes (Westerlies and Roaring Forties). Their effects, combined with the change in surface heating, create large circulation patterns in each of the Atlantic, Indian and Pacific Ocean basins, moving clockwise north of the equator and anticlockwise south of the equator.

In the deep ocean (at depths below about one kilometre), water movement is governed by variations in the density of water. Along the coastlines, local effects such as tides and



Sea surface height measurement from satellite is one of the tools used by scientists to detect ocean currents and eddies that affect fish distribution and productivity. (Credit: CLS/CNES) coastal winds, sediments, nutrients and rainfall run-off combine to influence the behaviour of continental seas.

Coastal upwelling is the physical mechanism that is of primary importance to coastal fisheries around the world. It is usually associated with a wind that drives water away from the coast, drawing deeper, cooler and nutrient-rich water up to replace it.

Scientists and fishers know that the constantly changing conditions of the ocean influence the environment of all coastal and deep-ocean fisheries and conditions for the growth of phytoplankton.

Climatic variations, stronger or weaker ocean currents, rising or falling ocean temperatures, ocean upwelling and varying levels of salinity and nutrient concentration affect the breeding, abundance and distribution of all species in the marine food chain—from minute plankton to our favourite fish.

Around the world, fisheries on many species occur in areas where fish aggregate due to environmental conditions, such as surface water temperatures and fronts where warm, nutrient—depleted waters meet cooler, nutrient—rich waters.

This factor is well-recognised because the correlation between the catch of fish and the surface temperature, the most easily—measured oceanographic feature—has been the most studied environmental condition.

However, new ocean-measuring technologies, deployment of multi-frequency acoustic systems and powerful supercomputers have enabled scientists to widen their investigations into how closely-aligned is the development and movement patterns of fish stocks (from spawning through to harvest) to the ocean environment.

Hauling skipjack tuna aboard (Photo credit: Peter Sharples, Oceanic Fisheries Programme, Secretariat of the Pacific Community)

TIDES AND SEA LEVEL

Tidal conditions in coastal regions are also relevant to fisheries productivity and the tidal modelling and prediction activities are conducted under the South Pacific Sea Level and Climate Monitoring Project focussed on the Exclusive Economic Zones of four countries Vanuatu, Tuvalu, Samoa and Fiji will be an aid to local fishing.

The system being developed will enable users to generate tidal information at locations and islands including ocean locations which are far removed from the locations of tide gauge instrumentation.

TUNA

Over 70 per cent of world tuna landings, amounting to over three million metric tons annually, are taken from the Pacific Ocean.

The skipjack (*Katsuwonus pelamis*), a surface tuna, is the most widely fished species in the Pacific and forms more than two-thirds of all catches in that ocean. The huge warm pool (29°C average over a surface area larger than Europe), situated in the western ocean, accounts for most skipjack catches in this ocean.

Skipjack tuna (Katsuwonus pelamis)
(Photo credit: CSIRO Marine Research)

Do skipjacks follow the interannual movements of this warm-water pool over several thousand kilometres, which movements cause the well known climate event *El Niño*? If so, how can this event be explained, since warm water is relatively poor in nutrients?

Such are the questions which the South Pacific Commission (SPC) and IRD (French Institute for Scientific Research of Development in Co-operation) have been studying. The findings of these and other studies undertaken in regional tuna research, are intended to achieve better fishery management in an area extending over 6,000 km along the equator.

Every three to four years, under the effect of a simultaneous change in the wind and current systems induced by a change in atmospheric pressure between French Polynesia and northern

Processing longline—caught mahi mahi in Suva
(Photo credit: Peter Sharples, Oceanic Fisheries Programme, Secretariat of the Pacific Community)

Port samplers working for Fiji Fisheries Division measure fish being transhipped from Taiwanese longliners in Suva, (Photo credit: Peter Sharples, Oceanic Fisheries Programme, Secretariat of the Pacific Community)

Australia, the eastern edge of the warm-water pool, located close to the equator at 180° longitude on average, moves 3000 km eastwards.

Well known as *El Niño*, this warming event of the central Pacific surface waters, which also affects the eastern part of the basin, is the warm phase in a global climate fluctuation system called ENSO (*El Niño* Southern Oscillation). *El Niño* is followed by a cool phase, referred to as *La Niña*, during which the warm-water pool is pushed beyond its average position towards the western coast of the equatorial Pacific, causing the temperatures of the central Pacific to fall below normal.

In order to determine whether tunas follow these west-to-east and east-to-west shifts of the warm-water mass, scientists have endeavoured to correlate environmental data signalling these movements with the fishery statistics gathered from this same oceanic area. Fisheries statistics are used to estimate variations in fish abundance in a given location.

The results obtained show that the largest tuna catches occur during *La Niña* episodes (1988–1989 and 1995) in the western Pacific basin (between 140° and160° east). On the other hand, during *El Niño* years (1992, 1994), maximum catches moved 2500 km further east and as far as 170° west in the Pacific.

These data, which reflect skipjack movements over several thousand kilometres, westward during *La Niña* and eastward during *El Niño*, were confirmed by a study carried out by the South Pacific Commission (SPC) on the movements of tagged tunas.

Why do tunas follow the movements of the warm-water pool, although this water is relatively poor in nutrients? One of the theories considered by the SPC scientists is that the organisms (zooplankton and micronekton) which surface tuna feed on, arrive in the warm-water body.

An indirect product of upwellings in the eastern Pacific, this zooplankton and micronekton is thought to be pushed westward by an equatorial current and to accumulate where warm and cool water masses meet.

Because of the movement of the warm-water mass and that of the planktonic organisms, this nutrient-rich zone (secondary production) which is very attractive for surface tuna, is thought to form a strip several hundred kilometres wide along the eastern edge of the warm-water mass. It would therefore be in search of food that skipjacks would follow the back-and-forth movement of the warm-water pool through various warm phases (*El Niño*) and cool phases (*La Niña*) of ENSO.

The demonstration of this correlation between tuna movements in the equatorial Pacific and the *El Niño* climate event offers rewarding prospects for better management of tuna fishing in this oceanic region.

Fresh pole and line caught skipjack being chilled in seawater and processed (seared, re-chilled and vacuum-packed in matter of minutes) in Suva (Photo credit: Peter Sharples, Oceanic Fisheries Programme, Secretariat of the Pacific Community)

It is possible to forecast the appearance of an *El Niño* event and the movement of the warm-water pool, and therefore tuna migrations, at least two months in advance using the basic index formed by the change in atmospheric pressure between French Polynesia and northern Australia.

In addition, simulation models today make it possible to forecast an *El Niño* event up to one year in advance. This index, in the same way as these models, could be used to define the zones most favourable for fishing in advance and establish whether fish abundance variations are due to their migration towards other areas or results from fishing.

Overall, this would make it possible to gain a better understanding of tuna abundance variations in the equatorial Pacific and prepare fishing strategies compatible with the requirements of sustainable exploitation of oceanic resources.

SUMMARY

Factors in ocean variability are linked to climate variability, although the influences of longer term climate changes are yet to be determined.

Fisheries and aquaculture management policies, and scientific assessment approaches, do not currently incorporate the effects of climate variability and climate change. Yet fishers are using the latest research and sophisticated data collection systems to target their prey.

Researchers are beginning major studies to provide ocean forecasts for coastal and marine industries, including fisheries, using tools to provide near real-time information on ocean behaviour.

The data and information provided by the South Pacific Sea Level and Climate Monitoring Project makes a major contribution to this forecasting and prediction.

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Patrick Lehodey, *South Pacific Commission, New Caledonia*
Joël Picaut, *CLS, Toulouse, France*
Vincent Lyne, *CSIRO Marine Research, Australia*

FURTHER INFORMATION

Regional Coordinator
AMSAT
PO Box 17955
Suva FIJI
Telephone +679 3304 003
Facsimile +679 3304 003
Email amsatck@connect.com.fj

Project Manager
AMSAT
PO Box 341
Curtin ACT 2605 AUSTRALIA
Telephone +61 2 6281 8450
Facsimile +61 2 6281 8436
Email amsatho@amsat.com.au

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