Climate Change, Fisheries, Trade and Competitiveness: Understanding Impacts and Formulating Responses for Commonwealth Small States

November 2009

Prepared for the Commonwealth Secretariat by:

Graeme Macfadyen and Edward Allison*

Commonwealth Secretariat

* The paper has been prepared for the Commonwealth Secretariat by Graeme Macfadyen, Poseidon Aquatic Resource Management Ltd, Geneva, Switzerland, in association with Dr. Edward Allison, World Fish Centre, Malaysia. Views expressed here are those of the authors, and do not necessarily reflect those of the Commonwealth Secretariat or its Members.

Contacts:

International Trade and Regional Co-operation Section
Economic Affairs Division
Commonwealth Secretariat
Marlborough House
Pall Mall
London SW1Y 5HX
UK

Tel: +44 7747 6252
Fax: +44 7747 6235

Table of Contents

Table of Tables

Table of Figures

Acronyms

ACP	African Caribbean and Pacific (countries)
ADB	Asian Development Bank
AFIPEK	Association of Fisheries Processors and Exporters of Kenya
CCRF	Code of Conduct for Responsible Fisheries
CDM	Clean Development Mechanism
CGIAR	Consultative Group on International Agricultural Research
CITES	Convention on International Trade in Endangered Species
CO2	Carbon Dioxide
DRM	Disaster Risk Management
EEZ	Exclusive Economic Zone
ENSO	El Niño Southern Oscillation
EU	European Union
FAO	Food and Agriculture Organisation (of the UN)
FFA	Forum Fisheries Agency
GATT	General Agreement on Tariff and Trade
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHF	Global Humanitarian Forum
GNI	Gross National Income
HACCP	Hazard Analysis and Critical Control Point
(I)NGO	(International) Non-Governmental Organisation
IOC	Indian Ocean Commission
IOTC	Indian Ocean Tuna Commission
IPCC	Intergovernmental Panel on Climate Change
KMFRI	Kenya Management and Fisheries Research Institute
LDCF	Least Developed Countries Fund
LME	Large Marine Ecosystem
LVFO	Lake Victoria Fisheries Organisation
MEA	Multilateral Environmental Agreements
MIFCO	Maldives Industrial Fishing Company
MPA	Marine Protected Area
MRC	Marine Research Council (of Maldives)
NACA	Network of Aquaculture Centers of Asia
NAPA	National Adaptation Programmes of Action
PRSP	Poverty Reduction Strategy Paper
REDD	Reducing Emissions from Degradation and Deforestation
SCCF	Special Climate Change Fund
SCM	Subsidies and Countervailing Measures
SIDS	Small Island Developing States
SPC	South Pacific Commission
UN	United Nations
UNCLOS	United Nation Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNFCCC	UN Framework Convention on Climate Change
WCPFC	Western and Central Pacific Fisheries Commission
WTO	World Trade Organisation

Executive Summary

Introduction

It is widely recognised that the world's poorest countries will be most affected by the impacts associated with global climate change. Fourteen of the world's 50 least developed countries[1] are Commonwealth States[2], and of the one hundred countries classified as most vulnerable to climate change (Ayers & Huq, 2007), 45 are Commonwealth States, 31 are Commonwealth Small States, and 27 are Commonwealth Small Island Developing States (SIDS). At the same time analyses of both fisheries (Allison et al 2009) and aquaculture (Handisyde et al, 2006) sectors suggest that poorer countries tend to be more nutritionally and economically dependent on fish than wealthier countries (in terms of higher per capita consumption, a greater share of agriculture sector employment and GDP, and a larger share of exports). This is certainly true of many small developing Commonwealth States, and especially so of those that are SIDS. But while agriculture, forestry and freshwater resources have been central in climate policy discussions, the effects of climate change on fisheries resources - and the implications for health and livelihoods in the developing world - have been largely ignored (Dulvy & Allison, 2009).

This report thus focuses specifically on the likely impact of climate change on the trade and competitiveness of the fisheries sector in small developing Commonwealth States and thus contributes to bringing the fisheries sector into a more central role in policy discussion on climate change. An assessment of the climatic change implications on the trade and competitiveness of the fisheries requires consideration first of the climatic-fisheries impact pathways i.e. physical and chemical changes in oceans, lakes and rivers resulting from climate change, then of how such changes are likely to effect fish and ecosystems, and finally how these changes will impact on the trade and competitiveness of the fisheries sector particularly fishers/fish farmers, communities and national economies. A better understanding of these impact pathways can be used to inform policy recommendations on enhancing fisheries-specific trade and climate change mitigation measures, and to highlight appropriate adaptation initiatives in the fisheries sector. Both adaptation and mitigation in the fisheries sector are likely to be critical for small developing Commonwealth States in maintaining or increasing trade competitiveness, and in realising the opportunities emanating from globalisation.

Physical and chemical changes in oceans, lakes and rivers, and resulting impacts on ecosystems and on fish populations

Changes in oceans, lakes and rivers impacting on ecosystems and fish populations include changes: to heat content and temperature; salinity, density and stratification; ocean circulation and coastal upwelling; sea, lake and river levels; sedimentation brought about by climate-induced changes to land use; ocean acidification; and low frequency climate variability patterns (e.g. El Niño Southern Oscillation (ENSO) and intrinsic variability operating at decadal and longer timescales). In turn, these physical changes have the potential to result in changes in: physiological, spawning and recruitment processes of fish; primary production (e.g. diatoms and phytoplankton); secondary production (e.g. zooplankton); distributions of fish (through permanent movement, or changes to migration patterns); the abundance of fish (due to changes in primary and secondary production); phenology (e.g. timing of life-cycle evens such as spawning); species invasions and disease; and other food web impacts.

[1] As defined by the UN office of the high representative for the least developed countries, landlocked developing countries and small island developing states

[2] There are a total of 53 Commonwealth Member States

Many of the potential pathways of impact linking global warming, through physical and chemical changes in oceans and fresh waters, to effects on aquatic ecosystems, have been identified in the scientific literature. Some of these pathways have been modeled and their effects quantified but it is still not possible to make predictions about the combined effects of all of these changes, and how they may reinforce or counter-act each other. It is thus impossible to make confident science-based forecasts about the future composition, distribution and productivity of exploited fish species. However it is possible to identify which pathways are likely to have special relevance to different kinds of fishery system (inshore/coastal, reef-based, oceanic), infer the direction of change that can be expected in these fisheries, and identify a number of potential impacts on the trade and competitiveness of the fisheries sector (in small developing Commonwealth States) and on fishers, fisheries-dependent communities, and national economies.

Impacts of climate change on the fisheries sector, and more widely in national economies

Changes in fish populations and ecosystems from climate change are likely to have resulting impacts on the fisheries sector and national economies. Climate change may also directly affect fishing operations and fishing communities independently of impacts on fish and ecosystems (e.g. through sea level rises and increased storm severity affecting fishing and fish-farming people's homes and productive assets).

Impacts can occur at two main levels, which correspond approximately to the domains of micro- and macro-economic analysis:

- w*ithin the sector* - impacts on the incomes, assets, and livelihoods of individual fishers, fish farmers, processors, and those engaged in marketing and the provision of inputs to the sector; and
- *at the national level* - impacts on revenues, exports, per capita fish supply, and contributions to employment and GDP .

The potential impacts on these two levels will vary by region/location, and differing levels of adaptive capacity of individuals, communities, fleets and economies and societies. In general terms, the impacts of climate change are likely to be experienced by all those within the sector, regardless of the relative importance of the sector in the wider economy, and investment in adaptation that is commensurate with the size of the sector will be required. Macro-economic concerns arise only when fisheries are sufficiently prominent in society and the economy to be a concern for national economic planning. This will be the case for many small developing Commonwealth States, particularly many island states, where fisheries number among the major export revenue sources.

Within-sector impacts, which may affect all links in the supply chain (e.g. producers, processors, those transporting and selling fish) in terms of incomes, value-added, employment and food security, may include the following:

Changes in fishing/business strategies and methods (e.g. types of gear, forms of processing) to reflect changes in the abundance, distribution, and phenology of different fish species. Many developing Commonwealth States have important tuna and coastal reef fisheries, both which could be severely impacted.

Changes to aquaculture as coastal and inland areas become more/less suitable for aquaculture with changes in sea/lake levels, and changes in water quality/properties;
changes in marketing chains and end market destinations, resulting from shifts in the species mix of wild catches, changes in the balance of production between capture fisheries and aquaculture, and changes between marine and inland resources;

Shifts in the balance between fishing/fish farming and other livelihood activities, with those in the sector seeking to divest if fishing/farm farming becomes less profitable, while alternatively reduced livelihood opportunities in agriculture and other sectors may result in more people looking to fishing as a 'safety-net' occupation;

The willingness of stakeholders to invest in community or participatory management (itself important in enhancing adaptive capacity), if stocks are seen to be subject to climate-driven processes beyond the control of local management. Conversely, the threat of climate change impacts may galvanize local management to minimize impacts and enhance adaptation;

*Damage and increased safety risks from increased severity, and potentially frequency, of extreme weather event*s. Such damage can include flooding and damage or loss of fish farming infrastructure and standing stocks, fishing vessels and gear, and business assets in ancillary occupations (boat-building yards, marine engineers workshops, fishing gear shops, fish processing equipment, retail premises). Extreme weather events can also damage sector infrastructure and institutional capacity (e.g. including to harbours, research and extension facilities) as well as fisherfolk's homes, lives and health in coastal and floodplain areas (e.g. loss of life, and increases in post-disaster epidemic diseases such as cholera and other enteric diseases, and pathogens with aquatic life-stages such as malaria and bilharzias)

Climate-induced changes in the fishery sector may also have ***wider societal and economic implications at the national level***, and these will be greatest where fish and fisheries play important roles in society and the economy.

Rent generation from the sector
For many small developing Commonwealth States the value of fisheries in the EEZ is considerable and the sale of fishing licences to foreign vessels in return for access to national waters makes substantive contributions to GDP. Governments also generate revenue from domestic fisheries through the collection of various fees and taxes relating to fishing, processing and trading inputs and outputs. Where revenues are substantial, they can be used for general budget support and for investment in development that has benefits beyond the fishery sector. Even where revenues are modest, they are often used to support expenditures outside the sector. Key sources of revenue from fisheries, all of which are threatened by climate change, thus include:

- Licence fee income from both domestic and foreign fleets fishing in the EEZ
- Lease of fishing rights
- Vessel registration fees
- Taxes on landings and/or sales
- Export duties and royalties
- Income and company taxation from employees and owners of fishing and processing companies.

Impacts on food and nutritional security

Food security of fisherfolk is achieved through income from fish sales, while having access to fish provides direct nutritional security (access to a healthy, balanced diet, rather than just access to sufficient calories). As population increases, per capita supply of fish is decreasing globally, despite the rapid rise of aquaculture production. This 'fish gap'is largest in Africa, where fish consumption rates are the lowest in the world, despite Africans having proportionally greater reliance on fish as a source of dietary animal protein than people in developed countries. As fish become scarcer and their value rises, there is also concern that the supply of fish to lower income consumers is decreasing fastest. Globally, this is seen in the net transfer of fish from low income food deficit countries to developed countries. When these trends are considered in the light of projected production decreases in capture fisheries due to climate change, this poses important questions for policy to balance local nutritional needs with the revenue generating potential of export-oriented production.

Employment, safety nets and the social and cultural role of fisheries

The fisheries and aquaculture sectors can be important sources of employment, even in landlocked countries. And in many small island developing states and archipelago countries (e.g. Philippines, Indonesia, the Solomon Islands), the fisheries sector is an integral part of cultural identity. Climate change, coupled with resource over-exploitation, may lead to shrinking of the fishery sector, with loss of the strong cultural affinity with the coast and marine environment. The accessible fisheries of inland and inter-tidal and near-shore marine waters have a role as seasonal or crisis-related 'safety nets' for people displaced from other sectors; in Senegal and Ghana, for example, drought and market and policy failures in agriculture led to an influx of people seeking employment in fisheries during the 1990s, greatly increasing the pressure on near-shore fishery resources. As climate change begins to impact inland and near-shore fisheries, and with the need for more restrictive access to maintain the flow of trade and other benefits from fisheries, the role of fisheries as a 'safety net' is becoming less viable. This may require greater state and/or donor financing of social protection measures to replace the lost safety net function of small-scale fishing.

Costs of adaptation

To maintain the flow of benefits to society and the economy from fisheries, governments are likely to have to increase their investments in developing coherent 'climate proof' sectoral policy and legislation, management and development. Costs are likely in association with all the policy issues/options discussed below when we consider linkages between climate change policy and fisheries trade policy supportive of enhanced/maintained trade and competitiveness.

Vulnerability of small developing Commonwealth States to the impacts of climate change

The ability of small developing Commonwealth States to deal with the wide range of climate-change induced impacts discussed above depends on their vulnerability. Vulnerability is a product of three factors: *exposure* to the physical climate change impacts and effects on fish and ecosystems; *sensitivity* i.e. the degree to which individuals and nations are dependent on fisheries and therefore sensitive to any changes in the sector; and *adaptive capacity*, or the ability or capacity of individuals or countries to modify behaviour or change to cope with actual or expected changes. At the individual or micro-level, there are numerous adaptation strategies in fisheries and aquaculture, primarily relating to business and operational strategy, but adaptation may include seeking to exit the sector all together. And while such measures are the responsibility of private citizens or firms to undertake, the government has an important role in creating an enabling environment for adaptation to take place, and in providing a regulatory environment that prevents reactive adaptation that has negative environmental, social and economic consequences. At the national, adaptive response are determined by policy choices, which are discussed in more detail below.

To date, vulnerability analysis has used a limited range of indicators for exposure, dependency, and adaptive capacity, and indicators of adaptive capacity have focused on the ability of the wider economy and governance system to absorb any impacts to the fishery sector. In this study, using three case studies of Kenya, Maldives, and the Solomon Islands, we explore the feasibility of moving towards vulnerability analysis that a) uses a far wider range of indicators, and b) which has more fisheries sector-focused indicators of adaptive capacity based on sector governance. The indicators used were found to be extremely useful in identifying vulnerability of these three developing Commonwealth States.

Case studies of Kenya, Maldives and the Solomon Islands

The case studies start by considering a number of key assumptions and questions of methodology in assessing potential future impacts of climate change, and vulnerability of countries to it. These relate to: the fact that climate change is just one of many factors impacting on a country's fisheries sector and its competitiveness (and could be a relatively unimportant compared to others such as fisheries governance and management); the difficulties in assessing the magnitude of potential change over different, and potentially long, timescales; and the uncertainties in many climate change models and lack of resolution at country level. For all of these reasons, it is both inappropriate and virtually impossible to make quantitative projections as to how baseline data for Kenya, Maldives and the Solomon Islands might change in the future in response to climate change and other drivers of change. Nevertheless, there is now a significant body of literature available to suggest the different *types* of physical changes resulting from climate change, and the possible impact *pathways* to the effects on ecosystems and fish production, and in turn the impacts on trade and competitiveness of the fisheries sector and on fishers, communities and nations.

Some key findings from the case studies are that:

- With regards to dependency on fisheries production and trade, fisheries sector dependency is lower in Kenya than in Maldives and the Solomon Islands, and Maldives exhibits the highest levels of dependency in national terms. However in all countries there are very high dependencies on the sector for both food security and employment in specific locations;
- All three countries face potential impacts in terms of declining reef fisheries. These are likely to be far more important in Maldives and the Solomon Islands given their greater importance for food security/subsistence, than in Kenya. In the case of Maldives threats to reef fisheries are particularly severe given potential impacts on the bait fishery on which the whole pole and line tuna industry is based, and the importance of reefs for tourism which has strong linkages with the fisheries sector;
- Changes to tuna migrations away from the EEZs of all three countries could result in declines in the trade in foreign vessel licences in all three countries, but reduction in foreign licence revenues will be less important in Maldives than in the other two countries given that current levels of revenue generation from such sources are low;
- Changes to tuna migrations could result in additional threats to canning operations in both Maldives and the Solomon Islands, due to reduced availability of fish. These processing plants are already under severe financial pressures given high input costs

compared to many competitors (e.g. of cans, oils, packaging), and erosion of preferential tariff regimes with the EU.

- Any changes to the balance of species in Lake Victoria would have huge impacts in Kenya, given the relative importance of different species for export and domestic consumption, and differing levels of value-added and employment generated by different species;
- Increases in extreme weather events and associated costs are likely to be less in Kenya and Maldives than in Solomons (especially the southern areas of the country which may be at special risk of more extreme events); and
- The indicators of adaptive capacity for both Kenya and the Solomon Islands provide considerable cause for alarm with respect to the countries' ability to deal with any future changes resulting from climate change. Maldives, despite its greater dependency on fisheries, may not necessarily be more vulnerable given its greater ability for adaptation.

Linkages between a) climate change and trade competitiveness and b) climate change and fisheries trade policy supportive of enhanced/maintained trade and competitiveness in Commonwealth States

Implications of climate change for trade competitiveness

At the most fundamental level, climate change has the potential to impact on total fish production volumes available for trade, both domestically and to export markets[3]. The impacts of climate change on the production of different species will vary depending on the magnitude of the physical change brought about by climate change, the ability of fish species and ecosystems to adapt to deal with physical changes or their adaptive response to avoidance of these changes, and the response of fishers, communities and nations. Trade impacts from changes in production levels and species mix, and less predictable, more frequent and stronger extreme weather events, could include the following:

- Trade volumes to different export market destinations, due to their different preferences for particular species;
- Total trade values, due to differing unit values of different species and changes in prices based on differing elasticities of supply for differing species;
- The balance of production exported and traded domestically;
- The balance of production traded and consumed on a subsistence basis;
- The balance in trade from marine and inland fisheries;
- The balance in trade from capture fisheries and aquaculture;
- The contribution of fisheries sector exports to total exports;
- Balance of trade and foreign exchange earnings;
- The reliability of supplies due to increasing seasonal and annual variations in catches, and major discontinuities following extreme events; and
- The ability of countries to trade in fisheries licences with vessels from other countries in return for access to fish their waters.

The seriousness and extent of these impacts and the competitiveness on any one country will be dependent on the response of consumers, private sector stakeholders, and governments, as well as the comparative impacts of climate change on competitor countries. What then can individuals and countries do to ensure that they maintain trade competitiveness in the face of

[3] It is important also to remember the important role of fishing as a subsistence activity in terms of food security

the potential impacts of climate changes? Responses and related policy fall into two main categories, both of which constitute ways of maintaining competitiveness: adaptation; and mitigation. Adaptation and mitigation offer potential to maintain or increase fisheries trade both domestically and internationally. This potential will be realized through two main mechanisms:

- Helping to ensure that production levels from capture fisheries and aquaculture are maintained or increased on a sustainable basis for trade, and to assist with safeguarding of private sector profits; and
- Pursuing policy options that are very specifically trade-related, and which provide opportunities that could result in competitive advantages being gained by countries implementing them.

Adaptive measures in the fisheries sector

Fisheries-specific adaptive measures offer potential to maintain or increase fisheries trade both domestically and internationally, because they help to ensure that production levels from capture fisheries and aquaculture will be maintained or increased on a sustainable basis, with this production then being available to be traded.

Re-building stocks and improving fisheries governance. Stocks that are not overfished are likely to be more resilient to climate change impacts. Thus initiatives aimed more generally at management of the sector (e.g. decommissioning, introduction of fishing rights, improved monitoring control and surveillance) may all help to improve the adaptive capacity of fisheries to climate change. This in turn may require institution building of fisheries administrations, representative sector organizations, and civil society engaged with the fisheries sector.

Strategies regarding onshore fisheries and coastal infrastructure. Provision of safe havens/harbours for the fishing sector to protect vessels can ensure continuing levels of catches available for trade, while climate-proofing any such developments through careful siting and appropriate engineering will be increasingly important.

Managing declining incomes if fish catches fall due to lower catches, and efforts aimed at diversification and fostering alternative livelihood activities. Enabling exit from the fishery sector in response to downturns, by providing training in alternative occupations or through general investments in skills and capabilities, may be important in fisheries that are declining or subject to reduced productivity under projected climate change.

Dealing with fisheries' status as a 'safety net' activity. In many countries, climate change impacts on livelihoods in other sectors e.g. agriculture, may result in increased pressure on fish resources, in turn requiring specific policy to deal with part-time/occasional fishermen wishing to exploit fish resources given reduced land-based income generating activities, so as to ensure that fish catches are sustainable.

Disaster preparedness and response. Policy-level responses can include:

- Invest in improved weather information and storm warnings
- Ensure that the fishery sector is included in national disaster preparedness and response planning
- Ensure that fisheries line management agencies are familiar with disaster preparedness and response procedures

- Ensure that specialist fisheries sector technical expertise is available to disaster relief agencies
- Rehabilitation periods (after emergency relief has been delivered) aimed not at restoring the flawed structures of the pre-disaster period, but at affecting the kinds of transformation to future reduce vulnerability.

Aquaculture development. Aquaculture production increases may in some cases be possible where capture fisheries production declines, thereby helping to ensure overall production levels for food security, incomes, employment and trade. Important will be the need for countries to ensure that adaption strategies 'climate-proof' any sector developments e.g. ensure that aquaculture development takes place in a way that minimizes the potential for extreme events to result in damage to assets. Other adaptive measures include species selection, selective breeding and genetic modification in aquaculture.

Inclusion of fisheries in the UNFCCC, NAPAs and PRSPs[4].

Funding for adaptation, and to support development objectives in fishing-dependent communities, can help to improve adaptive capacity. The UN Framework Convention on Climate Change seeks to define countries rights and responsibilities with respect to GHG emissions and adaptation funding. Inclusion of the fisheries sector in the text of the convention, due for ratification in Copenhagen in December 2009, would help secure its place in adaptation funding policy. An immediate policy action that could be taken is for Commonwealth States to support amendments to the current draft of the negotiating text to include mention of the need for adaptation in the fisheries sector. Specific reference to the fisheries sector in National Plans of Adaptation (NAPAs) to climate change signals priority for expenditure on adaptation in the sector, so a second policy initiative could be to ensure the sector is included in on-going reforms to existing plans or preparation of new NAPAs. Inclusion in PRSPs helps to ensure fisheries and aquaculture in the highly indebted poor countries receive a budget allocation in associated medium-term expenditure frameworks developed to implement PRSPs. This can contribute to maintaining sustainable fisheries and ensuring government investment in infrastructure, services and regulatory institutions that help to maintain or improve trade competitiveness.

Ecosystem-based adaptation. Coastal ecosystems like wetlands, coral reefs, mangroves all provide natural shoreline protection from storms and flooding, in addition to their role in maintaining sustainable fish supplies because of their importance as breeding and nursery areas. They also have important roles to play in tourism and global biodiversity conservation.

Mitigation in the fisheries sector

Mitigation options in the fisheries sector are very much at the early stages of investigation – few studies of energy consumption by the world's fishing fleets have been conducted and the current contribution of the fisheries sector to global warming is not known, as estimations of embodied carbon[5] in fisheries production and trade of the sector on a global basis have not been completed. Policy options to contribute towards climate change mitigation could however include taxation, regulation and incentives related to:

- Fuel use and/or vessel engine emissions;
- Technical innovations to reduce fuel usage and emissions in fishing vessel engines (e.g. more efficient vessel design reducing engine size requirements);

[4] Poverty Reduction Strategy Papers

[5] Refers to carbon dioxide emitted at all stages of a good's manufacturing process

- Promotion of fuel-efficient fishing methods (e.g. static methods rather than the use of active gear such as trawling with high energy requirements), through differential licensing conditions and/or decommissioning support;
- Research into support for low impact aquaculture e.g. herbivorous aquaculture species which may have a lower carbon footprint than carnivorous species.
- Improvements in building design and handling practices to reduce energy requirements and increase energy efficiency e.g. through better insulation in ice plants, freezing plants, cold stores and chill stores;
- Fuel use in the transportation of fish to markets;
- 'Environmentally-friendly' technologies; and
- Mangrove protection/replanting, due to its role in carbon sequestration.

Important for many of these policy options, and providing a strong link between climate change and trade policy is that countries could increase their competitive trading position through their implementation, for example through:

- It may be possible to capture the range of ecosystem service values of wetlands, coral reefs, and mangroves discussed above in such a way that they bring tangible financial benefits in the form of trade/payments. Means for doing so include conservation payments, payments for environmental services, linkages with carbon markets (e.g. REDD for mangroves), and funding/revenues through eco-tourism ventures;
- Market promotion and branding of fisheries sectors or products that use energy efficient standards in an attempt to reduce their carbon footprint; and
- More efficient production methods which could be expected to increase value-addition throughout the supply chain by reducing costs.

Climate change and fisheries trade – policy linkages

At the national and international level, a number of other policy issues are also likely to have linkages to both fisheries trade and climate change policy. Some examples are provided below, and suggest that negotiators from Commonwealth Developing States in a very wide range of policy fora (e.g. WTO, UNFCCC, EPAs, FPAs, FAO, CITES, NAPAs, PRSPs) need to be aware of potential linkages between climate change and fisheries trade competitiveness. This in turn suggests that it may be very important for Commonwealth States to consider the potential to strategically address climate change and trade competitiveness issues simultaneously in different fora so as to ensure a coordinated approach.

Domestic consumption vs export trade. With potential declines in fish production of certain species in some countries, policy discussion may need to focus on the relative advantages of trading fish domestically or internationally. Critical issues in this regard may not just relate to the financial/economic value-added from trade into different markets, but also to issues of food security (likely to become critical in many countries given climate change impacts coupled with population increases). This issue relates not just to the domestic or international trade of fish caught or produced domestically, but also the sale of access rights to foreign entities to fish in national EEZs.

The food miles debate. Initiatives in developed country markets on ‘food miles’ could have negative implications on developing country fish exporters, requiring special policy responses and support for the notion of ‘fair miles’ and a more nuanced understanding of carbon emissions.

Technical Barriers to Trade (TBTs). The UN Framework Convention on Climate Change, in its article 3.5, recognizes that action to address climate change may have trade implications. The Convention, the Kyoto Protocol and WTO's Technical Barriers to Trade agreement all strive to guard against arbitrary or unjustifiable trade discrimination related to climate change that create unnecessary obstacles to trade (for example high energy-use fishing methods could not be discriminated against by importing countries).

Fiscal measures (e.g. subsidies and domestic support mechanisms) for adaptation (and mitigation). Under GATT rules the SCM (subsidies and countervailing measures) agreement prohibits industry and sector-specific subsidies. Governments may however want to provide specific support for the poor and vulnerable facing particular risks from climate change. Commonwealth States therefore need devise careful strategies for funding of adaptation and mitigation that don't fall foul of the SCM agreement.

Aid for Trade. Set up in the course of the long-running Doha Round of global trade talks, the WTO work programme on aid-for-trade aims to mobilize additional funding to help poor countries overcome supply-side constraints that hamper their ability to benefit from the multilateral trading system. While aid-for-trade is primarily trade-related, the economic resilience that it creates could have positive effects in helping countries deal with the potential impacts of climate change. This would be particularly true if aid for trade can anticipate possible climate impacts on trade-related infrastructure or on key fish species/sectors likely to be impacted, and respond accordingly in the design, implementation and financing of relevant projects.[6]

CITES. There is a potential linkage between CITES[7] and trade in fish products, if certain fish species become rarer due to climatic impacts and are placed on CITES Appendices. A number of ornamental fish organisms are already included in such Appendices for example.

Trade issues in the FAO Code of Conduct for Responsible Fisheries (CCRF). A major issue addressed by the CCRF in Article 11 is the concept of "responsible fish trade". Definitions of what constitutes responsible and precautionary fisheries exploitation could change significantly due to climatic impacts, and could require countries to change fish trade policy accordingly.

Economic Partnership Agreements and erosion of tariff preferences. Non-reciprocal preferential trading regimes are being phased out. ACP countries have the potential to initial/sign 'goods-only EPAs', ' full EPAs' covering goods and services, negotiate reciprocal trade agreements, or to revert back to the generalized system of preferences (GSP) schemes of the EU for their trade relations with Europe. Opting for the GSP or the GSP+ scheme may hinder progress in implementation of the adaptive measures for the fisheries sector discussed above and transfer of environmental technologies, while signing EPAs also implies a level of financial support provided by the EU to help countries adapt to the erosion of preferential tariff regimes. Development funding associated with the signing of EPAs, could be used to support adaptive capacity initiatives.

---

[6] ICSTD

[7] CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is a voluntary international agreement between Governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival

Funding for adaptive and mitigating measures

Given competing demands for finance in small developing Commonwealth States, it is likely that they will need to identify external sources of funding to support climate change adaption and mitigation. A wide range of potential sources are available, which are explored in more detail in the main text of this report. They include:

- the UNFCCC's financial mechanism, operated through to GEF, which operates three funds: the GEF Trust Fund; the Least Developed Countries Fund (LDCF); and the Special Climate Change Fund (SCCF). (UNFCCC, 2009);
- The international carbon market which has emerged as a result of the Clean Development Mechanism (CDM) established in the Kyoto Protocol;
- The Adaption Fund under the Kyoto protocol, which is intended to fund adaptation projects and programmes in developing countries that are particularly vulnerable to climate change[8];
- Multilateral Environmental Agreements (MEAs) which may provide synergies with projects to help climate change adaptation and mitigation and potential funding. MEAs of potential interest to the fisheries sector include the Convention on Biological Diversity, and the Ramsar Convention on Wetlands;
- Multinational and bilateral donors; and
- Foundations and NGOs/INGOs.
- Rents collected by Government from the catching and processing sectors in developing Commonwealth States, which could be used to fund adaptation and mitigation;

The insurance market. Insurance can serve to enhance financial resilience to external shocks and provide an opportunity to spread and transfer risk. Support for insurance-related actions may also help to quantify risks and potential losses of climate change.

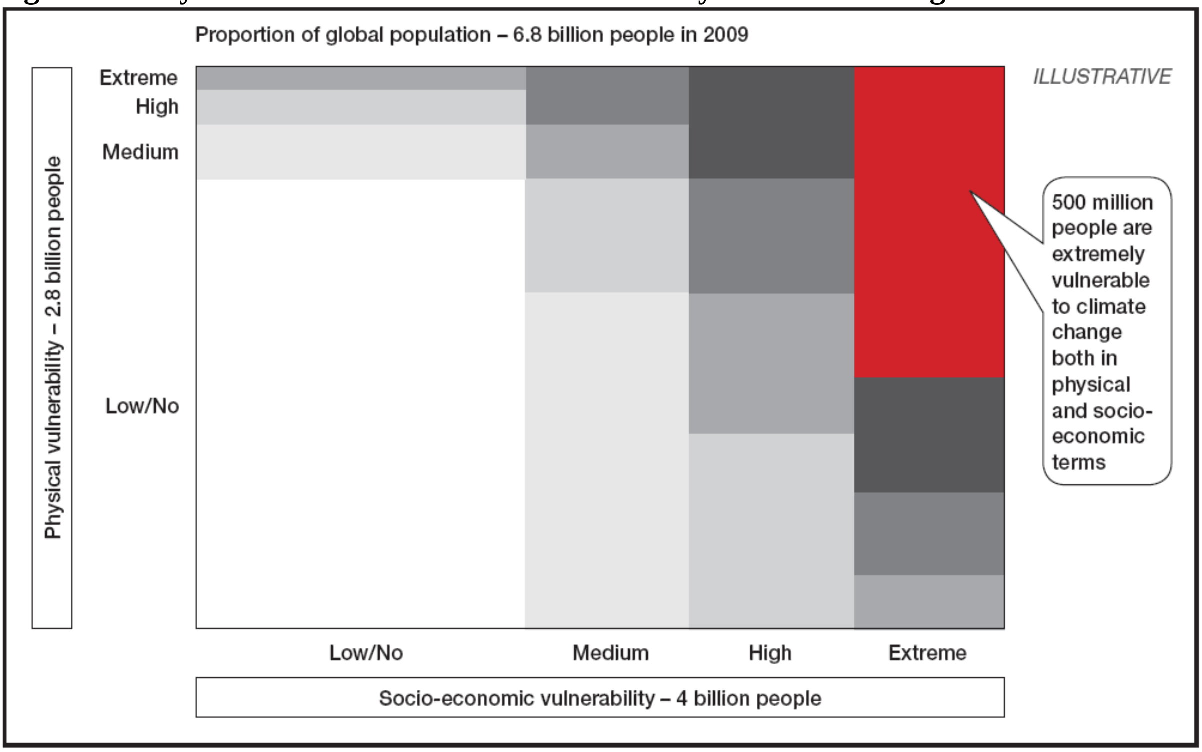
[8] Note that this Fund is yet to be operationalised, and the amount of monies that might be available is uncertain

1. Introduction

1.1 Background – the particular importance of climate change for Commonwealth States

Climate change issues have an especially high profile in 2009. The December 2009 15th meeting of the Committee of the Parties to the UN Framework Convention on Climate Change (UNFCCC) aims to set the climate change mitigation and adaptation agenda from 2012. This will replace the Kyoto Protocol which expires in that year. In an attempt to focus the minds of political leaders around the world on the imperative to avert ‘dangerous climate change’ (IPCC, 2007) a series of high-profile reports have emerged during this year, warning of the consequences of failure to reach agreement on curbing greenhouse gas emissions and continued inaction on funding adaptation measures to deal with unavoidable change. One such report is from the Global Humanitarian Forum (GHF, 2009) which estimates that the combination of physical vulnerability (living in areas that will be impacted by floods, droughts, sea-level rise and storms) and socio-economic vulnerability (having livelihoods dependent on climate-sensitive economic sectors, living in poverty, living in countries where resources for adaptation are limited) makes half a billion people extremely vulnerable to climate change impacts that are already being experienced (Figure 1). Many of these people live in small developing Commonwealth States.

Figure 1 – Physical and socio-economic vulnerability to climate change



Source: GHF 2009

It is widely recognized that the world’s poorest countries will bear the brunt of escalating greenhouse gas emissions, primarily through reduced food and water availability, and increasing frequency and severity of extreme events. Fourteen of the world’s 50 least developed countries[9] are Commonwealth States[10]. In addition, of the one hundred countries

[9] As defined by the UN office of the high representative for the least developed countries, landlocked developing countries and small island developing states

classified as most vulnerable to climate change (Ayers & Huq, 2007), 45 are Commonwealth States, 31 are Commonwealth Small States, and 27 are Commonwealth Small Island Developing States (SIDS).

Analyses of both fisheries (Allison et al 2009) and aquaculture (Handisyde et al, 2006) sectors, suggest both that poorer countries tend to be more nutritionally and economically dependent on fish than wealthier countries (in terms of higher per capita consumption, a greater share of agriculture sector employment and GDP, and a larger share of exports). But while agriculture, forestry and freshwater resources have been central in climate policy discussions, the effects of climate change on fisheries resources — and the implications for health and livelihoods in the developing world — have been largely ignored (Dulvy & Allison, 2009).

1.2 Objectives of this study

This study builds on other work recently completed by the Commonwealth Secretariat on the interface between trade and climate change. However, unlike previous work, it focuses specifically on the likely impact of climate change on the fisheries sector in small developing Commonwealth States, with a particular emphasis on trade and competitiveness. It thus contributes to bringing the fisheries sector into a more central role in policy discussion on climate change.

An assessment of the impacts of climate change on the trade and competitiveness of the fisheries sector requires an assessment of the climatic change implications on the trade and competitiveness of the fisheries requires consideration first of the climatic-fisheries impact pathways i.e. physical and chemical changes in oceans, lakes and rivers resulting from climate change, then of how such changes are likely to effect fish and ecosystems, and finally how these changes will impact on the trade and competitiveness of the fisheries sector particularly fishers/fish farmers, communities and national economies. A better understanding of these impact pathways, and the magnitude of the likely impacts, can be used to inform policy recommendations on enhancing fisheries-specific trade and climate change mitigation measures, and on promoting appropriate adaptation initiatives in the fisheries sector. The policy recommendations in this report focus strongly on the interface between trade and climate change policy; an interface which Commonwealth States must address if they are to realise the opportunities emanating from globalisation. It is intended that the outcome of this research and analysis will be considered for input into national, regional and international fora (e.g. WTO, UNFCCC) where trade and climate change policy issues are being discussed and formulated.

An analysis of the state of global negotiations on adaptation funding informs the recommendations we make in this report. This ensures that suggested adaptation policy measures can be linked to finance mechanisms. We hope this gives policy makers in small developing Commonwealth States some clearly identified entry points to secure access to funding to assist in implementing changes that will be necessary to maintain the role of fisheries in their economies.

1.3 Authors

This report has been prepared by Graeme Macfadyen and Dr. Edward Allison. Graeme Macfadyen is a director and founding partner of Poseidon Aquatic Resource Management

[10] There are a total of 53 Commonwealth Member States

Limited (www.consult-poseidon.com), a UK-based fisheries and marine environmental consultancy company working globally. Dr Edward Allison is Director for Policy, Economics and Social Science, at the WorldFish Center (www.worldfishcenter.org), one of the Consultative Group on International Agricultural Research (CGIAR) institutes.

1.4 Structure and purpose of this report

Following this introduction, this report is structured into five main Chapters. Chapters 2-4 are based on an extensive review of available literature, and summarise current knowledge on:

- Climate change impact pathways on oceans, lakes and rivers, and in turn on fish populations and ecosystems (Chapter 2);
- Potential climate change impacts on those within the fisheries sector and communities directly dependent on it, and the sector's contribution to national economies, (Chapter 3), and
- Vulnerability and resilience of fisheries-dependent economies to climate change (Chapter 4).

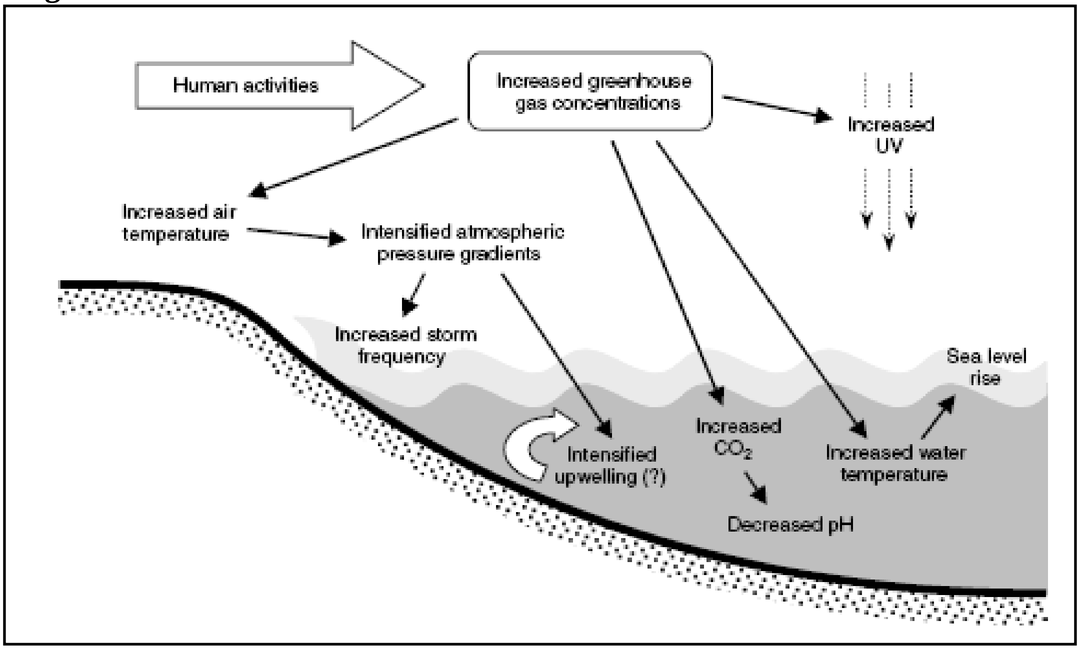
Chapter 5 then 'scales in' and considers three case studies: Kenya, Maldives and Solomons. For each of these countries current information on the fisheries sector is first provided to assess baseline conditions. In particular we consider a wide range of indicators which can be used to assess individual countries' exposure to climate change, their dependency on fisheries, and their adaptive capacity of dealing with changes. Discussion is then provided about potential physical climate change impacts on fish populations and ecosystems, based on the literature reviewed for Chapter 2. These impacts are then explored in terms of their implications on the trade and competitiveness of the fisheries sector, communities and national economies, based on both the magnitude of the potential impacts, and the dependency and adaptability of fishers, communities and national economies in each of the three countries.

Finally, in Chapter 6 we 'scale back out' again, and informed by the case studies, consider more specifically the impacts of climate change on trade and competitiveness, and the inter-linkages between climate change and fisheries trade policies. In particular we assess potential policy options for addressing climatic change adaptation and mitigation measures which would be supportive of enhanced trade and competitiveness of the fisheries sector in small developing Commonwealth States, and potentially also in other developing countries.

2. Climate change: pathways of impact on ocean, coastal and freshwater ecosystems and on fish populations

Climate change (global warming) is leading to changes in the basic biophysical processes that determine the structure and function of the oceans (Figure 2) and other aquatic ecosystems, and it is these ecosystems that sustain capture fisheries and provide the environments in which fish are farmed.

Figure 2: The main physical changes in the oceans attributable to anthropogenic global warming



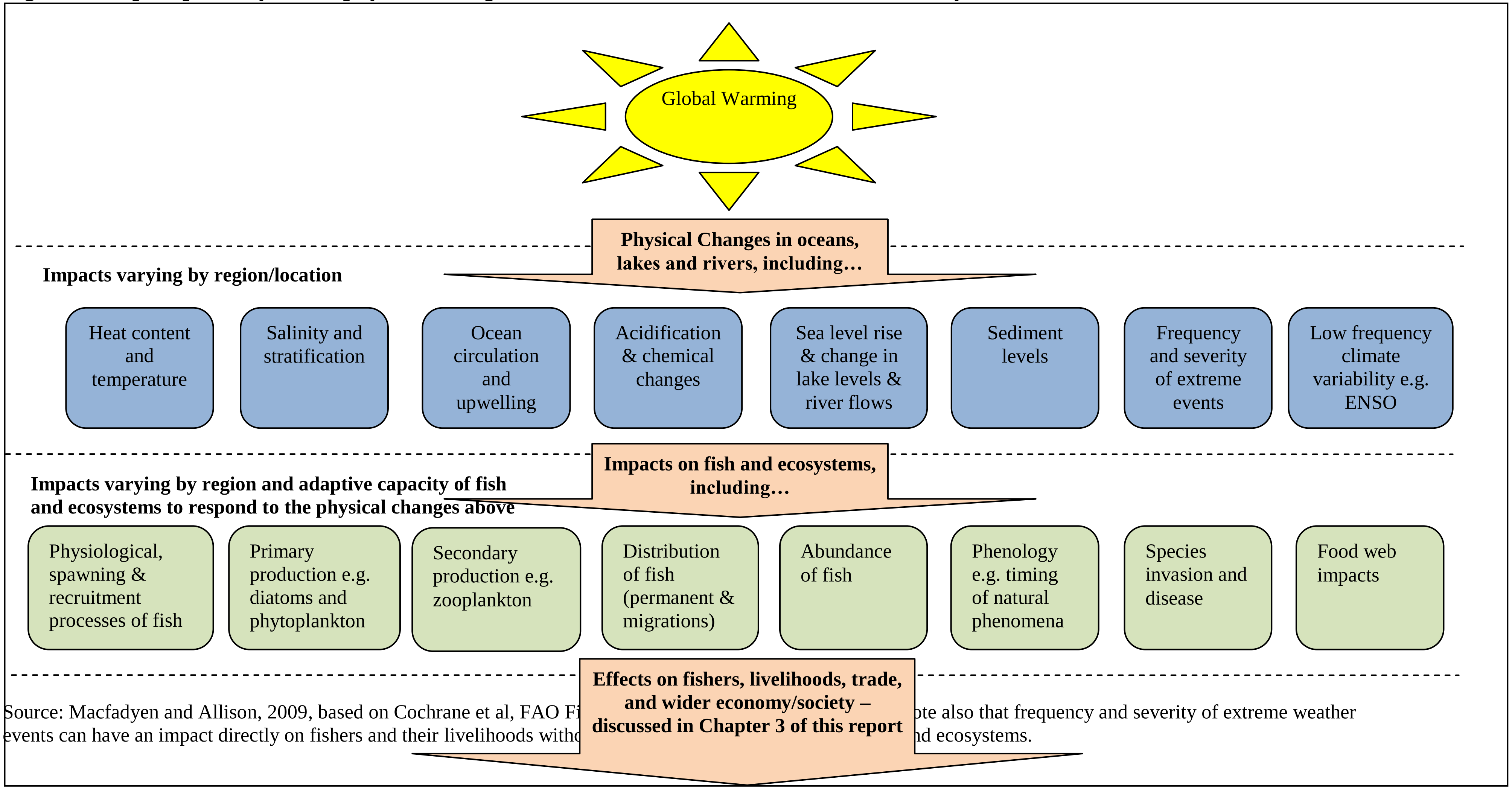
Source: Harley et al 2006

As recently reviewed by the Intergovernmental Panel on Climate Change (IPCC, 2007), climate change in the oceans and freshwaters leads to changes in physical processes such as: alternations in the major ocean currents and in the local circulation patterns in coastal systems; changes in the frequency and severity of the El Niño Southern Oscillation (ENSO, driven by the Humboldt Current in the Pacific); and thermal expansion and addition of ice-melt to the oceans, leading to sea level rise. In freshwater, rainfall and river-flow patterns and rates of evapo-transpiration are changing. Storms, floods and droughts are changing in frequency and intensity. Chemical changes brought about by warming are also leading to an acidification of the oceans, with consequences for ocean food chains and the formation of coral reefs.

The links between warming, these physical changes in hydrology and oceanography, the ecological changes in aquatic food webs, and the operation and economics of the fishing sector are thus complex. We structure this review around a simplified schema that illustrates some the main potential pathways of impact from physical and chemical changes to fish and ecosystems. Figure 3 outlines the main impact pathways, in summary form with additional text detail and explanation provided in Appendix 2. Some specific examples supported by literature are also provided in Table 1. These impacts on production and distribution of fish and on the structure and function of oceanic and aquatic ecosystems and food webs then interact with effects of increased storminess, floods, droughts and sea-level rise, and with a variety of indirect effects (including adaptation in other sectors), to have impacts on fisheries at household or operational level, community and sectoral level, and on national economies in countries where fisheries are significant (as discussed in Chapter 3).

Many of the potential pathways of impact linking global warming, through physical and chemical change of oceans and fresh waters, to effects on aquatic ecosystems, have been identified in the scientific literature. Some of these pathways have been modeled and their effects quantified but it is still not possible to make predictions about the combined effects of all of these changes, and how they may reinforce or counter-act each other. It is thus impossible to make confident science-based forecasts about the future composition, distribution and productivity of exploited fish species. What one can do, in some but not all cases, is to identify which pathways are likely to have special relevance to different kinds of fishery system (inshore, coastal, reef-based, oceanic) and infer the direction of change that can be expected in the fish resources within the waters of the countries studied and the means of production.

Figure 3: Impact pathways from physical changes in oceans, lakes and rivers to fish and ecosystems



Source: Macfadyen and Allison, 2009, based on Cochrane et al, FAO Fi… …ote also that frequency and severity of extreme weather events can have an impact directly on fishers and their livelihoods witho… …nd ecosystems.

Table 1: Examples of potential impact pathways through which climate change can affect the distribution and production of fish stocks

Type of changes	Climatic variable	Impacts	Potential outcomes for fisheries	Selected references
Physical environment	Ocean acidification	• Negative effects on calciferous animals, including slowed rates of coral growth	Declines in *production*	(Iglesias-Rodriguez et al., 2008, Hoegh-Guldberg et al., 2007)
	Warming of upper ocean layers	• Poleward shifts in plankton and fished species	Changes in *production* and *availability* of fished species	(Beaugrand et al., 2002, Perry et al., 2005)
		• Changes in timing of phytoplankton blooms • Changing zooplankton composition	Potential mismatch between prey (plankton) and predator (fished species) and declines in *production*	(Edwards and Richardson, 2004)
	Sea level rise	• Loss of coastal habitats • Saline intrusion into freshwater habitats	Reduced *production* of coastal marine and freshwater systems and related fisheries	
Fish stocks	Higher water temperatures Changes in ocean currents	• Changes in physiology and sex ratios of fished species • Altered timing of spawning, migrations, and/or peak abundance	Changes in timing and levels of *productivity* across marine and freshwater systems	(Sims et al., 2001, Sims et al., 2004, Pavlidis et al., 2000)
		• Increased invasive species, diseases and algal blooms	Reduced *production* of target species in marine and fresh water systems	(Harvell et al., 1999, Bruno et al., 2007, Edwards et al., 2006, Reid et al., 2007)
		• Effects on fish recruitment	Changes in abundance of juvenile fish and therefore *production* in marine and fresh water	(Kell et al., 2005, Kirby et al., 2007, Beaugrand, 2004, Planque and Fredou, 1999)
Ecosystems	Reduced water flows & increased droughts	• Changes in lake water levels • Changes in dry water flows in rivers	Reduced lake *productivity* Reduced river *productivity*	(Coe and Foley, 2001, Conway et al., 2005)
	Increased frequency of ENSO events	• Changes in timing and latitude of upwelling	Changes in pelagic fisheries *distribution*	(Lehodey et al., 2006, Lehodey et al., 1997)
	Higher water temperatures	• Increased frequency and severity of coral bleaching events	Reduced coral reef fisheries *productivity*	(Hoegh-Guldberg, 2005, Hoegh-Guldburg, 1999)
		• Changes in stratification, mixing, and nutrients in lakes and marine upwellings	Changes in *productivity*	(Bakun, 1990, O'Reilly et al., 2003, Behrenfeld et al., 2006)

Source: Allison et al, 2009

3. Climatic change implications for fisheries

3.1 Introduction

This Chapter considers climate change impacts on the multiple contributions that fisheries and aquaculture currently make to economies of developing Commonwealth States and other fish-producing countries that may compete with them in global and regional markets. Additional relevant and associated figures/maps are provided in Appendix 2.

The previous Chapter, along with the text in Appendix 2 reviewed the mechanisms through which climate change is predicted to affect fish species, populations and oceanic and aquatic habitats and ecosystems. In this Chapter, we consider the impacts of climate change on fisheries and aquaculture as social and economic systems. Thus, we elaborate on the fishery and aquaculture impacts that result from changing production and distribution of fish populations and the ecosystems that support them (Chapter 2), and we also consider the physical impacts climate change has directly on fishing operations and fishing communities, independently of impacts on fish and ecosystems (e.g. sea level rise and increased storm severity affecting fishing and fish-farming people's homes and fishing and aquaculture infrastructure). We also highlight some of the many and complex potential indirect effects of climate change on fisheries (e.g. increased investment in water storage and irrigated agriculture, leading to impacts on river and reservoir fisheries; emissions reduction policies leading to reduced subsidies on aviation fuel, in turn leading to increased costs of air-freighted fresh fish exports).

We consider impacts at two main levels, which correspond approximately to the domains of micro- and macro-economic analysis:

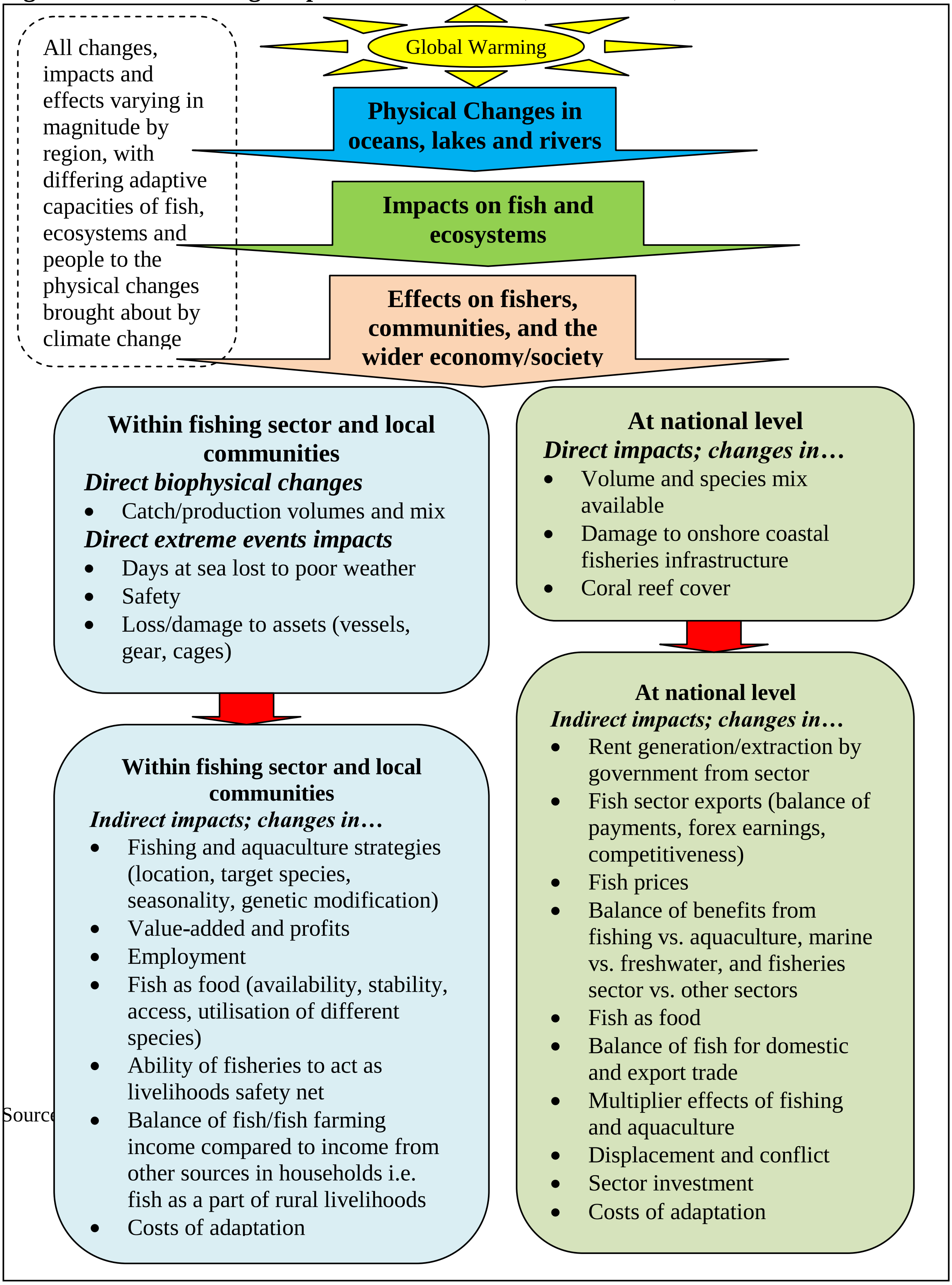
- *Within the sector* – impacts on incomes, assets, livelihoods of individual fishers, processors, fish farmers and communities; and
- *Sector contribution to national economies* – impacts on revenues, exports, per capita fish supply, contribution to employment and GDP at national levels.

The potential impacts on these two levels will vary by region/location, and differing levels of adaptive capacity of individuals, communities, fleets and economies and societies. In general terms, macro-economic concerns arise only when fisheries are sufficiently prominent in society and the economy to be a concern for national economic planning. This will be the case for many small developing Commonwealth States, particularly many island states, where fisheries number among the major export revenue sources. Within the sector, the impacts of climate change will be experienced by all, regardless of the relative importance of the sector in the wider economy, and investment in adaptation that is commensurate with the size of the sector will be required.

Climate-related impacts will also be affected by other non-climate related stresses and opportunities. In capture fisheries, the principal additional stress is heavy pressure from poorly regulated fishing activity; in aquaculture, it is competing uses for coastal, land and water resources. The broader issue of adaptive capacity, vulnerability and resilience to potential impacts is discussed more fully in Chapter 4.

This Chapter is divided into two sub-sections. The first explores climate change implications within the sector for fisher/farmers, and related communities. The second considers wider impacts within national economies across of range of societal concerns (employment, food security, poverty reduction). (Chapter 6 focuses more specifically on climate change implications for small developing Commonwealth States with respect to trade and markets). Figure 4 below provides a pictorial representation of the impacts discussed in the two sub-sections of this Chapter.

Figure 4: Climate change implications for fishers, communities, and national economies



3.2 Climate change implications for fishers, communities, fleets and national economies

3.2.1. Within-sector impacts

Direct and indirect impacts of changes in production volumes and species mix and of changes in aquatic environmental conditions

Changes in total catch, the composition of the catch, and the distribution of fish – all likely under the global warming-induced ocean temperature changes and freshwater availability described in Chapter 2 – will have impacts on costs and earnings of fisherfolk. While some areas may experience an increase in fish production – as has been suggested for the Arabian Sea (Goes et al 2005) – many areas will see reductions in production associated with reduced primary productivity and, for near-shore tropical fisheries, habitat damage from coral bleaching, as well as other stresses on the coastal environment. These could lead to the following types of impact:

Changes in fishing methods used; for example from targeting small pelagic fish with seines to diving for shellfish, or from line-fishing to pot and trap-fishing, as different species become more or less available.

Changes in aquaculture production systems – This could include the use of warmer-water adapted species, or species able to grow on a diet low in fish-derived feed - itself in short supply due to excess demand and impacts of climate change on small-pelagic stocks used for fish oil and fish meal- (Mullon; work in progress). There could also be changes in production systems – for example in coastal areas, there may be a greater inland penetration of brackish-water aquaculture, such as shrimp farming, as low-lying coastal land gets flooded by salt water more often and loses its value as rice-growing land (Government of Bangladesh, 2008). Increased frequency of toxic algal blooms – associated with both temperature rise and increased nutrient levels – could close off shellfish fisheries, such as those for scallops, oysters and mussels. We could also see a shift towards adoption of more 'climate-proof' closed or recirculation systems in aquaculture – akin to intensive poultry production – where the production environment is under more direct human control.

Changes to marketing chains - many species of fish currently traded in higher-value international markets by Commonwealth States and other developing countries are both suffering intense exploitation and are sensitive to climate change. These include the fish traded in the live reef-fish trade to Asia, and the global trade in tuna species. Domestic urban and export markets that are supplied from aquaculture dependent on the collection from the wild of climate-sensitive natural larvae, spat or 'seed' could begin to disappear in their current locations. These may include oysters, mussels, some shrimp and crab species, spiny lobsters and some groupers and, in freshwaters, some of the Indian major carps. An obvious adaptive measure is to close the life-cycle of these species by developing hatcheries, but this can be both technologically demanding, expensive, and lead to loss of an important source of livelihood for the poor. In coastal Bangladesh, for example, hundreds of thousands of people make a seasonal living by collecting shrimp post-larvae for the country's export-orientated shrimp farming sector (Ahmed et al., 2009).

Shifts in the balance between fishing, aquaculture and other livelihood activities – If fishing becomes less profitable or predictable, fisherfolk will invest more in seeking alternative occupations. Although some disinvestment will be beneficial where there is over-capacity and over-reliance on fisheries, diversification can also imply less investment in efficient technology and a consequent reduction in comparative advantage. Alternatively, with agriculture also impacted by climate change and increasing drought-induced crop failure in some areas (e.g. Southern Africa, Sahel fringe), more people could come into fishing as a 'safety net' occupation, further threatening over-exploited fish stocks and reducing resource rents and sectoral efficiency and competitiveness in export markets.

In aquaculture, problems with disease management and a lack of stable and equitable access to input and output markets mean that it can be a high risk venture. Further climate-associated risks could slow the growth of aquaculture and lead to further capital intensification, reducing recent gains in closing the 'supply gap' through provision of lower-cost food to lower-income fish consumers, and providing millions of small-holder farmers in developing countries with a new cash-crop and nutritious supplement to staple crops.

Willingness to invest in community or participatory resource management: In a fishery where stocks are perceived to be subject to change from climate-driven processes obviously beyond the control of local management, management institutions may weaken as fishers perceive no returns on investment in current restraint in the form of gear, catch, or area restrictions. Conversely, the threat of climate change may galavanise local management in developing a broader habitat-based conservation approach to maximize the likelihood that fisheries will be maintained, even if species turnover occurs.

Direct and indirect impacts of increased storm severity and sea level rise

There are on-going scientific controversies around the general perception that storm frequency and severity are increasing due to climate change, and that there may be changes in seasonality and typical track of storm events. An emerging consensus around recent trends and predictions for hurricane energy (a measure of storm severity) indicate no evidence for increased frequency of storms, but strong evidence for a trend for increasing severity and therefore destructiveness of storms over the last 20-40 years (i.e. exceeding the periodicity of decadal cycles in the ocean climate system and attributable to anthropogenic warming); this trend is particularly evident in the western Atlantic (Emanuel et al. 2008).

Countries around the equator are least likely to be affected as most major tropical storms are generated around latitudes 8 and 35 degrees, north and South of the equator (See Figure 18 in Appendix 2). The distributional implications of these predicted changes in storm severity are:

- Countries near the equator or in parts of the ocean that are outside the major storm areas (e.g. Coastal countries in West Africa, Commonwealth states such as Kenya and Tanzania, Maldives, Papua New Guinea, Solomon Islands; and non-Commonwealth States such as the countries on the West coast of Latin America, Indonesia) are likely to see smaller changes in the costs of storm damage relative to those inside the major storm areas (e.g. Commonwealth States in the Caribbean, Mozambique, Mauritius, Bangladesh, India; and non-Commonwealth States such as the Philippines, Vietnam and Myanmar and the non-Commonwealth Caribbean);
- Small developing countries in the 'hurricane belt' of the Caribbean will be affected even more than many such countries in the Indian and Pacific Oceans;
- Storm damage affecting the fisheries and aquaculture sector is likely to be greatest in low-elevation densely populated areas subject to sea-level rise and located in areas of known storm tracks (e.g. Bangladesh, Guyana); and

- Countries with a history of living with extreme weather (e.g. Caribbean islands, Bangladesh) generally have a range of effective adaptations, although these events will always have both human and economic costs.

Adaptation to reduce the loss of life and damage from storms may itself impose unforeseen sectoral efficiency and competiveness costs. Fishing days in the Bay of Bengal have been greatly reduced by the number of early warnings for severe weather that are now available to fleets. Some of these warnings are false alarms, which involve returning to port or staying in port needlessly.

The kinds of damage experienced as a result of increased severity of high winds, storm surges and floods may include:

- Damage to productive assets –flooding and destruction of fish-farming installations and loss of fish stocks; loss and damage to boats and fishing gear (see Macfadyen et al 2009 for some examples of costs), and to business assets in ancillary occupations (boat-building yards, marine engineers workshops, fishing gear shops, fish processing equipment, retail premises etc). As fisherfolk and fish-farmers often have diverse income sources that complement or supplement often seasonal fishing income, such damage can also include loss of perennial and annual crops and livestock, salinization of farm-land, and loss of assets from non-natural resource enterprises;
- Damage to sector infrastructure and institutional capacity, including to harbours, research and extension facilities, input and output marketing networks;
- Damage to coastal and floodplain fisherfolk's homes, lives and health - including loss of life and increase in post-disaster epidemic disease, such as cholera and other enteric diseases, and pathogens with aquatic life-stages, such as malaria and bilharzia; and
- Destruction of coastal ecosystems – Severe storms may directly damage coral reefs and mangroves, reconfigure the topography and water-flow of coastal lagoons and estuaries and erode beaches, leading to ecological damage that can slow the recovery of fisheries and aquaculture.

Within-sector impacts – synthesis

There are few documented examples to support the above suggested impact pathways for future climate change, partly because the effects of climate change are only just beginning to be felt, and also because current impacts take place in the context of many other drivers of change. However, experience with past storms and other natural disasters has been documented. Although the nature of change and response may be speculative at this stage, it is still possible to initiate focused diagnostic studies of individual production systems to evaluate critical exposure of different elements of the value chain to climate change: the vulnerability of aquaculture to supplies of climate-affected small pelagic fish is an obvious example; the vulnerability of the live reef fish trade to climate-induced coral bleaching is another. In Chapter 5, we attempt this approach, in a preliminary way, for the three case-study countries selected for this review.

3.2.2. Sector contribution to national economies

Climate-induced changes in the fishery sector will have wider societal and economic implications; these will be greatest where fish and fisheries play important roles in society and the economy.

Rent generation by governments from fisheries

Most fisheries are managed by governments, although some management functions are increasingly devolved to fishers and other stakeholders. In capture fisheries - in contrast to aquaculture- fish within territorial waters and exclusive economic zones (EEZs) are considered state property before being caught. Again, this is changing, with the introduction of individual transferable quotas, which effectively privatize the fish in the sea, so that a share of them 'belong' to quota-holders, who can then choose to try to catch that share, or lease or sell the rights to catch it to others. A market in fish quota can thus develop. These quota-based systems are not yet prevalent in small developing states and instead, fish are often considered either state property until caught, or are subject to various forms of formal and informal claim to community rights of access. Thus, most fishing rights are usufruct rights, rather than full property rights. Governments and other share-holders in fisheries generate revenues through the issue of licences that grant rights of access to state resources by both their own citizens, and citizens of other states who want to fish in their EEZ. For many small-island states, and those with rich coastal fishing grounds (e.g. in West Africa), the value of fisheries in the EEZ is considerable and the trade in fisheries-related services makes substantive contributions to GDP (FAO, 2006). Governments also generate revenue from domestic fisheries through the collection of various fees and taxes related to fishing, processing and trading inputs and outputs. Where revenues are substantial, they can be used for general budget support and for investment in development that has benefits beyond the fishery sector. Even where revenues are modest, they are often used to support expenditures outside the sector. In Uganda for example, local government expenditure in lakeshore districts is substantially supported by fishing-related fees and taxes (Allison, 2002, and Macfadyen 2008).

Key sources of revenue from fisheries, all of which are threatened by climate change, include:

- Licence fee income from foreign fleets fishing in the EEZ;
- Lease of fishing rights;
- Vessel registration fees;
- Taxes on landings and/or sales;
- Export duties; and
- Income and company taxation from fishing and processing companies and those working within them.

Impacts on food and nutritional security

Food security of fisherfolk is achieved through income from fish sales, while having access to fish provides direct nutritional security (access to a healthy, balanced diet, rather than just access to sufficient calories). As population increases, per capita supply of fish is decreasing globally, despite the rapid rise of aquaculture production. This 'fish gap'is largest in Africa, where fish consumption rates are the lowest in the world, despite Africans having proportionally greater reliance on fish as a source of dietary animal protein than people in developed countries. As fish become scarcer and their value rises, there is also concern that the supply of fish to lower income consumers is decreasing fastest. Globally, this is seen in the net transfer of fish from low income food deficit countries to developed countries. When these trends are considered in the light of projected production decreases in capture fisheries due to climate change, this poses important questions for policy to balance local nutritional needs with the revenue generating potential of export-oriented production. Fortunately, fish species supplying export markets are usually not the same as those supplying lower-income consumers in domestic and regional markets, although conflicts of interest can occur in fisheries used for both food and fish-meal or fish-oil.

In West Africa, the combination of increasing exports and weakening upwelling reducing fish production, based on a decadal cycle, has been projected to lead to an undersupply of 1.3 million tonnes in 2009 if apparent consumption is maintained at its 2003 level, and of 3.6 million tonnes if apparent consumption continues the 4% actual annual increase (driven by population increase and development) seen through the 1990s Upwelling off the West African coast is predicted to weaken under the influence of global warming. This will decrease fish supplies, further increasing the gap between supply and demand (see Figure 19 Appendix 2).

Employment, safety nets and the social and cultural role of fisheries
The fisheries and aquaculture sectors can be important sources of employment, even in landlocked countries e.g. one in ten adult Ugandans has a full- or part-time engagement in a fishery sector-related job (Allison, 2002). In many small island developing states and archipelago countries (e.g. Philippines, Indonesia, Solomon Islands), the fisheries sector is an integral part of cultural identity. Climate change, coupled with resource over-exploitation, may lead to shrinking of the fishery sector, with loss of the strong cultural affinity with the coast and marine environment that characterizes many such countries; such a loss has already occurred in maritime cultures of developed Commonwealth States – including the UK and coastal Canada. The social and economic costs of such industry restricting and down-sizing, and responses by Governments, may be considerable.

The accessible fisheries of inland and inter-tidal and near-shore marine waters have a role as seasonal or crisis-related 'safety nets' for people displaced from other sectors; in Senegal and Ghana ,for example, drought and market and policy failures in agriculture led to an influx of people seeking employment in fisheries during the 1990s, greatly increasing the pressure on near-shore fishery resources.

As climate change begins to impact inland and near-shore fisheries, and with the need for more restrictive access to maintain the flow of trade and other benefits from fisheries, the role of fisheries as a 'safety net' is becoming less viable. This may require greater state and/or donor financing of social protection measures to replace the lost safety net function of small-scale fishing.

Costs of adaptation
To maintain the flow of benefits to society and the economy from fisheries, governments are likely to have to increase their investments in developing coherent 'climate proof' sectoral policy and legislation, management and development. The following costs are likely to arise to address adaptation, or in response to fisheries decline due to climate change:

- Investments in 'climate proofing' infrastructure (e.g. coastal defenses, design of harbours etc);
- Social and economic costs of redundancies in fishing and aquaculture sector;
- Weather-linked unemployment insurance for fisherfolk (mostly used in developed countries; few developing countries have this kind of formal social security system);
- Costs of ecosystem maintenance and repair – e.g. marine protected areas, restoration of mangroves, artificial reef construction, beach replenishment, maintaining 'environmental flows' in rivers; and

- There will also be a need to consider the costs to fisheries and aquaculture of adaptation in other sectors (e.g. considering in-stream generation of hydropower rather than dams where there are important riverine fisheries; use of ‘soft’ coastal defenses with fish habitat value (mangroves, artificial reefs, protecting existing reefs) where fisheries are important to coastal livelihoods.

Additional discussion on adaptive strategies is provided in Chapter 6.

4. Vulnerability and resilience of the fisheries sector to climate change impacts

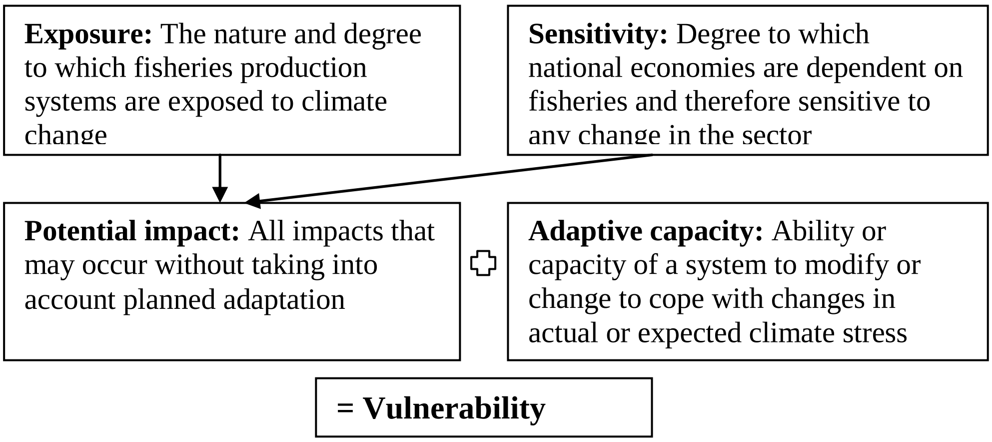
In this Chapter we present the application of a conceptual model to assess the vulnerability of different countries based on the degree of exposure to climate change, the degree of economic dependence on fisheries, and an index of national capacity to adapt to foreseen impacts, based on a recent global analysis (Allison et al 2009). We discuss implications of these results for small developing countries in the Commonwealth.

A recent study on the vulnerability of national economies and food systems to climate impacts on fisheries has revealed that African countries are the most vulnerable to the likely impacts of climate change on fisheries. This is in spite of over 80 percent of the world's fishers being in South and Southeast Asia, and fish catches being greater in Latin America and Asia. What makes African fisheries so vulnerable? The analysis suggests that semi-arid countries with significant coastal or inland fisheries have high exposure to future increases in temperature (and linked changes in precipitation, hydrology and coastal current systems), high catches, exports and high nutritional dependence on fish for protein, and low capacity to adapt to change due to their comparatively small or weak economies and low human development indices. These countries include Angola, Congo, Mauritania, Mali, Sierra Leone, Senegal and Niger.

Fisheries provide employment for up to ten million people in Africa and provide a vital source of protein to 200 million people. Protein may be particularly limited in these countries resulting in high dependency on wild caught fish and bushmeat. Other vulnerable nations include Rift valley countries such as Malawi, Uganda and Mozambique and Asian river-dependent fishery nations including Pakistan, Bangladesh and Cambodia. Countries such as Russia, Peru and Columbia are sensitive to climate changes due to their high catches and reliance on exports or high employment from fisheries, but their larger economies and higher human development indices mean they are likely to have a higher adaptive capacity to deal with potential impacts.

Global vulnerability of fisheries systems to climate change

Vulnerability to climate change is defined by the Intergovernmental Panel on Climate Change as a combination of the potential impact (sensitivity plus exposure) and adaptive capacity.



National exposure to climate change was measured as the average predicted surface air temperature in 2050. Sensitivity represented the national relative importance of fisheries and was a composite of: number of fishers, fish export value as a proportion of total export value, size of fisheries employment sector, total catch and percent contribution of fish to daily protein intake. Adaptive capacity (resilience) was a composite of human development indices and economic performance, including; life expectancy, literacy rates, school attendance, size of economy, political stability and good governance, law, accountability and corruptibility.

In Figure 5 below, the darker colours represent higher exposure to climate change (Figure a), higher sensitivity (Figure b), lower adaptive capacity (Figure c) and higher vulnerability (Figure d). West African and Central African fisheries form the bulk of the countries whose economies are most vulnerable to climate impacts on fisheries. Countries shaded in grey are those for which data are unavailable. Data for many small-island developing states were not available for all three components of vulnerability, so these are missing from the analysis.

Figure 5: Exposure, sensitivity, adaptive capacity, and vulnerability to climate change impacts on fisheries

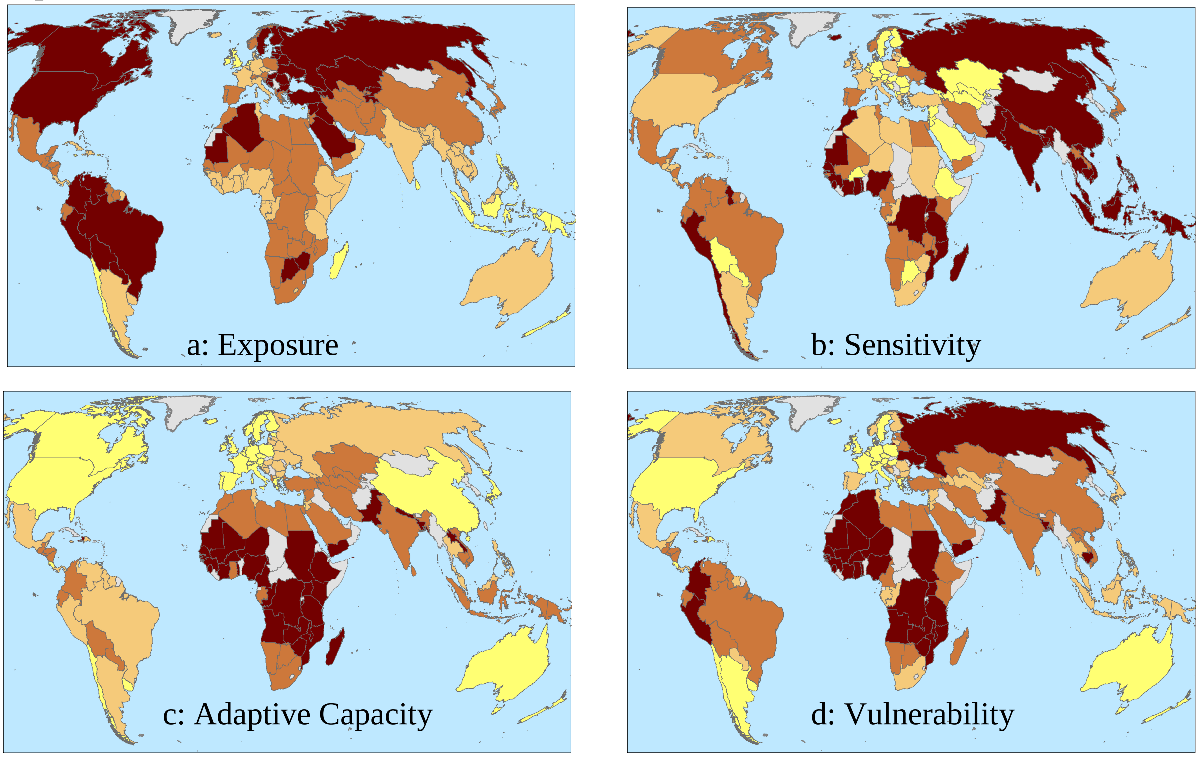


Table 2 below shows the relative vulnerabilities of national economies to climate change-driven impacts on fisheries. The 33 'highly vulnerable' countries (the top quartile of the dataset) are ranked by vulnerability under IPCC scenario B2 (local development, lower emissions); vulnerability rankings under scenario A1FI (rapid development, high emissions) are presented in parentheses. Index values (rankings) of exposure (E), sensitivity (S) and adaptive capacity (AC) are presented under scenario B2. All rankings are relative to the entire dataset (n = 132 countries). Least Developed Countries are listed in bold and Commonwealth Countries are highlighted with shading.

Table 2: Relative vulnerabilities of national economies to climate change-driven impacts on fisheries

Rank	Country	Vulnerability	E	S	AC
1	**Angola**	0.77 (2)	0.74 (34)	0.60 (38)	0.98 (1)
2	**DR Congo**	0.75 (1)	0.65 (59)	0.67 (20)	0.94 (4)
3	Russian Federation	0.73 (7)	1.00 (1)	0.67 (22)	0.52 (75)
4	**Mauritania**	0.73 (6)	0.76 (26)	0.59 (48)	0.83 (11)
5	**Senegal**	0.72 (5)	0.65 (59)	0.74 (9)	0.78 (18)
6	**Mali**	0.72 (3)	0.74 (34)	0.57 (57)	0.85 (9)
7	**Sierra Leone**	0.71 (4)	0.50	0.68 (19)	0.96 (3)
8	**Mozambique**	0.69 (11)	0.68 (48)	0.59 (46)	0.81 (13)
9	**Niger**	0.69 (13)	0.68 (48)	0.43	0.97 (2)
10	Peru	0.69 (9)	0.82 (18)	0.73 (10)	0.51 (76)

Rank	Country	Vulnerability	E	S	AC
11	Morocco	0.69 (12)	0.74 (34)	0.69 (16)	0.63 (39)
12	**Bangladesh**	0.68 (8)	0.53 (93)	0.80 (4)	0.72 (32)
13	**Zambia**	0.68 (21)	0.74 (34)	0.54 (69)	0.77 (20)
14	Ukraine	0.68 (20)	0.91 (4)	0.59 (42)	0.54 (69)
15	**Malawi**	0.68 (18)	0.71 (43)	0.55 (63)	0.77 (19)
16	**Uganda**	0.68 (14)	0.62 (69)	0.65 (26)	0.76 (25)
17	Zimbabwe	0.67 (31)	0.88 (7)	0.35	0.79 (16)
18	Côte d'Ivoire	0.67 (10)	0.56 (85)	0.61 (34)	0.84 (10)
19	**Yemen**	0.67 (22)	0.68 (48)	0.56 (61)	0.77 (22)
20	Pakistan	0.67 (15)	0.62 (69)	0.61 (32)	0.76 (24)
21	**Burundi**	0.66 (16)	0.59 (77)	0.50 (84)	0.91 (6)
22	**Guinea**	0.66 (17)	0.59 (77)	0.60 (37)	0.80 (14)
23	Nigeria	0.65 (23)	0.53 (93)	0.65 (25)	0.78 (17)
24	Colombia	0.65 (28)	0.82 (18)	0.59 (43)	0.54 (66)
25	Ghana	0.65 (25)	0.53 (93)	0.76 (7)	0.66 (36)
26	**Guinea-Bissau**	0.64 (26)	0.56 (85)	0.50 (83)	0.88 (7)
27	Vietnam	0.64 (24)	0.53 (93)	0.85 (1)	0.55 (63)
28	Venezuela	0.64 (32)	0.79 (23)	0.60 (39)	0.53 (71)
29	Algeria	0.64 (36)	0.82 (18)	0.46 (94)	0.64 (38)
30	**Cambodia**	0.64 (27)	0.56 (85)	0.69 (18)	0.67 (35)
31	**Tanzania**	0.64 (19)	0.5 (103)	0.66 (24)	0.75 (26)
32	**Gambia**	0.63 (33)	0.62 (69)	0.55 (65)	0.73 (30)
33	Turkey	0.63 (44)	0.82 (18)	0.52 (74)	0.55 (65)

Source: Based on Allison et al. 2009

Other measures of exposure could equally include sea level rise and extreme weather events. Sea level rises and extreme weather events lead to risks to human life and to habitation, destruction of coastal infrastructure, loss of fishing and fish-farming assets, reduction of fishing time at sea and a range of secondary effects, which may include disease epidemics after floods, and even the need to migrate out of a badly affected or increasingly unsafe area. The areas most vulnerable are those where physical exposure to risks is highest due to topography and local and regional weather systems (Figure 13 in Appendix 2) and where fishing and aquaculture are mainstays of the local, regional or national economy. Such areas include the coastal areas of the Philippines, the countries bordering the South China Sea and the Bay of Bengal, Indonesia and other island and archipelago nations. Main risks are associated with monsoon-season storms which also bring heavy rainfall. If they occur during spring tides, flooding can be especially severe and will become more so as sea level rises.

The differential vulnerability to storms of similar magnitude is demonstrated by comparing the impacts of Cyclone Sidr, which hit Bangladesh in November 2007 and Cyclone Nargis, which hit Myanmar in May 2008. Both caused extensive damage to agriculture, aquaculture and fisheries, as well as infrastructure, but the main contrast is in loss of human life: over 3,500 people were killed in Bangladesh, while over 150,000 people died in Myanmar; the difference in fatalities is attributable to a large part to Bangladesh's investment in disaster preparedness and response capacity – including both coastal defences, storm and flood shelters and, crucially, early warnings communicated by cell phone networks set up expressly for this purpose (Webster, 2008).

SIDS may also be especially vulnerable to climate change (and other impacts) due to the following reasons:

- Geographic isolation;
- Small physical size;
- Ecological uniqueness and fragility;
- Rapid human population growth and high densities;
- Limited natural resources;
- High dependence on marine resources;
- Sensitive and exposed to extremely damaging natural disasters;
- Small economies with low diversification (thinness);
- Economic openness;
- Low elevation of above mean level; and
- Poorly-developed infrastructure and limited capacity

In inland areas, the fishery and aquaculture systems of the major river basins, deltas and floodplains of Asia and Africa are also particularly vulnerable to changes in the seasonal flood cycle, and to increased severity of floods and droughts.

To date, vulnerability analysis has focused on the ability of the wider economy and governance system to absorb any impacts to the fishery sector (Allison et al., 2009). The suggested indicators in Table 3 move towards a more fisheries sector-focused index of adaptive capacity. In the next Chapter of this report when we examine three Commonwealth countries (see Sections 5.2 and 5.3), we also provide a wide range of additional indicators related to exposure and dependency/sensitivity which could be considered in future work.

Refining a fisheries-specific vulnerability index (incorporating exposure, dependency and adaptive capacity) and applying it to all Commonwealth States is beyond the scope of the present study, but such an analysis could be conducted for the fisheries sector as part of any more detailed analysis of potential climate change impacts on food security, poverty reduction, trade and economic growth.

Table 3: Potential fishery-sector adaptive capacity indicators for national-level analysis.

Adaptive capacity indicator	Explanation	Potential source(s)
Scientific Robustness of fishery management advice	Better management advice can help set precautionary catch limits to sustain stocks; healthy fish stocks are more climate resilient	Mora et al. 2009
Policy transparency	Policy that has been subject to scrutiny and participation of a range of stakeholders is more likely to be implemented and its measures complied with.	Mora et al. 2009
Capacity to implement management	Good policy and transparent participatory processes to develop it will be meaningless without capacity to implement its measures. This indicator assesses fishery management capacity but could represent ability to implement policy more generally.	Mora et al. 2009
Reliance on subsidies	The more reliant on subsidies a fishery is, the less sustainable it is likely to be in the long run, because it can allow fishing to profit from a severely depleted fishery. But subsidies can also buffer against negative climate impacts in the short term	Mora et al. 2009
Fishing capacity relative to fishing opportunities	Over-capacity undermines sustainability and adaptive capacity.	Mora et al. 2009
Extent of fishing by foreign vessels	Can be seen as negative in the context of sustainability, but if properly controlled and generating revenue without competing with local fleets, could be beneficial for adaptation. E.g. if onshore facilities are prone to sea-level rise and storm damage with increasing frequency, exploiting fisheries through vessels based elsewhere may be more cost effective than maintaining a domestic fleet and processing capacity that has to be rebuilt after each hurricane	Mora et al. 2009
Probability of sustainable fisheries	The greater the likelihood of sustainability, the greater the likely capacity of the fishery to adapt to climate change	Mora et al. 2009
Level of compliance with FAO Code of Conduct for Responsible Fisheries (CCRF)	CCRF aims to ensure that fisheries are governed for environmental, economic and social sustainability; such fisheries would be better able to withstand pressures and shocks – including those arising from climate change; Compliance is also indicative of governance capacity – an important element of adaptive capacity	Pitcher et al. 2009 (note only available for some countries)

Adaptive capacity indicator	Explanation	Potential source(s)
Inclusion of fisheries sector in national Poverty Reduction Strategy Papers (applicable only to the Highly Indebted Poor Countries)	Recognition of the fisheries sector in PRSPs increases the likelihood of budgetary allocation to the sector in medium term expenditure frameworks. This should contribute to support for sector development	Thorpe et al (2005a, b; 2006 a, b) and http://www.imf.org/external/NP/prsp/prsp.asp
Inclusion of fisheries and aquaculture sector project plans in National Plans of Adaptation (NAPAs)	Finance for climate adaptation is supposed to be allocated via NAPAs; a suitable indicator could be the ratio between proportional spend on fisheries in NAPA to proportional contribution of fisheries to GDP	http://unfccc.int/files/adaptation/application/pdf/coastal_marine_e.pdf
Inclusion of fisheries and aquaculture in national disaster risk management (DRM) planning	When fisherfolk and fish farmers are included in DRM plans, the damage suffered by the sector will be reduced	FAO/WorldFish/NACA guidelines in preparation
Relative poverty of fishing-dependent households	National poverty surveys, case-studies of poverty	Unlikely to be available in the near future; data coverage will be patchy as few countries have included fisherfolk in large-scale national poverty surveys and small-scale livelihoods surveys are seldom representative and not done with standardized methods
Proportion of shoreline protected by natural defenses (e.g. mangroves and reefs)	Mangroves and reefs help fish resources deal with stresses resulting from exposure to climate change	Maina et al, vulnerability analysis, in preparation (WCS, Kenya)
Proportion of coastline protected by man-made structures	Protected coastline will reduce damage to homes and infrastructure from storms and floods.	Data from Middlesex Flood Hazard Research Center.
Proportion of fishers and/or fish-farmers with weather-linked insurance	Very low at present as micro-insurance is not generally available in fisheries and aquaculture	Swiss Re, Munich Re, IRC and private sector micro-insurance specialists

5. Case studies of the potential impacts of climate change on the fisheries sector

5.1 Introduction and case study selection

In this Chapter we take the analysis presented in Chapters 2-4 and assess the potential impacts of climate change on three countries. For each country we:

- Present baseline indicators and figures on the fisheries/aquaculture sector and national economies in the main body of the text, as well as considerable additional description for each country in Appendix 3, Appendix 4, and Appendix 5;
- Provide some information on current trade; and
- Outline possible climate change impacts and consider how the baseline figures, the status quo, and current trade might be affected by climate change.

Potential responses by the three case study countries are not explored in detail in this chapter because they are considered in more detail in Chapter 6.

The case study countries selected are: the Maldives, Solomon Islands, and Kenya. These countries were chosen because:

- Two of the three are included in the 50 least developed countries of the world, and all three are included in the list of the 100 countries in the world most vulnerable to climate change;
- They have high, but differing levels of dependency on fisheries;
- They are mix of small island states and continental countries;
- They have differing sizes of population (two small and one large), and gross national income per capita (two low and one a middle income country);
- They are geographically disperse;
- They all have considerable levels of processing in-country (canneries exist in Maldives and Solomons, and in Kenya there are a number of Nile perch and marine fish processing plants), and a high level of exports. We can thus expect climate change impacts to have significant effects on sector employment and trade;
- In the case of Kenya, the presence of Lake Victoria provides an opportunity to consider potential balances between production and trade from marine fisheries on the one hand, and inland freshwater fisheries on the other; and
- Changes to marine fisheries production could have corresponding impacts on efforts to develop aquaculture (both marine and freshwater) as an adaptive strategy for potentially declining capture production, and the three case studies have differing potentials for aquaculture development.

The intention of this Chapter is to move from the rather generalized descriptions of potential impacts of climate change in the previous sector, and to consider on a more localised basis how such changes might materialize and what they might mean in practical terms for fishers, communities and governments in the case study countries.

5.2 Baseline information

In this section we provide data tables to facilitate comparison between the Maldives, Kenya and the Solomon Islands. These tables are also important in informing the subsequent discussion on climate change impact scenarios because they provide a range of indicators related to:

- potential exposure to climate change impacts;

- dependency on fisheries and therefore sensitivity to any changes; and
- adaptive capacity

As noted earlier, when taken together, these factors provide an indication of the vulnerability of countries to climate change.

The tables below provide a far more comprehensive set of indicators of exposure, dependency and adaptive capacity for the fisheries sector than we believe has been considered previously.

The data tables are based primarily on the World Resources Institute's Earthtrends database[11], the University of British Columbia's Sea Around Us Project[12], and FAO statistics[13], but are updated and expanded where we have more recent data from other sources. Data indicators are grouped into three main categories relating to:

- coastal and marine ecosystems and fish production;
- communities and livelihoods; and
- national economies.

Table 4: Baseline indicators of coastal and marine ecosystems, and fish production

Country Indicator	Kenya	Maldives	Solomon Islands	Relevance/type of indicator
Aquaculture production, tonnes (2005 Kenya, 2001 Solomons)	1,047	0	15	Dependency on production for trade, incomes and livelihoods
Inland capture fisheries production, tonnes / $million (2007)	193,600 / 67	0 / 0	0 / 0	
Domestic marine capture fisheries production, tonnes (2007)	6,399	143,597	31,290	
Foreign catches in EEZ, tonnes (2002)	n/a	n/a	80,123	Dependency on foreign licence revenues
Marine production as % of total production	3.3	100	100	Dependency and balance of sectors
Ratio of aquaculture to capture fisheries production (%)	0.5	0	0.1	
Territorial sea area, km2	12,382	125,858	212,294	Dependency and balance of species-type
EEZ area (part comprising continental shelf waters), km2	116,942 (11,073)	923,322 (34,538)	1,589,477 (36,282)	
Number of marine protected areas (2006)	12	25	24	Adaptive capacity
Area of MPAs, km2	2,858	n/a	926	
Coral reefs (% of global)	0.19	2.86	1.99	Exposure, dependency and adaptive capacity
Primary production ($mgC \cdot m^{-2} \cdot day^{-1}$)	572	387	267	Exposure through relationship with fish production

[11] www.earthtrends.wri.org
[12] www.seaaroundus.org
[13] www.fao.org

Table 5: Baseline indicators for communities, nutrition and livelihoods

Country / Indicator	Kenya	Maldives	Solomon Islands	Relevance/type of indicator
Mobile phone subscribers per 1000 people (2005)	134.6	345.3	12.6	Adaptive capacity and response preparedness to extreme weather events
Fish protein as % of total protein supply (2002)	21.0	54.8	23.1	Dependency (food security and employment/incomes)
Annual food supply per capita from fish and fish products, kg (2002)	4.4	185.9	39.2[14]	
People employed in fisheries and aquaculture (2000)	59,565	19,108	11,000	
Fisheries and aquaculture employment as % of total (2000)	0.35%	13.55%	4.35%	

Table 6: Baseline indicators at a national level

Country / Indicator	Kenya	Maldives	Solomon Islands	Relevance/type of indicator
Quantity of fish exports, tonnes (2006)	15,532	113,276	18,201	Dependency (trade)
Quantity of fish exports, $'000s (2006)	55,798	133,591	25,661	
Government revenue from sector, $ millions (foreign sources in brackets)	1.5-2.0 (0.5-0.6)	n/a (n/a)	1.5-2.0 (12.0)	
Population within 100km from coast, thousands (2000)	7.7	81.1	100.0	Exposure to possible sea level rise
Coastline length, km	1,586	2,001	9,880	
Total population in low elevation coastal zone (and %) (2000)[15]	280,327 (1%)	290,923 (100%)	87,075 (19%)	
Highest point above sea level	5,199m	2.4m	2,447m	
Secondary school net enrollment ratio %, (2006)	43	67	27	Adaptive capacity & potential employment in other sectors
International tourism receipts $ millions (2006)	1,182[16]	434	8	
www.doingbusiness.org ranking of 181 countries (2009)	82	69	89	
Literacy rate, all adults, % (2007)	73.6	97	n/a	
Total population growth rate (2000-2005 and 2045-2050)	2.61 / 1.26	1.57 / 0.61	2.57 / 0.89	Future dependency (fish availability per capita) and adaptive capacity (competing
Total population, thousands (2007, 2025, 2050)	37,538 / 57,176 / 84,757	306 / 411 / 510	496 / 705 / 955	

[14] Recent information (Bell et al, 2008) based on socio-economic surveys suggests that in coastal areas per capita consumption may be as high as 120kg/year

[15] From **http://sedac.ciesin.columbia.edu/gpw/lecz.jsp**. LECZ defined as under 10m

[16] Note that in Kenya a significant proportion of tourism receipts are non-maritime in nature

Country Indicator	**Kenya**	**Maldives**	**Solomon Islands**	**Relevance/type of indicator**
				demands)
GDP current in $, per capita / total (millions) (2006)	623 / 22,779	3,090 / 927	695 / 336	Adaptive capacity (not-fisheries specific)
Debt as a % of GNI (2006)	25.7	49.6	43.4	
% Population living on less or equal to $1/day	22.8	n/a	n/a	
Aid as % of government expenditure (2006)	22.5	7.5	n/a	
Global competitive index	93 of 134	n/a	n/a	
Control of corruption index (-2.5 worst governance, 0 average, 2.5 best governance), (2007)	-0.94	-0.78	-0.63	
Government effectiveness index (-2.5 worst, 0 average, 2.5 best)	-0.59	-0.19	-0.82	
Country has a PRSP	Yes	Yes	No	
Country has a NAPA	No	Yes	No	
Fisheries management effectiveness[17]	Orange	Orange	Red	Adaptive capacity (fisheries specific)
Fisheries mentioned in PRSP	?	Yes	n/a	
Fisheries mentioned in NAPA	n/a	Yes	n/a	

5.3 Assessment of potential climate change impacts on the fisheries sector in Kenya, Maldives and the Solomons Islands

5.3.1 Introduction

The assessment of the potential impacts of climate change on the fisheries sector in our case study countries must start with some important statements about assumptions and questions of methodology.

When discussing climate change impacts on the sector, it is most important to remember that climate change is just one of many factors affecting fisheries and related trade, and the competitiveness of countries *vis a vis* each other. It is very likely that other factors, for example policy, regulation and status with regards to fisheries management and the business environment, are likely to play a far greater role in any country's competitive position in both the short and long term. In the discussion to follow, other such factors are not considered except to the extent to which they may themselves impact on the climate change-related adaptive capacity of the case study countries.

It is also fundamental to consider time scales when assessing potential impacts of, and adaptation to, climate change. While some biophysical impacts of climate change and the frequency/magnitude of extreme weather events and resulting changes to the fisheries sector may be evident over short timeframes, it may take decades before some predicted changes are

[17] Mora C, et al 2009. This analysis provides an average of six different fishery management attributes evaluated for countries around the world (i.e. science, policy, enforcement, fishing effort, subsidies and foreign fishing), and rates countries as green, orange or red, corresponding to good, of cause for concern, and bad.

of significant magnitude to impact on the fisheries sector. The longer the timeframe used to consider the impacts of climate change on the fisheries sector, the more chance there is that changes to other factors (e.g. fisheries governance and management) may also have an impact on the sector, while in the short-term it also raises the relative importance of these other factors compared to the importance of climate change. In addition, scientific assessment of the *magnitude* and the *rate* of climate change impacts on the fisheries sector may only be possible over longer rather than shorter timeframes.

Making statements about future impacts on the sector is very problematic due to uncertainties in climate change models, and a lack of resolution in estimations at the country level. This means that it is almost impossible to prioritize adapting to different physical changes and their impacts on any one country, or to say with any certainty which may be more or less important over different time scales. Likewise, identifying how individuals, communities and nations may react and adapt to climate change in the future is problematic, even though we can make some estimates based on the indicators of adaptive capacity proposed in the baseline information above.

For all of these reasons, it is both inappropriate and virtually impossible to make quantitative *projections* as to how baseline data for Kenya, Maldives and the Solomon Islands might change in the future in response to climate change and other drivers of change. Nevertheless, as evidenced by the text earlier in this report, there is now a significant body of literature available to suggest the different *types* of physical changes resulting from climate change, and the possible impact *pathways* to the effects on ecosystems and fish production, and in turn the impacts on fishers, communities and nations. In the following text we therefore indicate some potential implications of climate change on the fisheries sector in the case study countries. These scenarios cover a broad range of potential impacts in each of the three countries, although we try to focus where possible on trade-specific impacts and issues of competitiveness.

As noted above, potential mechanisms to deal with climate change impacts and to ensure trade competitiveness, are not considered in detail for the case study countries. Policy responses applicable to all Commonwealth Developing States are presented in Chapter 6.

5.3.2 Kenya

Current trade position

Data on the quantity and value of fisheries exports from Kenya by product type are provided below, and reflect the very strong dominance of exports of freshwater Nile Perch from Lake Victoria.

Table 7: Kenyan fish exports by volume and value 2004-2006 (tonnes and $‘000s)

Export Quantity	2004	2005	2006
Fish fillets, fresh or chilled, nei	5,582	3,157	3,323
Fish meat, whether or not minced, frozen, nei	43	164	443
Fish, frozen, nei	381	438	1,724
Miscellaneous corals and shells	676	191	463
Miscellaneous dried fish, whether or not salted, nei	20	4	171
Nile perch fillets, frozen	10,386	5,477	7,584
Octopus, live, fresh or chilled	319	234	395
Shrimps and prawns, frozen, nei	73	92	163

Export Quantity	2004	2005	2006
Shrimps and prawns, not frozen, nei	171	273	295
Other	894	1,036	971
Total	18,545	11,066	15,532
Export Value	**2004**	**2005**	**2006**
Fish fillets, fresh or chilled, nei	18,114	15,826	14,298
Fish meat, whether or not minced, frozen, nei	129	457	1,369
Fish waste, nei	166	660	374
Fish, frozen, nei	1,152	1,324	5,863
Herrings, fresh or chilled, nei	.	-	330
Miscellaneous dried fish, whether or not salted, nei	17	47	373
Nile perch fillets, frozen	27,586	35,598	27,858
Octopus, live, fresh or chilled	1,026	1,194	1,290
Shrimps and prawns, frozen, nei	452	562	499
Shrimps and prawns, not frozen, nei	843	1,700	1,603
Other	3,657	3,013	1,941
Total	53,142	60,381	55,798

Source: FAO

Revenue (and profits/value-added) is made from the fishery not just at the first point of sale, but through supply chains for different products from the catching sector through to consumers. Of special significance in this regard is the revenue made from exports because of:

- the potential to add-value and generate high prices in export markets;
- the fact that earnings are made in foreign currency;
- the positive impacts of export trade on the balance of trade; and
- the perception that extracting taxes/rents from processors at the export level may be a relatively easy way for government to generate the revenues necessary to provide the funds needed to ensure future sustainable management and to contribute to the national treasury.

Export figures for Nile perch in recent years are provided below for Lake Victoria as a whole, and show declining volumes over the last three years, and relatively constant total export values overall (with declines in Uganda and Kenya, and increases in Tanzania).

The European Union (EU) is the preferred destination for Nile perch from all three countries bordering Lake Victoria as it offers higher prices than other markets, and particularly important markets are the Mediterranean countries. The EU is reported to represent around 60-70% of the value of exports from Kenya[18], but reliance on it is not constant and exporters from the region face a number of challenges in the form of import regulations in the EU[19], competition from other sources (notably Vietnamese catfish), the power of buyers overseas, trends towards environmental certification, and erosion of preferential tariff regimes.

[18] Pers. Comm., AFIPEK and Table 9

[19] The Lake Victoria Nile perch fishery has suffered three EU import bans. In 1997 Spain and Italy imposed a ban claiming the presence of *Salmonella*. In 1998 the EU imposed a ban on chilled fish as a result of cholera outbreaks in East Africa. A third EU ban was imposed in 1999 as a result of reported use of poisons by fishers to catch fish in Lake Victoria

Table 8: Exports of Nile perch from Lake Victoria, 2004-2007 ('000 tonnes and $'000s)

	Uganda		Kenya		Tanzania		Total	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
2004	30.0	102.9	15.7	52.0	34.7	87.5	80.4	242.4
2005	36.6	128.1	13.8	61.1	40.8	130.2	91.2	319.4
2006	32.0	137.0	11.9	54.5	40.8	127.5	84.7	319.0
2007	26.1	116.0	13.0	44.6	42.8	147.0	81.9	307.6

Source: FMP, Governments. Note: Processed weight and FoB values.

Table 9: Fresh and Frozen Fillet Imports from Lake Victoria[20]

Importer	% of Total
Europe	72
Australia	6
Japan	6
USA	5
Others	8

Source: LVFO, 2008

Kenyan processing companies exporting Nile Perch are based primarily in Kisumu on the lake shore. Declining export prices, coupled with high purchase prices for fish due to competition between buyers with declining volumes for the lake as a whole and increasing input costs, are resulting in considerable pressures on the processing sector. A number of factories have closed over the last 10 years due to such issues, as well in response to fish previously landed in Kisumu being diverted to Uganda and Tanzania once the processing industry developed in those two countries.[21]

Table 10: Nile Perch processing companies in Kenya

Company Name	Group / Independent
WE Tilley	Tilley
Peche Foods	Independent
FP (2000)	Marine and Agro
East African SF	Alpha
Prinsal	Marine and Agro
Capital	Independent
Igloo	Marine and Agro

With respect to marine fisheries, four domestic processing plants in Mombasa and industrial shrimp trawlers based at Mombasa produce marine fishery products for export. These enterprises export around 5,000 tonnes of marine fish products annually. Exports of tuna loins, generating employment for up to 1,000 people dependent on factory throughput, are derived from purchases from product transshipped in Mombassa, and not based on locally-caught fish.

[20] Globefish 2006

[21] A total of 25 factories are exporting Lake Victoria Nile Perch to Europe. 10 factories in Uganda, 6 in Kenya and 9 in Tanzania

Government revenue from the fisheries sector is primarily generated from export duties (see Appendix 3).

Exposure to physical impacts of climate change and effects on ecosystems and fish production

Table 11 and Table 12 provide some indication, based on the typology of possible physical changes and the literature discussed in Chapter 2 of this report, of the possible exposure of Kenya to physical impacts of climate change that may feed through impact pathways on fish and ecosystems to have an impact on the fisheries sector and related trade in Kenya.

Table 11: Possible physical impacts of climate change relevant for Kenyan fisheries

Physical changes	**Discussion**
Heat content and temperature	Lake and sea temperature increases - similar to main regional export competitors Ugunda and Tanzania, but increases likely to be less in Kenya than in temperate and sub-tropical countries
Salinity and stratification	Lake Victoria stratification could become stronger than in past leading to de-oxygenation in deep sheltered areas, such as Kenya's Winam gulf. Marine fisheries also potential for increased salinity and stratification
Ocean circulation and upwelling	Not relevant for lakes Oceans – Kenya EEZ not an upwelling zone
Acidification and chemical changes	Could affect coral reef formation on Kenyan coast
Sea and lake levels	Potential for increased variability in lake levels. Predictions about average lake levels unclear as increases in annual mean rainfall in East Africa could balance out increased evaporation, but recent declines in fish abundance in the East African Rift Valley lakes have been linked with climate impacts on lake ecosystems and declining lake levels. Note that sea level rises for Vietnam (main competitor in export markets for Nile Perch with its *Pangassius* aquaculture) may be significant and sea levels rises in the Mekong delta may reduce land space available for aquaculture
Sediment levels	Could have greater impact on inland fisheries than coastal fisheries through land use changes in Lake Victoria basin, although increases in coastal sedimentation could also have impacts on near-shore corals and fish species
Extreme weather events	Kenya less exposed to extreme events that many other countries (e.g. Pacific, Caribbean, Bay of Bengal)
Low frequency variability	Whole West Indian Ocean affected by El Niño events and decadal cycles. But not clear whether global warming will result in stronger and more frequent ENSO or not

Table 12: Possible impacts on fish and ecosystems in Kenyan fisheries

Impacts on fish and ecosystems	**Discussion**
Physiological spawning and recruitment	Lake Victoria commercial species (e.g. Nile Perch, tilapia) are adapted to a wide range of temperatures in other countries so there may be few impacts, but endemic species of biodiversity and local food security interest may be more affected. No current evidence

Impacts on fish and ecosystems	Discussion
	for which commercial species will be more/less affected than others Marine – could impact on balance of species not tolerant to higher temperatures (see Appendix 3 for more information on current marine and freshwater catches)
Primary production	Likely to decrease, but note baseline indicator tables suggest primary productivity relatively high, at least compared to the other two case study countries
Secondary production	Likely to decrease but local/regional models not available
Distribution of fish	Pole-ward movement of most fish suggests reduction in tuna and other species availability relative to other competitor producers at higher latitudes Temperature changes may impact on depth at which tuna and tuna-like species are found.
Abundance of fish	Could be potential changes in species mix of both commercial and non-commercial species. Likely to be the same for other export competitor countries in Lake. Impacts in marine fish abundance not clear from literature
Phenology	Changes in timing of spawning, migration seem likely, but specific details unknown
Species invasion and disease	Could be important in lake Victoria, probably less so in marine fisheries. Note also that there is virtually no aquaculture at present (which may be especially susceptible to increased disease occurrences)
Food web impacts	Potential simplification and changes to food webs as species mix changes, implying greater volatility of production, but details not known.

Impacts on fishers/communities, trade and national economies

As noted in the tables above, there are many physical changes from climate change that could impact on fish and ecosystems, and therefore on fishers, communities and national economies. However, determining the extent of exposure and therefore the impacts is not possible at the present time based on the scientific information available. However, based on the likely direction of change, and when considering the baseline indicators provided above and the additional information in Appendix 3, one can make some observations about potential impacts on the fisheries sector and related trade in Kenya over coming years.

With regards to dependency on fisheries production and trade, compared to the other two countries we examine below, fisheries sector dependency is relatively low in Kenya. For example fish as a % of total protein and sector employment as a % of total employment (see baseline indicator tables) are lower for Kenya than for both Maldives and the Solomon Islands. However these figures mask very high dependencies on the sector for both food security and employment in specific locations, e.g. around Lake Victoria and in some coastal communities. These are also the districts in Kenya with the highest proportion of people living in poverty, with fisheries providing one of the more promising contributions to reducing that poverty. And there are far greater numbers of people in absolute terms reliant directly on the sector for employment in Kenya than in Maldives and the Solomon Islands, with almost 60,000 people engaged in catching, processing and marketing fish.

Change in future volumes of production could have a number of important implications at the national level. For example, government sector revenue (currently estimated at around $2 million/year) could fall if Lake Victoria production declines, and/or if there are changes in tuna migrations/abundance. The latter would mean that foreign vessels would be less willing to buy licences to fish in Kenyan waters. While the current balance of production is strongly skewed in favour of inland fisheries, government revenues are more evenly balanced between those from Lake Victoria and those from marine fisheries, and foreign licences provide the government with important sources of export revenue. Declines in foreign exchange from fisheries may also be significant in light of predicted climate change-induced declines in agriculture cash crops (e.g. coffee) around the Lake Victoria basin (Hepworth and Goulden, 2008).

However, perhaps of greatest importance for the future, especially with regards to trade, will be any changes to the balance of species produced from Lake Victoria. All the main species (Nile Perch, tilapia, dagaa) have different end markets, and generate different levels of value-added and employment. The ability of different species to adapt to climate change could have huge impacts on those stakeholders that win and that lose, from any such changes. For example, fish processors on the lake shore are strongly export orientated based on Nile Perch (almost all of which is exported, and which represents almost all of national exports), and are already facing extreme pressure on margins due to recent declines in Nile Perch landings. Further reductions in landed quantities (without any changes in export prices, which are to some extent being kept low by prices of Vietnamese basa/catfish in EU markets – the main competitor) would be almost certain to result in further rationalization of the sector and resulting job losses. Processing of Nile Perch in factories also results in considerable levels of secondary processing of waste products e.g. fish skin and frames for regional markets, which would also be affected. By comparison, levels of processing and value-added are relatively low for both tilapia and dagaa.

Local demand for fish is strongly centered around dagaa and tilapia, which are favored over Nile Perch by local consumers on the grounds of taste, cultural preferences and price. Increases or decreases in these species could therefore have significant impacts on food and livelihood security. These impacts could be exaggerated if such species decline, given that high population growth rates at the national level also suggest that fish will be important in filling the food gap as a source of nutritional security.

Other potential implications of the physical changes and impacts on fish and ecosystems described in Table 11 and Table 12 could include:

- Costs associated with changes in lake levels. Any significant changes could require existing infrastructure (e.g. lakeside processing operations, fishers housing) either to be abandoned if levels rise, and if they fall for additional transport costs to be incurred, for example in transporting fish from landing sites to processing factories;
- Increased safety risks for fishers on Lake and Victoria and in marine areas with any increased severity or frequency in extreme weather events, due to low levels of motorization and low technology in the fishing fleet (see Appendix 3);
- A reduced ability for fisheries to act as a safety net for part-time fishermen if production falls; and

- A decline in marine reef fisheries if coral reefs are impacted by temperature and acidification changes, with some potential knock-on implications for the tourism sector, where visits to marine parks, sport fishing and scuba diving are ways in which value is captured locally from international tourism

Any future changes in the sector resulting from climate change will require individuals, communities and the government to adapt accordingly if sector and trade competitiveness is to be maintained. How will Kenya deal with these potential changes? As discussed earlier, the adaptive capacity of different countries is critical to their vulnerability to climate change. The baseline indicators for Kenya provided earlier provide cause for alarm. At the fisher/community level, one indicator of adaptive capacity proposed is mobile phone use. Mobile phones can be critical not just in communicating the arrival of extreme weather events, but also increasingly for obtaining information about changes in fish market prices. Mobile phone usage in Kenya is not especially high, although there are reports of phones influencing the fish supply chain and related prices on Lake Victoria. At the national level, adaptive capacity would also appear to be low, based on almost all of the adaptive capacity indicators in the baseline indicator tables above (e.g. the country demonstrates poor performance in global terms with regards to ease of doing business, GDP/capita, aid as % of government expenditure, global competitive index, corruption, and government effectiveness, and Kenya does not have a NAPA). The fisheries sector is relatively poorly served by services, healthcare, and education compared to many other countries, and sector governance also offers considerable room for improvement.

Policy recommendations applicable to all Commonwealth States with regards to adaptation are considered in Chapter 6 of this report. However, one potential area of opportunity specific to Kenya lies in increased aquaculture production of tilapia. Cage farming is expanding rapidly in many African countries e.g. Uganda and Malawi, and could be supported by the Government. Another policy action specific to Kenya is the preparation of a NAPA, and specific reference to fisheries within it.

5.3.3 Maldives

Current trade position

Fisheries account for 6% of GDP, around 12% of employment and 98% of the country’s physical export commodities (DPND, 2009). As can be seen from the following table, Maldivian fish trade is strongly dominated by tuna species (primarily skipjack and yellowfin). However there are also some valuable reef fisheries (e.g. for lobster, grouper, beche de mer, ornamental fish)

Table 13: Maldivian fish exports 2000-2006 (tonnes, and $‘000s)

Export quantity (tonnes)	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Fish fillets, fresh or chilled, nei	19	1	-	13	37	4	2,303
Fish meal fit for human consumption, nei	.	.	.	.	.	150	354
Fish, fresh or chilled, nei	590	-	-	-	-	-	310
Miscellaneous dried fish, whether or not salted, nei	536	79	117	122	132	76	8,613
Skipjack tuna, frozen	8,557	10,653	25,019	37,276	41,039	46,752	77,787
Tuna meal	2,080	2,123	2,770	2,377	2,400	2,868	2,593

Tunas prepared or preserved, not minced, nei	7,731	3,041	3,912	5,690	4,856	4,515	6,186
Tunas, fresh or chilled, nei	3	7	423	267	3	22	975
Yellowfin tuna, fresh or chilled	3,991	1,190	2,667	3,658	5,023	4,241	5,717
Yellowfin tuna, frozen, nei	1,368	2,629	2,494	9,947	9,776	8,089	7,941
Other	6,233	11,886	10,235	12,849	14,755	17,570	497
Total	31,108	31,609	47,637	72,199	78,021	84,287	113,276
Export value ($'000s)	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Fish fillets, fresh or chilled, nei	94	6	-	88	214	27	10,752
Fish, fresh or chilled, nei	1,750	-	-	-	-	-	1,277
Miscellaneous dried fish, whether or not salted, nei	3,144	70	86	92	106	50	11,492
Sea-cucumber, dried, salted or in brine	2,424	2,805	2,972	3,371	2,426	1,812	993
Skipjack tuna, frozen	4,066	5,575	14,905	20,354	26,712	33,722	59,520
Tuna meal	805	889	1,115	1,014	1,169	1,461	1,400
Tunas prepared or preserved, not minced, nei	10,869	4,264	6,841	9,791	8,964	9,523	15,378
Tunas, fresh or chilled, nei	22	41	1,741	1,240	5	49	5,269
Yellowfin tuna, fresh or chilled	5,263	5,215	8,436	10,072	14,019	14,733	18,372
Yellowfin tuna, frozen, nei	501	1,670	1,903	6,292	7,746	6,899	7,014
Other	11,985	23,440	17,988	24,157	28,894	34,255	2,124
Total	40,923	43,975	55,987	76,471	90,255	102,531	133,591

Source: FAO

The **pole and line** fishery has traditionally been the mainstay for domestic **skipjack** consumption, but now supports a substantial export trade. The main export market of frozen skipjack is Thailand while canned skipjack is primarily destined for the EU (mainly to Germany and the United Kingdom). There is also a significant portion of dried or smoked fish, commonly known as *'Maldive Fish'* that is exported to Sri Lanka by small scale processors. Whilst the vessels involved in pole and line skipjack fishing are larger and more powerful than in previous years, the method of fishing is largely unchanged, although multi-day (i.e. 2-3 day) trips have become more common than the single day trips of the past as vessels have got larger. Catches are either sold to local processors, or to one of to the 4 skipjack tuna collection permit holders, who have exclusive contracts with the government to purchase, process and export skipjack fish from designated fishery zones. These companies have considerable onshore infrastructure in the form of cold stores, ice plants, freezing plants, and canneries. Most skipjack is exported in canned or frozen form. Main competitors for canned product are of course other tuna canning exporters such as Thailand, Seychelles, West Africa and the Pacific.

The **handline** fishery is a more recent development, reflecting the increase in price and demand for fresh **yellowfin** tuna in Europe, the USA and Japan. The vessels used are the traditional pole and line mechanized 'Masdhoni' adapted for the larger fish. There are 11 European Union certified yellowfin processing factories in the Maldives. Maldive's main competitor in the yellowfin trade is Sri Lanka, and some additional discussion on the competitive position of Maldives with regards to Sri Lanka is therefore appropriate.

Sales to the EU represent more than 90% of Maldivian yellowfin exports[22] and represent the main export channel for longline caught tuna. These sales are generally made under contract (rather than being sold on an auction market as in Japan), and provide for guaranteed prices prior to shipment, which reduces risk. As shown in the graphs below, sales prices in EU markets are relatively stable (compared to those in the Japanese market). However, EU buyers are much more demanding about regular sales volumes; retailers place great importance on the reliability of supplies so as to build up consumer awareness about particular products. And while demand is generally strong in the EU market (although suffering seasonal differences with peak demand in the summer and over Christmas), the EU market is rather inflexible in absorbing large quantities of fish when they become available.

The issue of the GSP+ scheme also merits some discussion. The scheme was introduced after the tsunami and means that EU importers are not required to pay the normal 15% duty on tuna loins from Maldives that are imposed on imports from other countries (including India, but not Sri Lanka which is also covered by the scheme). This duty preference has recently been extended until 2014. The graphs below suggest that the average market price in the EU for tuna loins in 2007 was $13.58/kg. An import duty of 15% on this price would be $2.03/kg, and in the absence of the GSP+ scheme this cost would almost certainly be reflected in a lower export price for Maldivian exporters. Certainly it seems likely that the high recent prices paid in EU markets for Maldivian and Sri Lankan product have been to some extent driven by the GSP+ scheme. Exporters in Maldives report that financial viability would simply not exist without the GSP+ scheme[23], and while 2014 is a long way off, this does highlight the inherent financial weakness of the export sector.

The export sector also experiences a number of constraints related to operating costs. The viability of export sector, and therefore the prices exporters can pay vessels, depend heavily on air freight costs to European markets. Exporters report some problems in booking air freight space and of scheduled flights being cancelled in the off-season for tourism, and offloads of product have been known. In addition, at certain times of the year westerly trade winds combine with high passenger numbers to result in increased fuel requirements and luggage carried, thereby reducing cargo space and increasing costs at the same time. If product is offloaded, or air freight space is not available on a chosen day, this potentially results in lost orders or reduced prices; EU buyers may not want product as part of a subsequent shipment due to their strict requirements on shelf life.

The financial viability of export operations based on yellowfin exports is also undermined by operational costs in Maldives compared to those in Sri Lanka, primarily because almost all inputs are imported and labour is relatively expensive. Some comparative costs for Maldives and Sri Lanka are shown below.

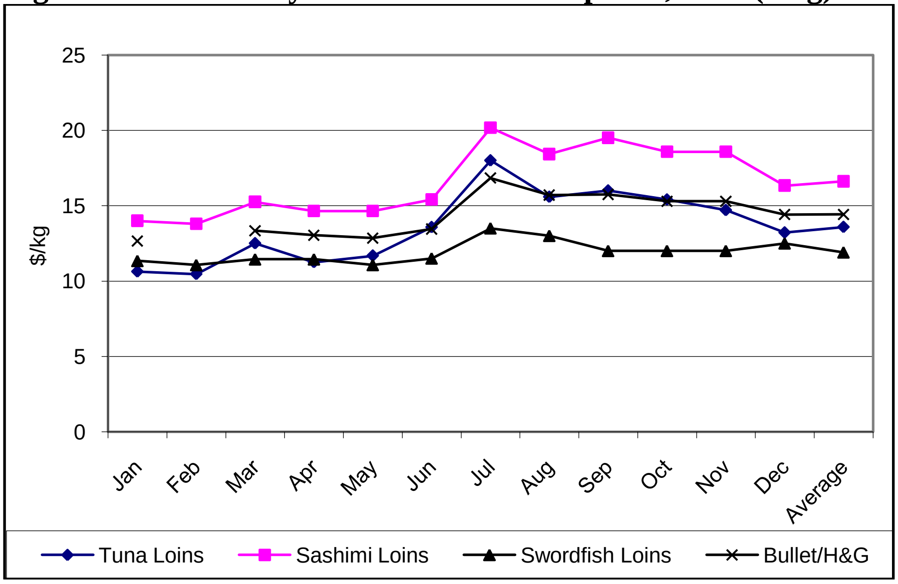
[22] Pers. Comm. MSPEA, 2008
[23] Pers. Comm. MSPEA, 2008

Table 14: Maldivian and Sri Lankan export operating costs

Cost item for loins to EU	Maldives	Sri Lanka
Processing and packaging (includes processing, vacuum packing, ice and styrofoam boxes)	$1.9-2.00/kg	$0.90-1/kg of loin
Air freight	$3.00-3.40/kg	$1.95-$2.50/kg
Issuing of export/health certificate per consignment	$0.15/kg	$2
Investment loan interest	c.a. 10%	15-28%

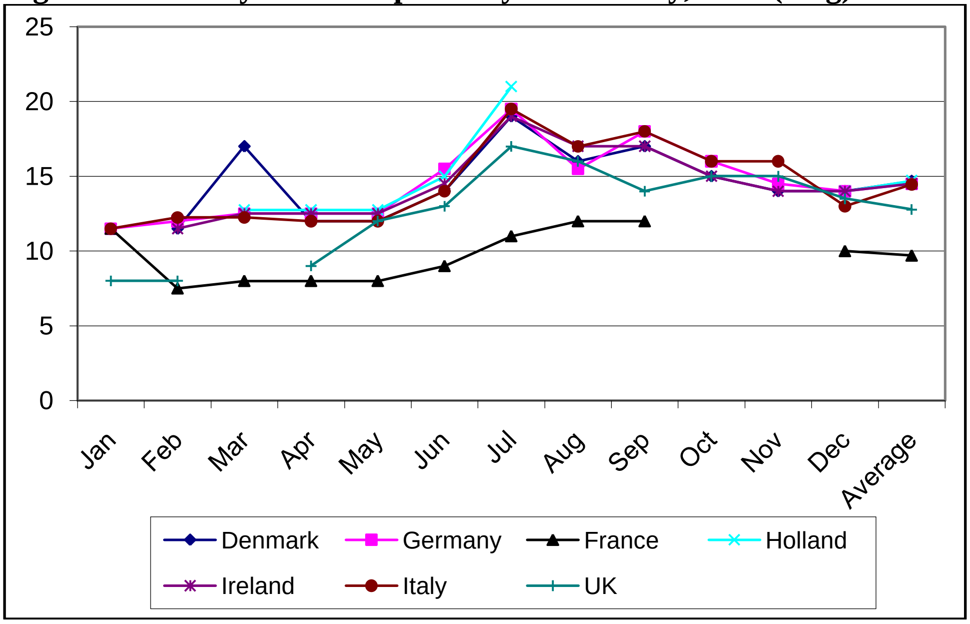
The data in the Figures below are based on sales records for processor/exporters in Sri Lanka. Prices in different EU countries can be expected, at least to some extent, to be based on individual relationships between export companies and their buyers, and prices may vary slightly between Sri Lankan and Maldivian product, especially given that current catches are caught using handlines in Maldives and longlines in Sri Lanka (typically with higher quality fish being caught on longlines compared to pole and line). Thus while Maldivian processors/exporters can be expected to obtain different prices for similar products in any one country of the EU, the prices shown below can be taken as broadly indicative of prices currently being paid to Maldivian exporters, and those that might be expected in the future for longline caught fish.

Figure 6: EU monthly tuna and swordfish prices, 2007 ($/kg)



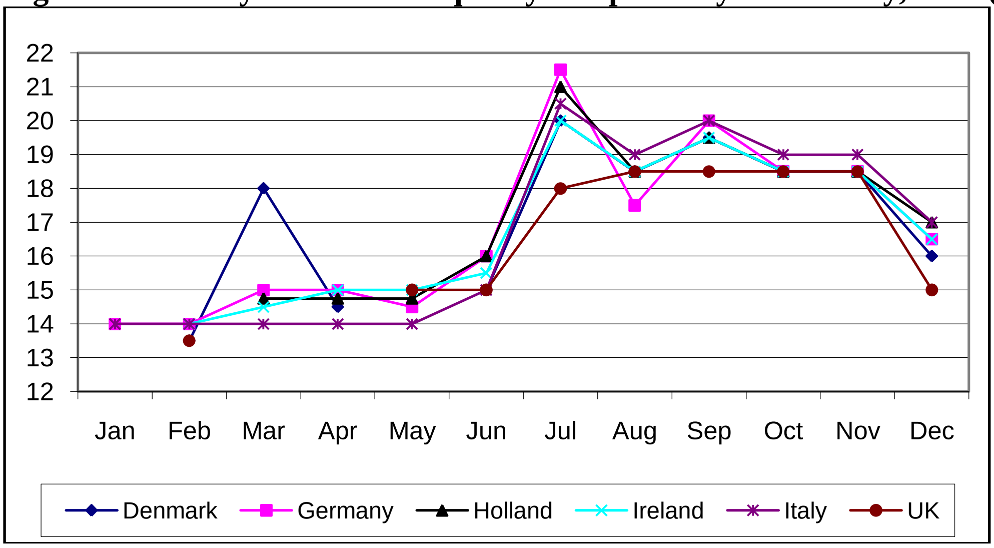
Source: Export invoices of Sri Lankan exporters
Notes: Prices based on an average of prices across all countries. Not weighted by volume.

Figure 7: Monthly tuna loin prices by EU country, 2007 ($/kg)



Source: Export invoices of Sri Lankan exporters

Figure 8: Monthly tuna sashimi quality loin prices by EU country, 2007 ($/kg)



Source: Export invoices of Sri Lankan exporters
Note: Y-axis scale does not start at zero, which accentuates monthly differences

With the increases in the tourism sector, together with the improved air and sea transportation, **reef** fisheries have developed significantly for both local consumption and for export. Reef are sold to many of the tourism islands, while main markets for ornamental reef fish include the United Kingdom, France, Italy, Russia, Switzerland, Japan Germany and Sri Lanka. Groupers are exported in live or chilled form mainly to Hong Kong, Taiwan and Thailand.

Government sector revenues from the fisheries sector (from domestic charges and foreign longline licence fees) are not known, but Government is reported to be in favour of excluding all foreign licence holders due to low levels of payment received, difficulties in policing foreign activity, and a desire to increase domestic longline activity.

Physical impacts of climate change and effects on ecosystems and fish production

The description of potential impact pathways of climate change in Maldives, follows the same pattern and structure as that for Kenya above.

Table 15: Possible physical impacts of climate change relevant for Maldivian fisheries

Physical changes	Discussion
Heat content and temperature	Potential increases, but may be less in Maldives than in temperate and sub-tropical countries
Salinity and stratification	Potential for increased salinity and stratification
Ocean circulation and upwelling	Maldives EEZ not upwelling zone
Acidification and chemical changes	Ocean-wide and could affect coral reef formation in Maldivian atolls
Sea and lake levels	Sea level rises particularly important for Maldives in relative terms given low mean elevation above sea level
Sediment levels	No changes as no riverine outflows
Extreme weather events	Maldives less exposed to extreme events that many other countries (e.g. Pacific, Caribbean, Bay of Bengal)
Low frequency variability	Whole West Indian Ocean affected by El Niño events and decadal cycles. But not clear whether global warming will result in stronger and more frequent ENSO or not 1998 coral bleaching and reduction in tuna catches both associated with 1997 El Niño event

Table 16: Possible impacts on fish and ecosystems in Maldivian fisheries

Impacts on fish and ecosystems	Discussion
Physiological spawning and recruitment	Could impact on balance of species not tolerant to higher temperatures (see Appendix 4 for information on current catch balances)
Primary production	Likely to decrease
Secondary production	Likely to decrease but local/regional models not available
Distribution of fish	Pole-ward movement of most fish suggests reduction in tuna and other species availability relative to other competitor producers at higher latitudes Temperature changes may impact on depth at which tuna and tuna-like species are found.
Abundance of fish	Could be potential changes in species mix of both commercial and non-commercial species (the latter important for tourism). But impacts not clear from literature
Phenology	Changes in timing of spawning, migration seem likely, but specific details unknown
Species invasion and disease	No aquaculture, and impacts unlikely to be significant
Food web impacts	Potential simplification and changes to food webs as species mix changes, implying greater volatility of production

Impacts on fishers/communities, trade and national economies
As is evident from Appendix 4 and the text above, Maldivian fisheries are very strongly dominated by catches of tuna and tuna-like species, and there is a very high dependency at both community and national level on the fisheries sector. There are no inland fisheries, and potential for aquaculture development is thought to be relatively limited (primarily due to issues associated with competitiveness given the need for importation of all inputs) so any changes to fish catches resulting from climate change impacts will have a very significant effect on the country.

At the community/local level, on many islands the fisheries sector provides the only source of income with island economic life concentrated solely around fishing activity. This is especially so in many of the outlying atolls, as economic activity in the country is strongly centered around Male. This high dependency relates to the catching sector, 'cottage-based' processing of tuna into *Maldive fish* for export to Sri Lanka (which provides an important source of income to women in the country), and in the provision of inputs to the sector. Most Maldivians eat tuna almost every day, and fisheries provide a staggering 54.8% of protein consumed, and around 14% of total employment in the country. Changes in overall catch level of fish, and any increases in the unpredictability of the seasonality of catches (see Table 34), would have serious knock-on impacts on communities in terms of livelihoods.

On a national level, the country is also extremely dependent on fishing. The fisheries sector provides the only real source of foreign exchange for the country in addition to tourism. Fish canning activity generates much-needed employment (primarily for women), and has competitive advantages in terms of its location close to tuna resources. However, the processing sector faces competitive difficulties due to the imported costs of cans, oil, and packaging materials which are high compared to many other competitors. Any reductions in tuna catches due to climate change would therefore significantly undermine the one competitive advantage it does have – high catch rates in local waters. Erosion of preferential tariffs regimes with the EU poses additional threats for the future.

High value fresh (and frozen) exports of handline caught yellowfin tuna also generate important levels of income, employment and foreign exchange. Climate change impacts could threaten catches due to shifts in migration patterns, and also depths at which fish swim, thereby affecting catch rates if fishermen are not able to adjust their fishing methods accordingly. As noted above, Maldives' main competitor with regards to fresh yellowfin exports to the EU is Sri Lanka. Given the proximity of the two countries to each other, any changes brought about by climate change can expected to affect both countries similarly, therefore not negatively impacting on the relative competitive position of either country, although lower volumes of fish could be available for export.

However, perhaps of most importance in terms of threats to tuna sector is the potential impacts of climate change on the bait fishery. The pole and line and handline fishery, which accounts for almost all catches in Maldives, uses livebait which reside inside the atoll and coral reef lagoons. There is heavy pressure on this fishery and in some areas of the country night fishing is being used to attract bait, a sure sign that the fishery is under severe stress. Many stakeholders in the country feel that potential impacts of climate change on the bait fishery (through temperature changes and impacts on reef systems) pose perhaps the main threat to the industry as a whole. Table 35 in Appendix 4 provides some ideas as to how to tackle this threat. Importantly, Sri Lanka's longline industry does not rely on live bait, and so if the bait fishery were to collapse as a result of climate change, Maldives' competitive trade position vis a vis Sri Lanka would deteriorate.

Other impacts of climate change could flow from impacts on coral reefs (e.g. bleaching). These impacts could be felt directly by fishers through declines in catches and exports/trade of reef fish such as groupers and snappers (again, already under significant levels of fishing pressure). However other indirect impacts could also occur. For example, declining coral reef cover could reduce levels of tourism in the country. This could result in reduced sales of reef fish to tourism islands, as well as increased pressure on fisheries if tourism employment levels fall (because there are so few alternative livelihood opportunities in the country).

Other potential impacts of climate change on the fisheries sector in the Maldives given island elevation data, are:

- The costs associated with climate proofing any future fisheries infrastructure developments; and
- Threats to agriculture due to increased storm surges and potential for increased flooding and salinisation of soils. This could increase pressure and dependency on fisheries.

Government revenue from the issuing of foreign licences are not known, but are reported to be small, hence an ongoing policy debate in the country as to whether exclude foreign vessels altogether.

While the dependency on the sector in Maldives is far higher than in Kenya, there is some cause for optimism about Maldives' adaptive capacity to deal with these potential changes, thereby reducing its vulnerability. Baseline indicators of adaptive capacity are relatively encouraging with regards to GDP per capita (which are 4-5 times those in Kenya and the Solomon Islands), secondary school enrolment ratios and adult literacy rates, relatively low population growth rates, the doingbusiness.org ranking, and the number of marine protected areas. Maldives also has both a PRSP and a NAPA, and both of these specially include mention of the fisheries sector, indicating policy coherence and high-levels support for the sector. However, despite these causes for optimism, debt as a percentage of GNI is extremely high in the country, and servicing this debt in the future is likely to place considerable pressure on the ability of government to fund adaptation and mitigation initiatives (see Chapter 6.

5.3.4 Solomon Islands

Current trade position

Fish trade in the Solomon Islands is very strongly concentrated around tuna fishing.

Table 17: Solomon Islands fish exports 2000-2006 (tonnes, and $'000s)

Export Quantity	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Coral and the like	169	107	90	271	275	321	394
Fish meals, nei	-	185	329	146	133	57	179
Marine fish fillets, nei, frozen	.	.	.	.	.	.	21
Miscellaneous corals and shells	.	36	25	137	134	98	516
Other seaweeds and aquatic plants and products thereof	.	.	.	.	114	273	189

Export Quantity	2000	2001	2002	2003	2004	2005	2006
Rock lobsters (Jasus spp.), nei, frozen	.	.	.	.	1	4	10
Skipjack prepared or preserved, not minced, nei	2,500	322	1,397	1,339	443	637	950
Skipjack tuna, frozen	11,000	9,152	5,599	10,256	8,370	14,162	12,089
Tunas prepared or preserved, not minced, nei	.	.	.	26	1,095	2,374	2,117
Yellowfin tuna, frozen, nei	.	1,766	3,060	2,561	4,230	2,457	1,723
Other	1,034	1,986	1,842	1,388	1,403	365	13
Total	14,703	13,554	12,342	16,124	16,198	20,748	18,201
Export value ($'000s)	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Coral and the like	642	644	270	799	1,073	925	876
Marine fish fillets, nei, frozen	.	.	.	.	.	.	129
Miscellaneous corals and shells	.	169	67	274	443	267	431
Ornamental fish nei	3	194	94	326	265	229	226
Other seaweeds and aquatic plants and products thereof	.	.	.	.	87	178	132
Rock lobsters (Jasus spp.), nei, frozen	.	.	.	.	33	50	95
Skipjack prepared or preserved, not minced, nei	4,500	1,380	5,379	5,233	1,736	2,719	3,670
Skipjack tuna, frozen	6,700	5,488	3,179	6,634	6,216	11,115	9,624
Tunas prepared or preserved, not minced, nei	.	.	.	87	4,023	8,676	8,060
Yellowfin tuna, frozen, nei	.	1,070	2,777	2,170	4,327	2,494	2,182
Other	1,110	5,590	7,975	5,827	7,684	1,334	236
Total	12,955	14,535	19,741	21,350	25,887	27,987	25,661

Source: FAO

Important participants in the tuna industry are[24]:

- Soltai, formally known as Solomon Fishing and Processing Company Limited, which is the transformed Solomon Taiyo after the Japanese partner pulled out. It is now owned 51% by the national government through its investment arm (the Investment Corporation of the Solomon Islands) and 49% by Western Province. Its assets at the Noro base include 8 operational pole-and-line vessels, a cannery, tuna smoking (arabushi) facility, a 1600 mt freezer, and office/engineering facilities
- NFD, formally known as National Fisheries Developments Limited, operates three purse seine vessels. Formerly the company operated from a facility at Tulagi, but as a cost-reduction measure, moved to Noro in mid-2001. Besides the purse seiners, other assets include the fish aggregating devices used in conjunction with tuna fishing, reportedly about 80 to 200 FADs in 2002.

[24]Solco Company Limited, formerly as Solgreen, ceased operations in 2005.

- Other tuna companies based in the Solomon Islands are Global Investment and Mako. These companies appear to presently operate similarly, managing vessels and acting as vessel agents, with Honiara activities reduced/eliminated after the civil disturbances of 2001.
- Tradco Shipping Limited provides services to vessels, including assisting with trans-shipments and providing crew.

The tuna landed in the Solomon Islands are utilized in a variety of ways, depending on the fleet. It is difficult to make generalizations, but Table 18 provides an idea of trade destinations by domestic and foreign fleet segment. With respect to the tuna that is actually landed in the Solomon Islands, most is processed at the Noro Cannery and exported primarily to USA and Australian markets.

Table 18: Trade use of tuna catches in the Solomons by fleet

Fleet	**Usual Catch Disposal**
Domestic pole/line	Offloaded at Noro for canning or loining
Domestic purse seine	Some is processed (canned/loined) in Noro, but more typically it is shipped to overseas canneries
Domestic longline	High quality yellowfin and bigeye tuna are air freighted to Japan via Brisbane.
Korea purse seine	Vessels transship catch in Honiara (or an authorized port in a neighboring country) for shipment to overseas canneries
Taiwan purse seine	Vessels transship catch in Honiara (or an authorized port in a neighboring country) for shipment to overseas canneries
Japan purse seine	Return to Japan with the catch onboard for offloading in Japanese ports.
USA purse seine	Deliver the catch at one of the two canneries in Pago Pago, American Samoa
Taiwan longline	Deliver catch to canneries (usually Levuka, Fiji or Pago Pago, American Samoa) but also undertake some transshipping

As evidenced from the data above, in addition to the domestic catches, there are also significant foreign vessels catches in the country's EEZ by purse seine, longline and pole and line vessels. The fees paid by distant water fleets constitute a trade in fish resources, and represent an important source of foreign currency revenue.[25]

In 1994 distant water fees were USD1.5 million, in 1998 USD1.9 million, in 2004 USD3.9 million (Barclay and Cartwright 2007, 214). In 2005 fees totalled SBD26 million, and in 2006 SBD32 million (CBSI 2006). Improvements to the ways fees are calculated and the ways fees are paid to government (reducing 'leakage') increased access fees to SBD90 million in 2007 ($12 million), and are anticipated to reach SBD120 million in 2008. While domestic fleet catches have not grown in the last five years, catches by foreign fleets have increased. According to the Statistics Department at MFMR, this increase has been mostly fuelled by the Korean fleet, which accounted for over 44 per cent of the total catch for 2002-2007 period. Catches by the purse seine fleets based in Pacific Islands countries with multilateral access under the Federated States of Micronesia Arrangement and USA fleets

[25] Text drawn from 2008 DTIS study

have also steadily increased. The Taiwanese fleet has recorded a relatively small proportion of the catch, and this has not grown over the five year period, yet the number of Taiwanese vessels licensed in the Solomon Islands has grown, possibly because they fish in the Solomon Islands EEZ for only some months of the year.

Table 19: Foreign vessel numbers in Solomons

	2004	2005	2006	2007
Belize[b] Longline	-	-	-	5
China Longline	12	14	24	41
China Purse seine	6	6	6	6
Fiji Longline	3	3	18	12
Japan Longline	9	19	31	33
Japan Purse seine	21	32	26	34
Japan Pole & line	11	11	24	8
Korea Purse seine	28	28	28	28
Korea Longline	16	19	37	47
New Zealand	4	4	4	4
Taiwan Purse seine	29	31	33	33
Taiwan Longline	19	30	33	36
Vanuatu[c] Longline	11	11	10	10
FSM A Purse seine	5	3	31	34
USMLT	19	11	13	12

Source: Ministry of Fisheries and Marine Resources
Notes: a. Belize is a 'flag-of-convenience' country rather than a fishing state, so these vessels may be flagged in Belize but are really owned by companies in another country.
b. Vanuatu is also a flag-of-convenience country.

Most of the estimated 13,000 mt of fish caught annually by the subsistence fisheries of the Solomon Islands is not traded but consumed by the fishers' immediate or extended families in villages close to the fishing areas. In some communities, production in excess of immediate needs is salted or dried for future use. Subsistence fishers may occasionally collect products such as beche de mer, trochus, and pearl shell, which are sold through intermediaries to export dealers in Honiara. The small-scale commercial production, estimated at 3,200 mt annually, is characteristically sold in the markets of urban centres. Most markets are in Honiara, but they also exist in Gizo, Buala, Tulagi, Auki, Kirakira, and Lata.

Physical impacts of climate change and effects on ecosystems and fish production
The description of potential impact pathways of climate change in the Solomon Islands follows the same pattern and structure as that for Kenya and Maldives above.

Table 20: Possible physical impacts of climate change relevant for Solomon Islands fisheries

Physical changes	**Discussion**
Heat content and temperature	Warming intermediate in strength between coastal South East Asian seas and central Pacific
Salinity and stratification	Potential for increased salinity and stratification
Ocean circulation and upwelling	Solomons EEZ not upwelling zone. Potential changes to the South Equatorial Current and the South Subtropical Current

Physical changes	Discussion
Acidification and chemical changes	Ocean-wide and could affect coral reef formation on Solomon Islands coast
Sea and lake levels	Less impact than more northerly regions of the world
Sediment levels	May increase with deforestation affecting atoll lagoon fisheries, but probably limited change given low levels of riverine outflows
Extreme weather events	Southern half of Solomons more exposed to extreme events than northern islands, although still not as much as many other countries (in Pacific, Caribbean, Bay of Bengal)
Low frequency variability	Changes to Western Pacific Warm Pool during El Niño periods. Not clear whether global warming will result in stronger and more frequent ENSO or not.

Table 21: Possible impacts on fish and ecosystems in Solomon Islands fisheries

Impacts on fish and ecosystems	Discussion
Physiological spawning and recruitment	Could impact on balance of species not tolerant to higher temperatures (see Appendix 5 for information on current catch balances)
Primary production	Likely to decrease
Secondary production	Likely to decrease but local/regional models not available
Distribution of fish	Shift in distribution of skipjack may favour Micronesia over Melanesia (including Solomons) – see Chapter 2. Temperature changes may impact on depth at which tuna and tuna-like species are found.
Abundance of fish	Could be potential changes in species mix of both commercial and non-commercial species (the latter important for tourism). But impacts not clear from literature
Phenology	Changes in timing of spawning, migration seem likely, but specific details unknown
Species invasion and disease	Little aquaculture, and impacts unlikely to be significant
Food web impacts	Potential simplification and changes to food webs as species mix changes, implying greater volatility of production

Impacts on fishers/communities, trade and national economies

Like Maldives, the Solomon Islands fisheries sector is very strongly dominated by catches of tuna and tuna-like species (see additional information in Appendix 5). However, while most catches in Maldivian waters are taken by national vessels, in the Solomon Islands the domestic sector accounts for only around 25% of total catches in the EEZ. Domestic catches include both coastal reef/demersal fish, and offhsore tuna (using pole and line, longline, and purse seine methods). Foreign offshore catches represent around 75% of total catches made in the country's huge EEZ[26] and are almost exclusively tuna and tuna-like species, and have historically been dominated by Taiwanese, Japanese and USA vessels. More recently EU vessels from Spain and France are able to fish in the EEZ following the signing of a fisheries partnership agreement in 2006 with the EU.

[26] Note that foreign catches vary considerably between years due to tuna migration patterns which may differ)

The dominance of catches by foreign vessels explains why at a national level, when compared to Maldives, dependency on the sector is more strongly based on trade in licences and foreign licence revenue (thought to be around $12 million per year) than on revenues and employment resulting from domestic catches. Foreign vessels sell very limited amounts of product to the local cannery, and either transship in Solomons or land direct to other canneries in other countries.

Nevertheless, on a national basis the fisheries sector still provides for 4.35% of total employment– high by international standards. The domestic tuna cannery provides for both export earnings and around 300 jobs (mainly women), and in Western Province (where the cannery is located) it is estimated that around 35-40% of all employment is associated with fisheries. The number of people employed has decreased in recent years as cannery production has declined; like canning activity in Maldives, key competitive difficulties have arisen due to the cost of importing cans. Erosion of preferential tariffs regimes with the EU poses additional threats for the future.[27]

Per capita fish consumption is high in the Solomons compared to international averages. Low-grade canned product (which now utilizes the by-product of loining) has become a staple food in the country, and domestic caught coastal fish is also very important in terms of its contribution to protein. In many coastal communities the sector provides a critical food security function on a subsistence basis. Recent estimates (Bell, 2008) have suggested that 64% of per capita consumption on a national basis and 73% in rural areas are based on subsistence activities rather than on fish being purchased. Forecasts of fish required in the Solomons to meet per capita consumption of fish for good nutrition based on population growth are 29,900 tonnes by 2030.

Taking these factors together, and considering other information presented in Appendix 5, key potential threats in terms of exposure to climate change discussed in Table 20 and Table 21 are could be:

- Shifts in tuna migrations away from the Solomons EEZ, which would significantly impact on foreign licence revenue, and potentially further endanger the continuing existence of the tuna cannery in the country as well as placing pressure on the viability of locally based tuna vessels;
- Temperature changes impacting on depths at which tuna and tuna-like species are caught, potentially impacting on catch rates and revenues;
- Reductions in coastal fish resources, so important for fish nutrition on a subsistence basis, due to the fact that reef formation will become more geographically restricted, leading to erosion and loss of existing reefs (see Figure 15 in Appendix 2);
- The costs associated with climate proofing any future fisheries infrastructure developments; and
- Increased safety risks, especially in the southern part of the country, from increased frequency/severity of extreme weather events.

The adaptive capacity of the Solomon Islands to these threats is likely to be low. In addition to inherent vulnerabilities of many SIDS (see earlier discussion in Chapter 0), the baseline indicators on adaptive capacity provided in Table 4 to Table 6 suggest that Solomon Islands

[27] Solomon Islands products are tariff free compared to a 12-24 per cent tariff on imports from competitor countries in Southeast Asia

is very vulnerable to potential climate change impacts on the sector. Mobile phone use (potentially very important for safety on fishing vessels) is very low, there are fewer alternative employment opportunities in coastal tourism activities that in Maldives, the doingbusiness.org ranking is the lowest of the three case study countries as is the government effectiveness index, population growth rates and aid as a percentage of GNI are both high, and GDP/capita is very low. Finally, it is also notable that the country as no PRSP and no NAPA, so by definition has no specific provisions made for the fisheries sector.

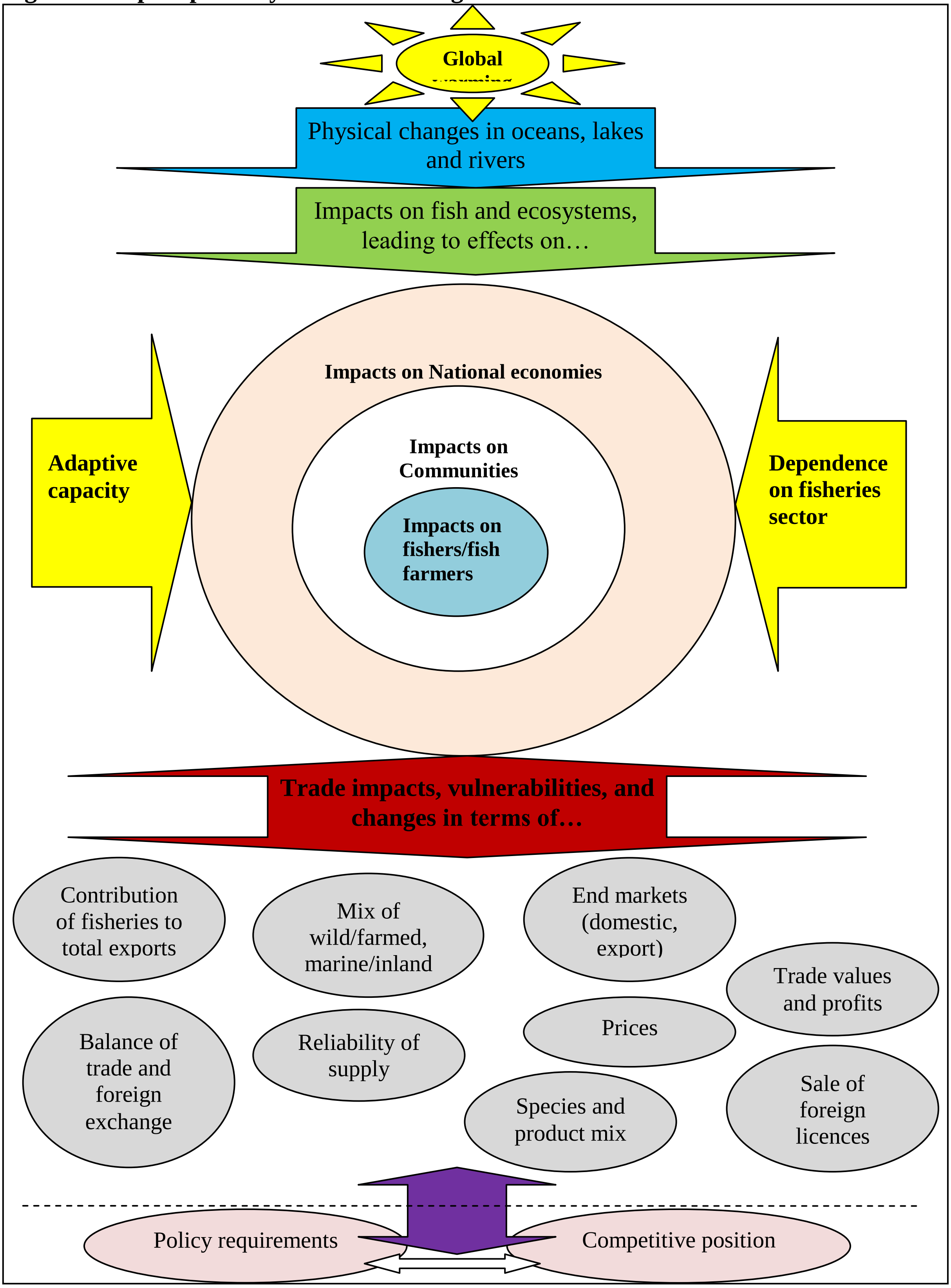
6. Impacts of climate change on trade competitiveness, and climate change and fisheries trade policies supportive of enhanced trade and competitiveness of the fisheries sector in Commonwealth ACP States

6.1 Introduction and summary of climate change implications on trade and competitiveness of the fisheries sector

In the final Chapter of this report, informed by the text in Chapters 2-5, we consider the potential impacts of climate change more specifically on trade competitiveness, before examining inter-linkages between climate change policies as they pertain to the fisheries sector and fisheries trade policy, and we identify a number of policy options supportive of enhanced trade and competitiveness of the fisheries sector in Commonwealth ACP States. We conclude the report with a short section highlighting a number of areas worthy of additional policy research.

The impacts of climate change on the production and trade of different species will vary depending on the magnitude of the physical change brought about by climate change, the ability of fish species and ecosystems to adapt to deal with physical changes or their adaptive response to avoidance of these changes, and the response of fishers, communities and nations. The impact pathways have been described earlier in this report. These potential changes and impacts, all of which may affect competitive positions and require appropriate policy responses, are summarized schematically in Figure 9, before being elaborated in the subsequent text.

Figure 9: Impact pathway of climate change on fisheries trade



Source: Macfadyen and Allison, 2009

Drawing on the discussion presented in Chapters 2 and 3, some of the key physical impacts of climate change which are likely to feed through into to trade impacts include:

- Increasing severity of extreme events, sea level rise and changes in flood regimes and river/lake levels in inland waters could result in trade-specific impacts such as:
  - Variability of supplies due to increasing seasonal and annual variations in catches;
  - Major discontinuities in supply due to damage to infrastructure, perhaps prolonged due to problems with meeting HACCP and other hygiene and quality standards in the aftermath of a major disruption to market infrastructure and institutional capacity;
  - Adaptation affecting the structure of the marketing chain – for example it may be necessary to locate major processing facilities away from flood or storm-surge prone coastal areas, adding an extra link in the transportation chain and thereby increasing costs of local value-addition in marketing; and
  - Countries little-impacted by sea level rises - those with good coastal defenses or in regions of lower sea level rise, or with low or substitutable coastal land values - will gain competitive advantage in terms of trade;
- For oceanic systems and small islands, changes in primary production are likely to provide a good indication of likely change in fish production, and therefore potential fish yields available for trade, both domestically and to export markets[28]. Some countries and areas will gain competitive advantages over others depending on the differential impacts discussed in Chapter 2 and Appendix 2. In some areas, decreased pelagic primary production could reinforce a general trend towards increased cycling of marine coastal production through benthic (sea-bed) systems and organisms low in the food chain, due to overfishing and a process known as 'fishing down the food web' (Pauly et al, 1995), thereby changing the balance of fish available for trade;
- Changes in fish distribution could also have very significant impacts on the fish that is available to be traded by different countries, thereby affecting competitiveness. For example, as shown in Appendix 2, warming in the Pacific is likely to shift the distribution of skipjack tuna further into the central pacific, and away from current centers of fishing such as Papua New Guinea and Solomon Islands;
- In fishery trade terms, changes in fish yields and species mix also mean that production chains and consumers will need to adapt to new/different types of fish;
- Disease and reduced aquaculture yields due to thermally stressed fish could reduce overall production levels, and the balance of species available for trade, to differing extents in different countries. Those countries currently not relying strongly on aquaculture trade may be less affected than those that are in cases where aquaculture is strongly impacted by climate change (the Asia/Pacific region currently accounts for more than 90% of global aquaculture production);
- Changes in production systems could lead to different aquaculture species being available for trade e.g. more brackishwater shrimp due to coastal flooding, and reduced quantities of shellfish due an increased frequency of toxic algal blooms.

The direct and indirect impacts on trade of changes in production volumes and species mix and of changes in aquatic environmental conditions could therefore result in a wide range of trade impacts. These could include changes in:

- Trade volumes to different export market destinations, due to their different preferences for particular species;
- Total trade values, due to differing unit values of different species, and changes in prices based on differing elasticities of supply for differing species;

[28] It is also remember the important role of fishing as a subsistence activity in terms of food security

- The balance of production exported and traded domestically;
- The balance of production traded and consumed on a subsistence basis;
- The balance in trade from marine and inland fisheries (volume and values);
- The balance in trade between capture fisheries and aquaculture (volume and values);
- The contribution of fisheries sector exports to total exports;
- Balance of trade and foreign exchange earnings;
- Value-added/profits from trade due to differing production costs of different species and different sales prices; and
- The ability of countries to trade in fisheries licences with vessels from other countries in return for access to fish their waters.

Critical to an assessment of these impacts is that they may be felt to differing degrees, thereby creating winners and losers, by:

- different regions, countries and local areas; and
- different links within the supply chain (e.g. fishers/fish farmers, agents, processors, wholesalers, retailers, and consumers)

The seriousness and extent of these impacts and the competitiveness on any one country will be dependent on the response of consumers, private sector stakeholders, and governments, as well as the comparative impacts of climate change on competitor countries.

What then can individuals and countries do to ensure that they maintain trade competitiveness in the face of the potential impacts of climate changes discussed throughout this report?

Responses and related policy fall into two main categories, both of which constitute ways of maintaining competitiveness:

- Adaptation; and
- Mitigation.

Adaptation relates to ways of helping the fisheries sector adapt to the changes and potential impacts of climate change discussed earlier in this report. Mitigation relates to ways of reducing the contribution of the fisheries sector to global warming.

Adaptation and mitigation offer potential to maintain or increase fisheries trade both domestically and internationally. This potential will be realized through two main mechanisms:

- Helping to ensure that production levels from capture fisheries and aquaculture are maintained or increased on a sustainable basis for trade, and to assist with safeguarding of private sector profits; and
- Pursuing policy options that are very specifically trade-related, and which provide opportunities that could result in competitive advantages being gained by countries implementing them.

Adaptation and mitigation to climate change impacts are the focus of the following two sub-sections of this report, and demonstrate how individuals, communities and countries can increase their resilience to climate change impacts and maintain their competitive trade position.

6.2 Adaptive responses at the individual fishers and fishing community level to maintain/increase trade competitiveness in the face of climate change impacts

Resilience to climate change impacts, and an ability to maintain trade competitiveness, can be assessed in terms of the ability of people and communities involved in the sector to adapt to climate change. Impacts of climate change may be felt by the catching sector, aquaculture, processors, and traders/marketers in post-harvest activities, or in the wider national economy in countries with high fishery dependence. This section presents tabulated summaries identifying possible measures that can be taken to deal with and adapt to climate change impacts and to react in an adaptive manner such that trade can be maintained. These suggestions are drawn from earlier reviews of fishing peoples' existing strategies to adapt to climate variability and change (Allison & Ellis, 2001; Allison et. al, 2005; FAO, 2007; Daw et al., 2008; De Silva, 2008).

Table 22: Examples of adaptation options for fisheries

Impact of climate change on fisheries	Potential adaptation measures	Reactive/ anticipatory
Reduced yields	Access higher value markets/shifting targeted species	Either
	Increase effort or fishing power	Either
	Reduce costs to increase efficiency	Either
	Diversify livelihoods	Either
	Exit the fishery	Either
Increased variability of fisheries	Diversify livelihood portfolio	Either
	Engage with insurance schemes	Anticipatory
Change in distribution of fisheries	Migration of fishing effort/strategies and processing/distribution facilities	Either
Reduced profitability	Exit the fishery, or focus on other ways to maintain profits	Either
Vulnerability of infrastructure and communities to flooding, sea level rise and storm surges	Add new or improved physical flood and coastal defences	Anticipatory
	Managed retreat/accommodation	Either
	Rehabilitate infrastructure, design disaster response	Anticipatory
	Set up early warning systems, education	Anticipatory
Increased dangers of fishing	Invest in improved vessel stability, safety and communications	Anticipatory

Source: Daw et al., in FAO, 2008

Table 23: Adaptation to climate change impacts on aquaculture

Climatic Change Element	Impacts on aquaculture or related function	Adaptive measures
Warming	Raise above optimal range of tolerance of farmed species	Use better feeds, more care in handling, selective breeding and genetic improvements For higher temperature tolerance (and other related conditions)
	Increase in growth; higher production	Increase feed input; adjust harvest and market production schedules

Climatic Change Element	Impacts on aquaculture or related function	Adaptive measures
	Increase in eutrophication and upwelling; mortality of farmed stock	Improve planning and siting to conform to CC predictions; establish regular monitoring and emergency procedures
	Increase virulence of dormant pathogens and expansion of new diseases	Focus management to reduce stress; set up biosecurity measures; monitor to reduce health risks; improve treatments, management strategies; make genetic improvements for higher resistance
	Limitations on fish meal and fish oil supplies/ price	Identify fish meal and fish oil replacement; develop new forms of feed management, make genetic improvement for alternative feeds; shift to non-carnivorous species; culture bivalves And seaweeds wherever possible
Sea level rise and other circulation changes	Intrusion of salt water	Shift stenohaline species upstream; introduce marine or euryhaline species in old facilities
	Loss of agricultural land	Provide alternative livelihoods through aquaculture, building capacity and infrastructure
	Reduced catches from coastal fisheries, seedstock disruptions, reduced options for aquaculture feeds; income loss to fishers	Make greater use of hatchery seed; protect nursery habitats; develop/use formulated pellet feeds (higher cost but less environmentally degrading); develop alternative livelihoods for suppliers
	Increase of harmful algal blooms (HABs)	Improve monitoring and early warning systems; change water abstraction points where feasible
Acidification	Impact on calcareous shell formation/deposition	Adapt production and handling techniques; move production zones
Water stress and drought conditions	Limitations for freshwater abstraction	Improve efficacy of water usage; encourage non-consumptive water use in aquaculture, e.g. culture based fisheries; encourage development of mariculture where possible
	Change in water-retention period (inland systems reduced, coastal lagoons increased)	Use different/faster growing fish species; increase efficacy of water sharing with primary users, e.g. irrigation of rice paddy; change species in lagoons
	Reduced availability and period change of wild seed stocks	Shift to artificially propagated seed (extra cost); improve seed quality and production efficiency; close the life cycle of more farmed species
Extreme weather events	Destruction of facilities; loss of stock; loss of business; mass scale escape with the potential to impact on biodiversity	Encourage uptake of individual/cluster insurance; improve siting and design to minimize damage, loss and mass escapes; encourage use of indigenous species to minimize impacts on biodiversity, use non-reproducing stock in farming systems

Source: De Silva in FAO 2008

6.3 Adaptive responses by governments for the fisheries sector to maintain/increase trade competitiveness in the face of climate change impacts

While many of the measures discussed above will be the responsibility of private citizens and firms to undertake, governments have an important role in creating a) an enabling environment for adaptation to take place, and b) a regulatory environment that prevents reactive adaptation that has negative environmental, social and economic consequences.

The elements of such an enabling environment include, for example:

- Establishment of fisheries management frameworks that provide for a) flexible and adaptive decision-making by communities in response to climate change e.g. co-management, and b) more sustainable exploitation, increasing the ability of the sector to deal with change;
- Participation in international networks for disaster preparedness e.g. tsunami early warning systems;
- Ensuring an enabling business environment (e.g. as defined by parameters/indicators assessed in www.doingbusiness.org) which facilities trade and the generation of value-addition for those in the sector; and
- Support for technological developments facilitating adaptive measures e.g. reduction of tariffs on the importation of clean environmental technology, allocation of government research monies for work on adaptive strategies.

Examples of some elements of a regulatory environment which could need to be considered to prevent negative impacts of reactive adaptation might include:

- Regulation related to the concentration of fishing rights in the hands of those most able to adapt to climate change impacts (which could have significant negative social impacts in some areas as well as economic gains for those acquiring a greater share of fishing opportunities);
- Controls on potentially harmful environmental impacts of the development of aquaculture in response to declining capture fisheries e.g. introduction of non-endemic species, waste discharge, disease

The following paragraphs provide some additional explanation of how specific policy and management responses taken by government can be used to maintain/enhance trade competitiveness.

Re-building stocks and improving fisheries governance

Stocks that are not overfished are likely to be more resilient to climate change impacts. Thus initiatives aimed more generally at management of the sector (e.g. decommissioning, introduction of fishing rights, improved monitoring control and surveillance) may all help to improve the adaptive capacity of fisheries to climate change. This in turn may require institution building of fisheries administrations, representative sector organizations, and civil society engaged with the fisheries sector.

Strategies regarding onshore fisheries and coastal infrastructure

Provision of safe havens/harbours for the fishing sector to protect vessels can ensure continuing levels of catches available for trade, while climate-proofing any such developments through careful siting and appropriate engineering will be increasingly important. In addition, investment decisions on where to site onshore landings, marketing and processing infrastructure must take into account sea and lake level changes, and potential changes in fleet structures and species mix.

Managing declining incomes if fish catches fall due to lower catches, and efforts aimed at diversification and fostering alternative livelihood activities
Enabling exit from the fishery sector in response to downturns, by providing training in alternative occupations or through general investments in skills and capabilities, may be important in fisheries that are declining or subject to reduced productivity under projected climate change. The exit of some participants may be critical in maintaining the viability of others that remain in business to produce and trade.

In less capital-intensive smaller-scale fisheries, complete exit may not be necessary, and facilitation of fisherfolk to engage in a range of other income-generating and subsistence activities may reduce dependency on climate-sensitive stocks. One frequently suggested alternative is aquaculture, but the transition from hunting to farming fish is not always as easy as it might seem – particularly for fisherfolk that own no suitable land, may lack secure tenure to sea areas, and/or have limited capital to invest in aquaculture technologies.

Other suitable policy measures to encourage diversification may therefore include:

- Removing or reducing entry barriers to alternative occupations (e.g. commodity-based trade taxes, small-business licence fees, official and unofficial taxes on freedom of movement);
- Providing generic enterprise development skills and support, for example training in financial planning, accounts, market analysis and so on; and
- Investing in educational provision for children– experience suggests that many fishing and rural communities experience outmigration of young people when they are educated, as such people are able to find their own alternatives to fishing.

Dealing with fisheries' status as a 'safety net' activity
In many countries, climate change impacts on livelihoods in other sectors e.g. agriculture, may result in increased pressure on fish resources, in turn requiring specific policy to deal with part-time/occasional fishermen wishing to exploit fish resources given reduced land-based income generating activities, so as to ensure that fish catches are sustainable. Failure to do so is likely to result in over-exploitation and reduced yields available for trade. This may include design and implementation of suitable access 'filters' to regulate any influx of people into community and state-managed fisheries, and also anticipation of this phenomenon and provision of incentives to reduce it, such as wider availability and use of social protection measures.

Disaster preparedness and response
Guidelines for implementation-level disaster preparedness and response specific to the fishery and aquaculture sectors, are currently being prepared by the WorldFish Center with FAO and the Network of Aquaculture Centers of Asia (NACA), and along with other policy-level guidelines already available suggest that key recommendations are:

- *Invest in improved weather information and storm warnings*. Given predicted increases in severity of extreme weather events, this may ensure that fishermen and their assets are not lost at sea, and that loss of life and damage to property on shore is reduced;

- *Ensure that the fishery sector is included in national disaster preparedness and response planning.* In many Tsunami-affected countries, this was not the case, leading to sometimes poorly planned and inappropriate responses and rebuilding programmes;
- *Ensure that fisheries line management agencies are familiar with disaster preparedness and response procedures.* Currently for example, most fisheries departments don't have specific disaster response plans built into sectoral master-plans;
- *Ensure that specialist fisheries sector technical expertise is available to disaster relief agencies.* Fisheries and aquaculture are technically specialized sub-sectors, and few of the major disaster relief agencies and NGOs that provide assistance in the aftermath of extreme events are familiar with the nature and status of fisheries and aquaculture prior to the disasters. After the Asian Tsunami, it was clear most disaster relief operations were unaware that many Asian fisheries were overcapitalized and stocks degraded, and livelihood rehabilitation efforts actually further increased capacity and made rebuilding fisheries more difficult; and
- *Building back better.* Disasters often reveal underlying vulnerabilities and weaknesses in infrastructure, the economy and society. Rehabilitation periods (after emergency relief has been delivered) should aim not at restoring the flawed structures of the pre-disaster period, but at affecting the kinds of transformation that will reduce future vulnerability.

All such efforts can be successful in safeguarding fishing sector assets and profits, thereby ensuring that business remain viable and can continue to produce and trade fish.

Aquaculture development

Aquaculture production increases may in some cases be possible where capture fisheries production declines, thereby helping to ensure overall production levels for food security, incomes, employment and trade. Important will be the need for countries to ensure that adaption strategies 'climate-proof' any sector developments e.g. ensure that aquaculture development takes place in a way that minimizes the potential for extreme events to result in damage to assets. This will require systems of land-use planning to ensure that aquaculture installations are not cited in vulnerable areas, or that aquaculture development does not erode adaptive capacity more generally (e.g. by undermining the natural flood and storm protection functions of mangroves and floodplain wetlands). Aquaculture development could also plan for adaptation through investment in technologies that reduce loss of stocks during floods. Examples include building higher pond dykes, switching to cage aquaculture, or surrounding flooded ponds with netting strung on poles – a simple but effective method for reducing stock losses that has successfully been used by Bangladeshi farmers exposed to recent cyclones. These technological innovations can be supported in policy through grant and finance schemes for 'climate proofing' and by provision of technical advice through extension services.

Species selection, selective breeding and genetic modification in aquaculture

In aquaculture, changing temperature and growing conditions may alter the comparative advantage between countries for culture of particular species, and it can be expected that production systems and marketing chains will need to adapt. There are four possible approaches to such adaptation, and governments have a critical role in all of them in facilitating private sector change through supporting research and an enabling policy environment:

- Alter the conditions of culture (e.g. move cage culture to deeper waters, pond culture to higher altitudes, introduce aeration – such adaptations may be costly).
- Altering the species that are cultured - either by using seed from wild populations that have become more abundant as a result of climate change, or importing seed from hatcheries in other areas. There are significant biosafety issues with bringing in species and strains that may not be naturally present; many such introductions have resulted in costly 'biological invasions' as species have escaped culture systems and become naturalized, often with negative consequences on native biodiversity, and on ecosystem functions important to the economy (Rahel and Olden, 2008).
- Using conventional animal breeding techniques to breed species more tolerant to new conditions (e.g. higher water temperatures, lower levels of dissolved oxygen, higher food conversion ratios) – obviously only possible where hatchery cultivation has been developed. This will exclude some important species in aquaculture that currently rely on seed caught from the natural environment.
- Genetic modification may be possible and necessary in aquaculture to develop cultured strains of important aquaculture species that are better able to deal with climate change impacts. There has been very little such work in fish and shellfish species to date.

Inclusion of fisheries in UNFCCC, NAPAs and PRSPs

Funding for adaptation, and to support development objectives in fishing-dependent communities, can help to improve adaptive capacity, thereby ensuring maintained production and trade. The UN Framework Convention on Climate Change seeks to define countries rights and responsibilities with respect to GHG emissions and adaptation funding. At the highest level, inclusion of the fisheries sector in the text of the convention, due for ratification in Copenhagen in December 2009, would help secure its place in adaptation funding policy. A partnership of organizations concerned with fisheries and oceans have lobbied for this inclusion (e.g. see Dulvy and Allison, 2009) and have received the support of a number of State delegations to the UNFCCC. An immediate policy action that could be taken is for Commonwealth States to support amendments to the current draft of the negotiating text to include mention of the need for adaptation in the fisheries sector.

Specific reference to the fisheries sector in National Plans of Adaptation (NAPAs) to climate change signals priority for expenditure on adaptation in the sector, so a second policy initiative could be to ensure the sector is included in on-going reforms to existing plans or preparation of new NAPAs.

Inclusion in Poverty Reduction Strategy Papers (PRSPs) helps to ensure fisheries and aquaculture in the highly indebted poor countries receive a budget allocation in associated medium-term expenditure frameworks developed to implement PRSPs. This can contribute to maintaining sustainable fisheries and ensuring government investment in infrastructure, services and regulatory institutions that help to maintain or improve trade competitiveness.

Ecosystem-based adaptation

Coastal ecosystems like wetlands, coral reefs, mangroves all provide natural shoreline protection from storms and flooding, in addition to their role in maintaining sustainable fish production and trade because of their importance as breeding and nursery areas. They also have important roles to play in tourism and global biodiversity conservation. The overall policy context is set by a range of international and regional legislative and planning frameworks, including Regional Seas Commissions, the environmental provisions of the UN

Convention on the Law of the Sea (UNCLOS), the Convention on Biodiversity, the Ecosystem Approach to Fisheries Management, and the Code of conduct for Responsible Fisheries. Recent impetus to these initiatives is given by the May 2009 Manado Declaration on the Oceans.

6.4 Trade and climate change policy linkages in maintaining trade competitiveness

The section above outlined a number of *climate change policies* (e.g. adaptation and mitigation in the fisheries sector) which could be used by Commonwealth States to protect their fisheries trade competitiveness. However, at the national and international level, there are a number of key linkages between *(fisheries) climate change policy* and *(fisheries) trade policy* which are also very pertinent to maintaining/increasing trade competitiveness. These are discussed below.

Domestic consumption vs. international trade

With potential declines in fish production of certain species in some countries, policy must be informed by the relative advantages of trading fish domestically and internationally, and in certain cases where production declines due to climate change impacts, policy makers may be required to make explicit choices between trading internationally and domestic consumption. Critical issues in this regard may not just relate to the financial/economic value-added from trade into different markets, but also to issues of food security (likely to become critical in many countries given climate change impacts coupled with population increases)[29].

This issue relates not just to the domestic or international trade of fish caught or produced domestically, but also the sale of access rights to foreign entities to fish in national EEZs. The sale of these rights represent a trade, but governments may be less willing and/or able to sell licences if fish abundance is reduced by climate change - on the one hand there will be less incentive for foreign vessels to pay fees if fish resources are less available, while on the other governments may chose to safeguard resources for domestic catch and consumption to protect local incomes and food security.

The food miles debate and carbon footprints

Initiatives in developed country markets on 'food miles' could have negative implications on developing country fish exporters, thereby requiring special policy responses. Such responses could include support for the notion of 'fair miles' and a more nuanced understanding of carbon emissions (see also following discussion on mitigating measures). For example, embodied carbon[30] in locally produced goods in developed countries may be much higher than in goods exported by developing countries and sold in developed countries, even allowing for the carbon footprint from transportation, while the question of the extent to which end consumers should be responsible for carbon emissions is also of increasing concern to many less developed countries with important export sectors. As noted below in the discussion on mitigation measures such as reducing carbon emissions also offer the potential for exporters to brand/market products as being carbon neutral or to demonstrate initiatives aimed at reducing carbon emissions.

Trade in ecosystem-based services

It may be possible to capture the range of ecosystem service values of wetlands, coral reefs, and mangroves discussed above in such a way that they bring tangible financial benefits in

---

[29] Note also that food security can be achieved indirectly through exports and resulting revenues

[30] Refers to carbon dioxide emitted at all stages of a good's manufacturing process.

the form of trade/payments. Means for doing so include conservation payments, payments for environmental services, linkages with carbon markets (e.g. REDD for mangroves), and funding/revenues through eco-tourism ventures. This is an area for further research, as it remains largely untested, and the viability of various schemes will also depend on renegotiation of the Clean Development Mechanism in the UNFCCC process, and on developments in carbon markets.

Technical Barriers to Trade (TBTs)

The UN Framework Convention on Climate Change, in its article 3.5, recognizes that action to address climate change may have trade implications. Hence, in setting the guiding principles for the Convention, Parties cautioned that "measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade" (United Nations 1992). Similarly, Annex I Parties to the 1997 Kyoto Protocol have agreed to "strive to implement policies and measures in such a way as to minimize adverse effects, including the adverse effects of climate change, effects on international trade, and social, environmental and economic impacts on other Parties, especially developing country Parties" (United Nations 1998). In addition, WTO's Technical Barriers to Trade agreement prohibits standards that create unnecessary obstacles to trade (for example high energy-use fishing methods could not be discriminated against by importing countries).

Fiscal measures (e.g. subsidies and domestic support mechanisms) for adaptation (and mitigation)

Under GATT/WTO rules the SCM (subsidies and countervailing measures) agreement prohibits industry and sector-specific subsidies. Governments may however want to provide specific support for the poor and vulnerable facing particular risks from climate change. Commonwealth States therefore need devise careful strategies for funding of adaptation and mitigation in the fisheries sector that don't fall foul of the SCM agreement.

Aid for Trade

Set up in the course of the long-running Doha Round of global trade talks, the WTO work programme on aid-for-trade aims to mobilise additional funding to help poor countries overcome supply-side constraints that hamper their ability to benefit from the multilateral trading system. While aid-for-trade is primarily trade-related, the economic resilience that it creates could have positive effects in helping countries deal with the potential impacts of climate change. This would be particularly true if aid for trade can anticipate possible climate impacts on trade-related infrastructure or on key fish species/sectors likely to be impacted, and respond accordingly in the design, implementation and financing of relevant projects.[31]

CITES

There is a potential linkage between CITES[32] and trade in fish products, if certain fish species become rarer due to climatic impacts and are placed on CITES Appendices. A number of ornamental fish organisms are already included in such Appendices for example. Others could be added through climate change impacts on coral reefs, and could have impacts on both ornamental and live reef fish-for-food trade as well as trade in fish for food more

[31] ICSTD

[32] CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is a voluntary international agreement between Governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival

generally. The text below shows how inclusion in CITES listing can have very real impacts on trade.

Box 1: The case of queen conch and CITES listing

Prior to 1997, as much as 23.5% of the conch landings in Antigua and Barbuda were exported to the neighbouring French territories. Antigua and Barbuda acceded to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1997, and the first CITES review of Queen conch (Strombus gigas) in 1999, resulted in Appendix II listing, and a recommendation to suspend imports of Queen conch from Antigua-Barbuda and other Caribbean islands (Trinidad-Tobago, Barbados, Dominica, St. Lucia, etc). This was the direct result of Parties failing to respond to the recommendations of the CITES Animals Committee (a committee of experts that provide advice on species subject to CITES trade controls). Trade sanctions were removed from Antigua-Barbuda in 2006 following presentation to CITES Animals Committee, but the sanctions were the "final nail in the coffin" for Queen conch as an export commodity; conch exports to the European Community (French territories overseas) had already started to decline due to the stringent, harmonized, food safety regulations adopted by the EC (queen conch, a marine gastropod, was classified under regulations that dealt with bivalve mollusc by the EC, specifically, Directive 91/492/EEC), and trade of conch to the EC has not resumed due to the stringent food safety requirements. The Bahamas was able to retain access to the market but working to convince the CITES Animal Committee of the sustainability of the Queen Conch fishery has consumed, and continues to consume government resources, in terms of time, money and manpower.

Countries such as Jamaica which have an industrial conch fishery were better able to meet CITES trade recommendations regarding annual conch abundance surveys due to investment in research by the industry. In the case of Antigua-Barbuda, the cost of the first conch abundance survey was almost equal to 20% of the annual ex-vessel value of conch production, and more than five times the ex-vessel value of conch exports.

Source: Antigua and Barbuda Fisheries Division & Bahamas department of fisheries, Pers. Comm., 2009

Trade issues in the FAO Code of Conduct for Responsible Fisheries (CCRF)

A major issue addressed by the CCRF in Article 11 is the concept of "responsible fish trade": countries should promote trade of fish produced - either by aquaculture or capture fisheries - in a responsible way, or could prohibit trade in fish products not produced in such a manner. Definitions of what constitutes responsible and precautionary fisheries exploitation could change significantly due to climatic impacts, and could require countries to change fish trade policy accordingly.

Economic Partnership Agreements and erosion of tariff preferences

Non-reciprocal preferential trading regimes that have existed under the Lome/Cotonou Agreements since 1975 are being phased out. ACP countries have the potential to initial/sign 'goods-only EPAs', 'full EPAs' covering goods and services, negotiate reciprocal trade agreements, or to revert back to the generalized system of preferences (GSP) schemes of the EU for their trade relations with Europe. For many Commonwealth States, the EU represents a key export market. Opting for the GSP or the GSP+ scheme may hinder progress in implementation of the adaptive measures for the fisheries sector discussed above and transfer of environmental technologies.

6.5 Mitigating responses to climate change to maintain/increase trade competitiveness

Mitigation options in the fisheries sector are very much at the early stages of investigation – apart from some studies of energy consumption by the world's fishing fleets (Tyedmers et al, 2005) and a recent study on aquaculture, energy and carbon emissions conducted under the UK's Foresight programme (Bunting et al., 2009) there has been little consideration in the fisheries sector of energy and emissions reductions linked to issues around mitigation and carbon markets.

The current contribution of the fisheries sector to global warming is not known, as estimations of embodied carbon in fisheries production and trade of the sector on a global basis has not been completed, for example using life cycle analysis, carbon footprint analysis (Wackernagel and Rees, 2006), or hybrid life-cycle analysis (TERI, 2008).

Table 24 highlights some illustrative examples of the contribution of the sector to global warming through some key impacts, energy usages and emissions:

Table 24: Contribution of fisheries sector to global warming

Key impacts	Some examples (not intended to be exhaustive)
Construction of vessels and fishing gear	Energy use required to produce - steel or fiberglass use in the semi-industrial and industrial fleets - energy use required to produce fishing nets, lines, ropes (principally polyethylene and Nylon), hooks (metal), and floats (plastic) Wood (i.e. deforestation) used for vessels in artisanal fisheries
Construction of aquaculture plants equipment	- Clearance of vegetation (e.g. mangrove deforestation) during onshore site preparation - Energy use required to produce metals, ropes and plastics in cages, ponds, etc
Construction of onshore infrastructure need for fisheries trade	Energy use required to produce metals, plastics, cement and other materials used in the construction of: - landings infrastructure in the form of harbours, jetties - ice plants, freezing plants, cold stores, chill stores - fish processing factories and equipment - vehicles used for transportation - buildings used as marketing and sales outlets
Fuel use during operations and trade (from national power grids, private generators, or use of wood)	- Fuel use by fishing vessel engines in catching sector (note also used for catching fish used in aquaculture feed) - Energy used during aquaculture operations (e.g. to run pumps) - onshore electricity and fuel required in processing (may include fossil fuels in semi-industrial and industrial processing, and wood in small-scale processing) - Electricity and fuel required by marketing and sales outlets (e.g. for chill and cold storage, production of ice) - Fuel used during road, sea and air transportation through the whole supply chain from the point of landing to end consumers

Source: Macfadyen and Allison, 2009

Policy options to contribute towards climate change mitigation could therefore include taxation, regulation and incentives related to:

- Fuel use and/or vessel engine emissions;

- Technical innovations to reduce fuel usage and emissions in fishing vessel engines (e.g. more efficient vessel design reducing engine size requirements);
- Promotion of fuel-efficient fishing methods (e.g. static methods rather than the use of active gear such as trawling with high energy requirements), through differential licensing conditions and/or decommissioning support;
- Research into support for low impact aquaculture e.g. herbivorous aquaculture species which may have a lower carbon footprint than carnivorous species.
- Improvements in building design and handling practices to reduce energy requirements and increase energy efficiency e.g. through better insulation in ice plants, freezing plants, cold stores and chill stores;
- Reduction of fuel use in the transportation of fish to markets;
- 'Environmentally-friendly' technologies; and
- Mangrove protection/replanting, due to its role in carbon sequestration.

Important for many of these policy options, and providing a strong link between climate change and trade policy is that countries could increase their competitive trading position through their implementation, for example through:

- Linking mangrove conservation with the Reducing Emissions from Degradation and Deforestation (REDD) carbon credit scheme;
- Market promotion and branding of fisheries sectors or products that use energy efficient standards in an attempt to reduce their carbon footprint;[33] and
- More efficient production methods which could be expected to increase value-addition throughout the supply chain by reducing costs.

6.6 Synthesis of policy fora of relevance to climate change and trade competitiveness, and consideration of funding sources for adaptation and mitigation

What is clear from the above discussion is that there are many different policy fora which may be of relevance to climate change impacts and maintaining fisheries trade competitiveness. What seems critical is an understanding and awareness of the inter-linkages between these various fora and policies so that what is negotiated in one forum does not contradict or undermine the development efforts of Commonwealth States in other fora. This in turn suggests that it may be very important for Commonwealth States to consider the potential to strategically address climate change and trade competitiveness issues simultaneously in different fora so as to ensure a coordinated approach. For example:

- WTO negotiators from Commonwealth Developing States engaged with the issues of subsidies, need to be aware that the use of subsidies may be appropriate / necessary in special circumstances to support adaptation and mitigation so that countries continue to be able to produce and trade fish products. Likewise those involved with negotiating TBTs and aid for trade must be aware of the climate change linkages discussed above;
- Those preparing NAPAs and PRSPs must be made aware of the importance of the fisheries sector in terms of trade and national economies, so that the fisheries sector is specifically included in such documents;
- Eco-labelling and/or branding could provide market advantages in the form of improved prices and/or improved market access from enhanced trade competitiveness to compensate for investments in sustainable fisheries, adaptation and mitigation;

[33] The Maldivian president, Mohamed Nasheed, recently announced his intention that ‘ the Maldives will become the first carbon-neutral country in the world.’ (New York Times, 9th May 2009)

- Market standards and the use of safeguards may prevent poorer countries from taking advantage of trading opportunities. For example the new EU IUU regulation means that as of 1 Jan. 2010, all fishery products being sold into the European Community will have to be certified as having been caught legally. Competent authorities will have to provide catch certificates to exporters once they are satisfied that exports are not the product of IUU fishing. The need to provide appropriate assurances that fish is not coming from IUU fishing will certainly result in additional costs (administrative and potentially in terms of increased monitoring, control and surveillance) and could potentially result in trade impacts - in some cases it may be difficult for exports, especially from small-scale fisheries, to comply with the regulations given the problems that are frequently inherent with regulating and managing small-scale fisheries. Thus while ensuring sustainable exploitation is an important adaptive strategy in ensuring that fish production is available for trade, the effects of the IUU regulation may be felt in Commonwealth States by the catching sector (legal and IUU), the fishing trade and processing sector, and by public authorities;
- Fisheries access agreements, where they do not include adequate catch limits and enforcement mechanisms specified in the context of climate change impacts on stocks, may lead to long-term decline in fisheries resources and therefore trade in domestically caught products. Thus access agreement negotiators must ensure that sufficient safeguards are in place to prevent over-fishing and illegal activities while also assessing the relative merits of trade in foreign licences vs supporting export trade of nationally caught product;
- Commonwealth State representatives at the bi-annual FAO Committee on Fisheries (COFI) meetings should urge the FAO to further pursue normative and field-based initiatives aimed at adaptation and mitigation;
- Signing EPAs implies a level of financial support provided by the EU to help countries adapt to the erosion of preferential tariff regimes. Given the sorts of potential impacts of climate change highlighted in this study, and in particular the dependencies on fisheries and vulnerabilities shown in the case studies (e.g. threats to canneries in both Maldives and Solomon Islands), development funding associated with the signing of EPAs, could be used to support adaptive capacity initiatives. ACP countries may therefore be well served by signing full EPAs as a way of reducing vulnerability to climate change-induced impacts on the fisheries sector; and
- Commonwealth States that are Parties to CITES, or thinking of becoming so, must think carefully about the potential trade impacts of CITES listings when voting at the Conference of the Parties (CoP), which is the supreme decision-making body of the Convention and comprises all its member States. The impact of CITES listings on trade can be very real as evidenced by Box 1 above.

In addition to the being aware of which policy fora may be critical to both climate change and trade competitiveness, also of vital importance is that implementation of policy choices will in many cases require considerable levels of funding. It is therefore important to consider potential funding sources and mechanisms for the range of policy options available, as without appropriate funding, the adaptation and mitigating measures described above, may not be implemented, and with resulting negative impacts on the competitive position of individual countries with regards to fisheries trade.

The above text has already highlighted that inclusion of fisheries in both NAPAs and PRSPs can help to ensure that specific fisheries-sector funding is provided to support adaptation and mitigation. Funding could of course come directly from regular government budgets in

Commonwealth States, but given competing demands for finance, it is likely to be critical for Commonwealth States to identify external sources of funding to support climate change adaptation and mitigation.

Article 4 of the UNFCCC highlights that developed country Parties will provide financial resources to assist developing country Parties adapt to climate change. Such assistance may be necessary to support both physical investments and research and management requirements (human, financial). To facilitate financing for developing countries, the Convention has assigned the responsibility of operating its financial mechanism to GEF. The GEF operates three funds: the GEF Trust Fund; the Least Developed Countries Fund (LDCF); and the Special Climate Change Fund (SCCF). (UNFCCC, 2008)

- The GEF Trust Fund and its Strategic Priority on Adaptation (SPA) supports enabling activities and pilot demonstration projects that address adaptation and at the same time generate global environmental benefits. The GEF has allocated 50 million under the SPA of which 5 million has been devoted to piloting community adaptation initiatives through the Small Grants Programme;
- The LDCF was partly established to support adaptation projects identified by developed countries by their NAPAs; and
- The SCCF is partly designed to finance adaptation activities that increase resilience to the impacts of climate change, through a focus on water resources, land, agriculture, health, infrastructure development, disaster preparedness, and fragile ecosystems and coastal zones. Funding is available for establishing pilot projects for wider replicability and integration into national policy and sustainable development planning.

In addition to these funding sources, other potential funding mechanisms to support adaptation and mitigation include (UNFCCC, 2008):

- The international carbon market which has emerged as a result of the Clean Development Mechanism (CDM) established in the Kyoto Protocol. The CDM allows industrialized countries to help generate funding for adaptation in developing countries in the context of sustainable development while providing them a cost effective means of offsetting their greenhouse emissions. This mechanism enables approved emission reducing projects in developing countries to earn certified emission reduction units, each equivalent to one tonne of carbon dioxide, which the project participants in the developing country can then sell to buyers in industrialized countries;
- The Adaption Fund under the Kyoto protocol, which is intended to fund adaptation projects and programmes in developing countries that are particularly vulnerable to climate change[34]. The source of this funding is intended to be a 2% levy on proceeds from CDM projects (excluding those in least developed countries), as well as from voluntary sources;
- Multilateral Environmental Agreements (MEAs) which may provide funding and synergies with projects to help climate change adaptation and mitigation. MEAs of potential interest to the fisheries sector include the Convention on Biological Diversity, and the Ramsar Convention on Wetlands;

[34] Note that this Fund is yet to be operationalised, and the amount of monies that might be available is uncertain

- Multinational and bilateral donors. ACP countries may look especially to the EC/EuropeAid, and to bilateral funding sources from EU Member States (e.g. France, the UK, and Northern European countries which have a strong track record in fisheries sector support e.g. Norway/NORAD, Denmark/DANIDA, Sweden/SIDA), but the World Bank, UNEP, the African Development Bank, the Asian Development Bank, and USAID are other examples of organisations that may also provide funding opportunities; and
- Foundations and NGOs/INGOs. A number of foundations are known to be active in providing funding support to the fisheries sector (e.g. Packard Foundation, Oak Foundation, Pew Charitable Trusts), and many NGOs and INGOs (such as WWF, The Nature Conservancy and Conservation International) are now engaged in climate change work as it pertains to the fisheries/marine sector.

Finally, it is also worth noting the potentially important role of the private sector in providing funding to support climate change adaptation and mitigation. Three principle sources include

- Rents collected by Government from the catching and processing sectors in developing Commonwealth States, which could be used to fund adaptation and mitigation;
- Private sector retailers and consumers in developed countries. Based on experiences of market-based initiatives such as the Marine Stewardship Council aimed at environmental certification, such groups could be expected to be supportive of certification and branding initiatives surrounding mitigation initiatives and 'green' trade. This support could come in the form both of market access, but also potentially higher market prices; and
- The insurance market. Given the very significant potential costs of climate change to developing Commonwealth States, insurance can serve to enhance financial resilience to external shocks and provide an opportunity to spread and transfer risk. Support for insurance-related actions may also help to quantify risks and potential losses of climate change, with insurance rates reflecting mitigating measures. The insurance market in developing countries is currently not well developed, and considerable work is required in assessing specific issues in the fisheries sector and considering ways forward. Some relevant (non-fisheries specific) examples of recent initiatives include:
    - the micro-insurance scheme by the United Insurance Company Limited Hurricane Mitigation Programme, which operates in 14 Caribbean countries and aims to reduce the vulnerability of Caribbean property to hurricanes by providing financial incentives for insurance holders to put preventative measures in place;
    - Loans provided by microfinancing institutions such as Grameen in Bangladesh which are promoting loans to reduce vulnerability;
    - The Caribbean Catatrophe Risk Insurance Facility (CCRIF) which uses a portion of donor-funded capital reserves to assist in the establishment of a facility that assists countries in pooling their risk and reducing insurance costs; and
    - Other initiatives on a more global level such as the Insurance Working Group of the UNEP Finance Initiative (a public/private partnership between UNEP and 16 leaders of the global financial sector), and the Munich Climate Insurance Initiative which was initiated by Munich Re in 2005, as suggested in the UNFCCC and the Kyoto Protocol.

6.7 Future policy research needs

In preparing this report, it has become evident that a number of areas of research are urgently required to reduce the vulnerability of small developing Commonwealth States to potential climate change, and to ensure that trade competitiveness is not endangered by climate change impacts. These include:

- climate change risk assessments at national, rather than at regional/global scales, of the physical changes in oceans, lakes and rivers;
- improved and more robust assessments of physical impacts of climate change on fish and ecosystems, again at a more national level through downscaled global climate models, and at time-scales relevant to sectoral planning (e.g. to 2030 as well as to 2050 and 2100);
- more nuanced fisheries-specific indicators of exposure, dependency and adaptive capacity, to enable sector- and country-specific vulnerability analyses;
- research into embodied carbon and other mitigating measures, including the development of sector-specific carbon accounting methodologies and identification of critical carbon-costly links in global value chains in aquaculture and fishery products;
- identification of novel adaptive measures, and greater knowledge of the technical and political feasibility of those already identified; and
- economic research to evaluate the potential costs of adaptation and mitigation initiatives, and how to fund them

Appendix 1: Bibliography

Ahmed, N., E. H. Allison and J. F. Muir (2009) Rice fields to prawn farms: a blue revolution in southwest Bangladesh? Aquaculture International DOI 10.1007/s10499-009-9276-0 advance publ online 29th June 2009

Allison, E.H., A. Perry, M-C. Badjeck, W.N. Adger, N.L. Andrew, K. Brown, D. Conway, A. Halls, G.M Pilling, J.D. Reynolds, and N.K. Dulvy. (2009) Vulnerability of national economies to potential impacts of climate change on fisheries. Fish and Fisheries 10: 173-196.

Allison, E.H. (2003). Linking national fisheries policy to livelihoods on the shores of Lake Kyoga, Uganda. LADDER Working Paper No 9, ODG, Norwich, U.K. (http://www.odg.uea.ac.uk/ladder/)

Allison, E.H., and F. Ellis (2001). The livelihoods approach and management of small-scale fisheries. Marine Policy 25 (5) 377-388.

Allison, E.H., Adger, W.N., Badjeck, M-C., Brown, K., Conway, D., Dulvy, N.K., Halls, A., Perry, A., and Reynolds, J.D. (2005). Effects of climate change on the sustainability of capture and enhancement fisheries important to the poor: analysis of the vulnerability and adaptability of fisherfolk living in poverty. Project No. R4778J. Final Technical Report, Fisheries Management Science Programme, MRAG/DFID, London. 164 pp. **www.fmsp.org**

Ayers & Huq, 2007. Critical list: the 100 nations most vulnerable to climate change. IIED, December 2007.

Bakun, A. 1990. Global climate change and intensification of coastal ocean upwelling. Science, 247: 198–201.

Barange, M. and I. Perry, 2009. Physical and ecological impacts of climate change relevant to marine and inland capture fisheries and aquaculture. In FAO TP 530 (in press)

Beaugrand, G., Reid, P.C. Ibáñez, F., Lindley, J. A. & Edwards M. 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. Science, 296: 1692–1694.

Behrenfeld, M.J., O'Malley, R.T., Siegel, D.A., McClain, C.R., Sarmiento, J.L., Feldman, G.C.,Milligan, A.J., Falkowski, P.G., Letelier, R.M. & Boss E.S. 2006. Climate-driven trends in contemporary ocean productivity. Nature, 444: 752–755.

Bell, JD, et al. Planning the use of fish for food security in the Pacific. Marine Policy (2008, in press) – google this is now published.

Brewer and Peltzer, 2009. Limits to Marine Life. www.sciencemag.org

Bruno, J.F., Selig, E.R., Casey, K.S., et al. (2007) Thermal Stress and Coral Cover as Drivers of Coral Disease Outbreaks PLoS Biology 5, e124.

Bunting SW, Pretty J, Muir JF, 2009. Carbon and energy consumption futures for fisheries and aquaculture. interdisciplinary Centre for Environment and Society, University of Essex, UK and Institute of Aquaculture, University of Stirling, UK.

Cheung, W.W.L., Close, C., Lam, V., Watson, R. & Pauly, D. 2008. Application of macroecological theory to predict effects of climate change on global fisheries potential. Mar. Ecol. Progr. Ser., 365: 187–197.

Church, J.A. and White, N.J. (2006). A 20th century acceleration in global sea-level rise. Geophysical Research Letters, 33, L01602 ; redrawn by Hugo Ahlenius, UNEP/GRID-Arendal

Coe, M.T. & Foley, J.A. 2001. Human and natural impacts on the water resources of the Lake Chad basin. J. Geophys. Res., 106: 3349–3356.

Cochrane, K., de Young, C., Soto, D., Bahri T. (2009) Climate change implications for fisheries and aquaculture. Overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper 530. 2009 (in press)

Conway, D., Allison, E., Felstead, R. & Goulden, M. 2005. Rainfall variability in East Africa: implications for natural resources management and livelihoods. Philosophical transactions: mathematical, physical & engineering sciences, 363: 49–54.

Daw, Tim, W. Neil Adger, Katrina Brown and Marie-Caroline Badjeck, 2008. In FAO TP 530 in Press

deYoung, Brad, Manuel Barange, Gregory Beaugrand, Roger Harris, R. Ian Perry, Marten Scheffer and Francisco Werner, 2008. Regime shifts in marine ecosystems: detection, prediction and management. Trends in Ecology and Evolution Vol.23 No.7

Diaz, H. & V. Markgraf, eds. El Niño and the Southern Oscillation: multiscale variability and global and regional impacts, pp. 89–112. Cambridge, UK, Cambridge University Press.

Diaz and Rosenberg, 2008. Marine Ecosystems Spreading Dead Zones and Consequences for marine ecosystems. 321, 926 Science

Doney, S.C. 2006. Plankton in a warmer world. Nature, 444: 695–696.

Dulvy, N.K, and E.H. Allison (2009) A place at the table? Nature Reports Climate Change Published online: 28 May 2009 | doi:10.1038/climate.2009.52

Edwards, M. & Richardson, A.J. 2004. Impact of climate change on marine pelagic phenology and trophic mismatch. Nature, 430: 881–884.

Edwards, M.J., Johns, D.G., Leterme, S.C., Svendsen, E. & Richardson, A.J. 2006. Regional climate change and harmful algal blooms in the North East Atlantic. Limnol. Oceanogr., 51: 820–829.

Emanuel, K., R. Sundararajan and J. Williams (2008). Hurricanes and global warming;

results from downscaling IPCC AR4 simulations. Bulletin of the American Metreological Society, March 2008: 347-367.

Failler, P. & B. Samb (2006). Potential impacts of fish trade and climate change on fish supply in West Africa. FAO, SFLP Working Paper

FAO. 2006. Report of the expert consultation on the economic, social and institutional considerations of applying the ecosystem approach to fisheries management. Rome, Tuesday 6 June to Friday, 9 June 2006. FAO Fisheries Report No. 799. 15p. Rome. (also available at http://ftp.fao.org/docrep/fao/009/a0673e/a0673e00.pdf.)

FAO. 2007d. Building adaptive capacity to climate change. Policies to sustain livelihoods and fisheries. Newdirections in fisheries – a series of policy briefs on development issues, 08. 16 pp. Rome.

GHF, 2009. *The Anatomy of a Silent Crisis*. Global Humanitarian Forum, Geneva

Goes, J.I., Thoppil, P.G., Gomes, H. do R. & Fasullo, J.T. 2005. Warming of the Eurasian landmass is making the Arabian sea more productive. Science, 22: 545–547.

Government of Bangladesh, 2008. Climate Action Plan. Dhaka.

Grynberg, R., D. Forsyth, and R. Twum-Barima (1995). Tuna Industry Development Study – Country Profiles: Solomon Islands. Report 95/37, Forum Fisheries Agency, Honiara.

Guinotte et al. (2003) Coral Reefs Vol. 22, pp. 551-558

Handisyde, N.T., L.G. Ross, M-C. Badjeck & E.H. Allison (2006). The effects of climate change on world aquaculture: a global perspective. Final Technical Report, DFID Aquaculture and Fish Genetics Research Programme, Stirling Institute of Aquaculture, Stirling, U.K., 151 pp. http://www.aqua.stir.ac.uk/GISAP/climate/index.htm

Harley, C.D.G., Hughes, R.A., Hultgren, K.M., Miner, B.G., Sorte, C.J. B., Thornber, C.S., Rodriguez, L.F., Tomanek, L. & Williams, S.L. 2006. The impacts of climate change in coastal marine systems. Ecol. Lett., 9: 228–241.

Harvell, C.D., Kim, K., Burkholder, J.M., Colwell, R.R., Epstein, P.R., Grimes, J., Hofmann, E.E., Lipp, E., Osterhaus, A.D.M.E., Overstreet, R., Porter, J.W., Smith, G.W., & Vasta, G.R. 1999. Emerging marine diseases - climate links and anthropogenic factors. Science, 285: 1505–1510.

Hecky, R.E., Bootsma, H.A. & Odada, E. 2006. African lake management initiatives: the global connection. Lakes and reservoirs: research and management 11: pp. 203–213.

Hoegh-Guldberg, O., Hoegh-Guldberg, H., Veron, J.E.N., Green, A., Gomez, E. D., Lough, J., King, M., Ambariyanto, Hansen, L., Cinner, J., Dews, G., Russ, G., Schuttenberg, H. Z., Peñafl or, E.L., Eakin, C. M., Christensen, T. R. L., Abbey, M., Areki, F., Kosaka, R. A., Tewfik, A., Oliver, J. (2009). The Coral Triangle and Climate Change: Ecosystems, People and Societies at Risk. WWF Australia, Brisbane, 276 pp.

Hoegh-Guldberg, O. 2005. Low coral cover in a high- CO2 world. J. Geoph.l Res. 110, C09S06, doi:10.1029/2004JC002528.

Hoegh-Guldberg, O. 1999. Climate change, coral bleaching and the future of the world's coral reefs. Mar. Freshw. Res., 50: 839–866.

Iglesias-Rodriguez, M.D., Halloran, P.R., Rickaby, R.E.M., et al. (2008) Phytoplankton Calcification in a High-CO2 World. Science 320, 336-340.

IPCC (2007) Climate Change 2007: The Physical Science Basis. Summary for Policymakers. Intergovernmental Panel on Climate Change. p. 18.

Kell, L.T., Pilling, G.M., O'Brien, C.M. (2005) Implications of climate change for the management of North Sea cod (Gadus morhua). ICES Journal Of Marine Science 62, 1483-1491.

Kirby, R.R., Beaugrand, G., Lindley, J.A., Richardson, A.J., Edwards, M., Ried, C.P.R. (2007) Climate effects and benthic–pelagic coupling in the North Sea. Marine Ecology Progress Series 330, 31-38.

Lehodey, P., Alheit, J., Barange, M., Baumgartner, T., Beaugrand, G., Drinkwater, K., Fromentin, J-M., Hare, S.R., Ottersen, G., Perry, R.I., Roy, C., van der Lingen, C.D. & Werner, F. 2006. Climate variability, fish and fisheries. J. Climate, 19: 5009–5030.

Lehodey, P., Bertignac, M., Hampton, J., Lewis, T. & Picaut, J. 1997. El Niño Southern Oscillation and tuna in the western Pacific. Nature, 389: 715–718.

Mora C, Myers RA, Coll M, Libralato S, Pitcher TJ, et al. (2009) Management Effectiveness of the World's Marine Fisheries. PLoS Biol 7(6)

Macfadyen, G., 2008. Sustainable financing of LVFO institutions and development of a Business Plan for the organisation

Macfadyen, G., Huntington, T., Cappell, R. Abandoned, lost or otherwise discarded fishing gear. UNEP Regional Seas Reports and Studies, No. 185; FAO Fisheries and Aquaculture Technical Paper, No. 523. Rome, UNEP/FAO. 2009. 115p

Maina et al, in press

Maina, J., V. Venus, T. R. McClanahan, and M. Ateweberhan, 2008. Modelling susceptibility of coral reefs to environmental stress using remote sensing data and GIS models *Ecological Modelling* 2 1 2: 180–199

O'Reilly, C.M., Alin, S.R., Pilsnier, P.D., Cohen, A.S. & McKee, B.A. 2003. Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa. Nature, 424: 766–768.

Pauly, D, et a.l, 1995. Fishing down the food web

Pavlidis, M., Koumoundouros, G., Sterioti, A., Somarakis, S., Divanach, P., Kentouri, M. (2000) Evidence of temperature-dependent sex determination in the European sea bass (Dicentrarchus labrax L.). Journal Of Experimental Zoology 287, 225-232.

Perry, A.L., Low, P.J., Ellis, J.R. & Reynolds, J.D. 2005. Climate change and distribution shifts in marine species. Science, 308: 1912–1915.

Pitcher, Daniela Kalikoski, Ganapathiraju Pramod and Katherine Short. 2009. Not honouring the code. Countries are not complying with the UN Code of Conduct for Responsible Fisheries. Nature, Vol 457

Planque, B. & Fredou, T. 1999. Temperature and the recruitment of Atlantic cod (Ghadus morhua). Can. J. Fish. Aquat. Sci., 56: 2069–2077.

Rahmstorf, S. 2007. A semi-empirical approach to projecting future sea-level rise. Science, 315: 368–370

Reid, P.C., Johns, D.G., Edwards, M., Starr, M., Poulin, M., Snoeijs, P. (2007) A biological consequence of reducing Arctic sea ice cover: arrival of the Pacific diatom Neodenticulata seminae in the North Atlantic for the first time in 800,000 years. Global Change Biology 13, 1910-1921.

Sena S. De Silva1 & Doris Soto, 2008. In FAO TP 530 in Press

Sims, D.W., Genner, M.J., Southward, A.J. & Hawkins, S.J. 2001. Timing of squid migration reflects North Atlantic climate variability. Proc.Roy. Soc. London, B: Biol. Sci., 268: 2607–2611.

Sims, D.W., Wearmouth, V.J., Genner, M.J., Southward, A.J. & Hawkins, S.J. 2004. Lowtemperature-driven early spawning migration of a temperate marine fish. J. Anim. Ecol., 73: 333–341.

TERI, 2008. Ecological footprint: establishing a tool to measure and manage urban energy use in India and China. Unpublished research report

Thorpe,A, Reid,C., van Anrooy,R., Brugere,C., Becker,D. (2006a) Asian development and poverty reduction strategies: Integrating fisheries into the development discourse, Food Policy, 31:385-400;

Thorpe,A, Reid,C., van Anrooy,R., Brugere,C., Becker,D. (2000b) Poverty Reduction Strategy Papers and the fisheries sector: An opportunity forgone?, Journal of International Development, 2006;17:1-29;

Thorpe,A, Reid,C., van Anrooy,R., Brugere,C. (2005a) Integrating fisheries into the National Development Plans of Small Island Developing States (SIDS): Ten years on from Barbados, Natural Resources Forum, 29(1):51-69;

Thorpe,A, Reid,C., van Anrooy,R., Brugere,C (2005b). When fisheries influence national policy-making: An analysis of the national development strategies of major fish-producing nations in the developing world, Marine Policy, 29(3):211-22.

Tyedmers, P . Reg Watson, Daniel Pauly, 2005. Fueling Global Fishing Fleets. AMBIO: A Journal of the Human Environment, 34(8):635-638

UNFCCC, 2008. Climate Change: impacts, vulnerabilities and adaptation in developing countries

Wackernagel, M., and Rees, W., 1996. Our ecological footprint: reducing human impact on the earth. Philadelphia: new society publishers

Webster, P.J. 2008. Myanmar's deadly daffodil. Nature Geosciences doi: 10.1038/ngeo257 Published online: 20 July 2008

WorldFish, 2009. Waves of change: lessons learned in rehabilitating coastal livelihoods and communities after disasters.

Appendix 2: Additional text, maps and figures of relevance to Chapters 2 and 3

There are no global integrated assessments that predict the cumulative effects on fisheries of the physical changes described above, so in this review we draw together the overview done for FAO by Barange et al (2008) and examples from the global study of Allison et al (2009), supplemented by other case-studies, to assess qualitatively the likely impacts across the developing Commonwealth States with fishery and aquaculture interests. Unless specifically referenced otherwise, the text below is based strongly on, and attributable to Cochrane et al (in press) and Barange et al (2008).

Physical and biogeochemical drivers of change in oceanic, coastal and freshwater fisheries

The main climate changes that have a potential impact on fisheries are listed and briefly summarized below.

Heat content and temperature

The oceans are warming, but there are geographical differences in the extent of that warming, and there continue to be decadal cycles which can mean short-term cooling in some areas, despite the overall warming trend. Warming is not exclusive to surface waters, with deep warming being seen particularly clearly in the Atlantic Ocean. While coastal LMEs on the West Coast of the Americas have shown slight cooling, most other areas have warmed, with enclosed shelf seas (e.g. Mediterranean, Black Sea) showing particularly large increases.

Freshwaters are also warming and lake water levels have been decreasing due to increased water abstraction, increased evapo-transpiration and decreased rainfall. Africa's surface freshwaters are predicted to decline by up to 20% by 2050 and the thermal structure of the African Great Lakes to change. River run-off is expected to increase at higher latitudes and decrease in parts of Africa and Latin America.

Increases in temperature (and salinity, see below) from changes in precipitation, evaporation, river runoff and ice melt are likely to lead to increased vertical stratification and water column stability in oceans and lakes, reducing nutrient availability to the euphotic zone and thus primary and secondary production. Ecosystem productivity is likely to be reduced in most tropical and subtropical oceans, seas and lakes, and increased in high latitudes, with clear implications for the 51 of the 53 Commonwealth States located in tropical and sub regions. The result will be a projected decrease in overall fish productivity, although some areas may experience increases.

See Figure 10 and Figure 11 below.

Ocean salinity, density and stratification

Overall indications are that globally, oceans are becoming less saline due to greater precipitation, higher runoff, ice melting and advection, but that there are large regional differences. Salinity is increasing in the surface of the subtropical North Atlantic Ocean (15-42 °N), while further north and in the Southern Ocean waters are becoming less saline. Lower salinity is also reported in the Pacific, except in the upper 300m and in the subtropical gyre, where salinity is increasing, and the Indian Ocean is generally showing increases in salinity in the upper layers. Salinity affects fish species distribution, the growth and reproductive success of individual fish species and therefore the composition and productivity of fish communities, which will thus impact on fisheries.

Ocean circulation and coastal upwelling

Observed and predicted changes in the ocean's heat content and salinity are and will continue to affect circulation patterns. These are expected to decline, but at present there is conflicting and unclear evidence as to whether climate change will increase or decrease coastal upwelling (important in terms of its implications for biological production in the major fisheries of upwelling areas, such as the coasts of SW and NW Africa). Changes in upwelling seasonality may be affected by climate change, which will have important consequences for aquatic food webs, and therefore fisheries.

Sea level rise

Global average sea level has been rising at an average rate of 1.8 mm per year since 1961. The rate has accelerated since 1993 to about 3.1 mm per year. Higher rates in coming decades are likely, and recent research (e.g. Rahmstorf et al., 2007) indicates that they may be higher than even the most pessimistic IPCC 2007 scenario.

Sea level change is not geographically uniform, however, because it is controlled by regional ocean circulation processes. The largest losses of land and impact on populations and economies are likely to be in East and South-East Asia, although proportional impacts may be even higher on low-lying small-island developing states in the Pacific and Indian Oceans in particular (many of them Commonwealth States).

Rises in sea levels may affect coral reefs and rocky shore fish communities (subject to their ability to adapt in time with the pace of sea level rises), coastal wetlands (which are expected to decrease significantly), and coastal onshore infrastructure used by fishermen (e.g. housing, harbours). An economic analysis using a general equilibrium model suggests that indirect costs of sea-level rise will be greater and differently distributed to direct costs of the type described above, with the agriculture and natural resource dependent economies – the poorer countries - more affected.

See Figure 12 and Figure 14 below.

Land-ocean exchanges

Land-use change contributing to and resulting from climate change, particularly deforestation and hydrological modifications, has downstream impacts, particularly in terms of erosion in catchment areas and increased suspended sediment loads. In contrast, damming and channelisation have greatly reduced the supply of sediments to the coast from other rivers through retention of sediment by dams (many of which are themselves now being built as adaptations to climate change – e.g. to increase water storage, regulate floods, or reduce emissions from fossil fuel-based power generation). Levels of sedimentation have the potential to have significant impacts on fisheries through changes in turbidity, salinity, stratification, and nutrient availability, all of which affect estuarine and coastal ecosystems and the productivity of the phytoplankton community, but consequences may vary locally. Reef and sea-grass beds may be particularly sensitive to high levels of sediment input.

Ocean acidification and changes in chemical properties

Continued uptake of atmospheric CO_2 by the oceans has decreased the pH of surface seawater by 0.1 units in the last 200 years. Model estimates predict further reduction of 0.3 to 0.5 pH units over the next 100 years. It is expected that pH reduction will change the depth below which calcium carbonate dissolves, increasing the volume of ocean that is under-saturated with respect to aragonite and calcite, which are used by marine organisms to build their shells and by corals to build their skeletons. The impacts of these changes will be greater for some regions and ecosystems and may be most severe for shell-bearing organisms, tropical coral reefs and cold water corals in the Southern Ocean. See Figure 15 in Appendix 2. Ocean acidification has been portrayed in apocalyptic terms. The conclusions of a major new review (Doney et al., 2009) are more measured but still point to the need for urgent action on curbing emissions to prevent rapid change.

Changes in low frequency climate variability patterns

Natural climate variability takes place through intermittent one to two-year duration events (e.g. El Niño Southern Oscillation (ENSO)) and intrinsic variability operating at decadal and longer timescales. ENSO events are associated with many atmospheric and oceanic patterns, including abnormal patterns of rainfall over the tropics, Australia, southern Africa and India and parts of the Americas, easterly winds across the entire tropical Pacific, air pressure patterns throughout the tropics, and sea surface temperatures. Coincident ecological changes are both vast and global through their impacts in coastal upwelling systems: they increase coastal temperatures, reduce plankton production by lowering the thermocline (which inhibits upwelling of nutrients) and change trophodynamic relationships; they also have knock-on effects on the hydrological cycle and therefore on agriculture and even on forest fire severity, as in Indonesia following the 1997 ENS0 event. An example of fisheries impacts is that these ecosystem changes led to extensive coral bleaching observed in 1998, and large reductions in the catches of tuna in the tropical Western Indian Ocean following El Niño events in 1997 and 2006.

Some studies expect stronger and more frequent ENSO events as a result of global warming while others suggest that the evidence is still lacking, because ENSO is not well enough simulated in climate models to have full confidence in these projected changes.

Other naturally occurring climatic variability being impacted by climate change relate to atmospheric associations or teleconnections; changes in the position and intensity of atmospheric convection in one area result in adjustments in pressure cells in adjacent areas and can lead to altered wind and ocean current patterns on a global scale. Understanding these connections and how climate change will affect them is a research frontier for climate scientists.

Impacts of climate change on fish production and distribution, and ecosystems

Timing and success of physiological, spawning and recruitment processes

All living organisms have specific ranges of environmental conditions to which they are adapted and within which they perform optimally. Physiological performance may degrade and cause stress at temperatures outside the normal limits. Likely impacts of climate change include changes in timing and success of fertilization, survival and growth of young fish, timing and extent of migrations, and structure of food webs.

Primary production

Satellite observations suggest a 6% reduction in global oceanic primary production between the early 1980s and late 1990s, but with substantial regional differences. The climate–plankton link in the ocean is found most strongly in the tropics and mid latitudes, where the typically low levels of surface nutrients limit phytoplankton growth. Climate warming further inhibits mixing, reducing the upward nutrient supply and lowering productivity (Doney 2006). Reduced primary production is likely to mean reduced fish production in many aquatic ecosystems, although the relationship may not be straightforward as much productivity is derived from the 'microbial loop' and dependent on influx and cycling of organic material from terrestrial areas for continental shelf seas.

Secondary production

There are no global assessments to date of the potential impacts of climate change on oceanic secondary production (largely in the form of zooplankton), but indications are that differences in local and regional conditions make global trends difficult to detect. Most commercially exploited marine fish - particularly pelagic ones - depend on zooplankton for food at some stage in their life-cycle, so any impacts on the structure and function of zooplankton communities could be significant for such species.

Changes in fish distributions

Climate change is expected to drive most terrestrial and marine species ranges toward the poles, expanding the range of warmer-water species and contracting that of colder-water species. Such changes have already been documented in the North Sea and North Atlantic.
In pelagic fish, there may also be vertical movements to counteract surface warming.

See Figure 16 and Figure 17 below.

A recent study modeling 'climate envelopes' based on existing species distributions suggests that there will be substantive changes in distribution of fish communities, and large numbers of extinctions of species with restricted habitat ranges (Cheung et al., 2009).

Abundance changes

At the simplest level, biological production processes occur faster at higher temperatures. However, increased growth rates of fish (and hence increased biomass and production) will only occur in response to higher temperatures when food supply is adequate to these increased demands, and when other life-cycle processes (spawning migrations, fertilization, larval survival rates, disease immunity etc) are not negatively affected by climate change. Thus, it cannot be expected that warming will bring more and faster-growing fish.

Phenological changes

More than half of all terrestrial, freshwater or marine species studies have exhibited measurable changes in their phonologies (timing of life-cycle events) over the past 20 to 140 years, in line with climate changes. In the oceans, this includes changes in the timing and extent of seasonal phytoplankton blooms which have not been tracked by zooplankton, suggesting an emerging mismatch between food supply and the main intermediary consumer of primary production (and food of fish).

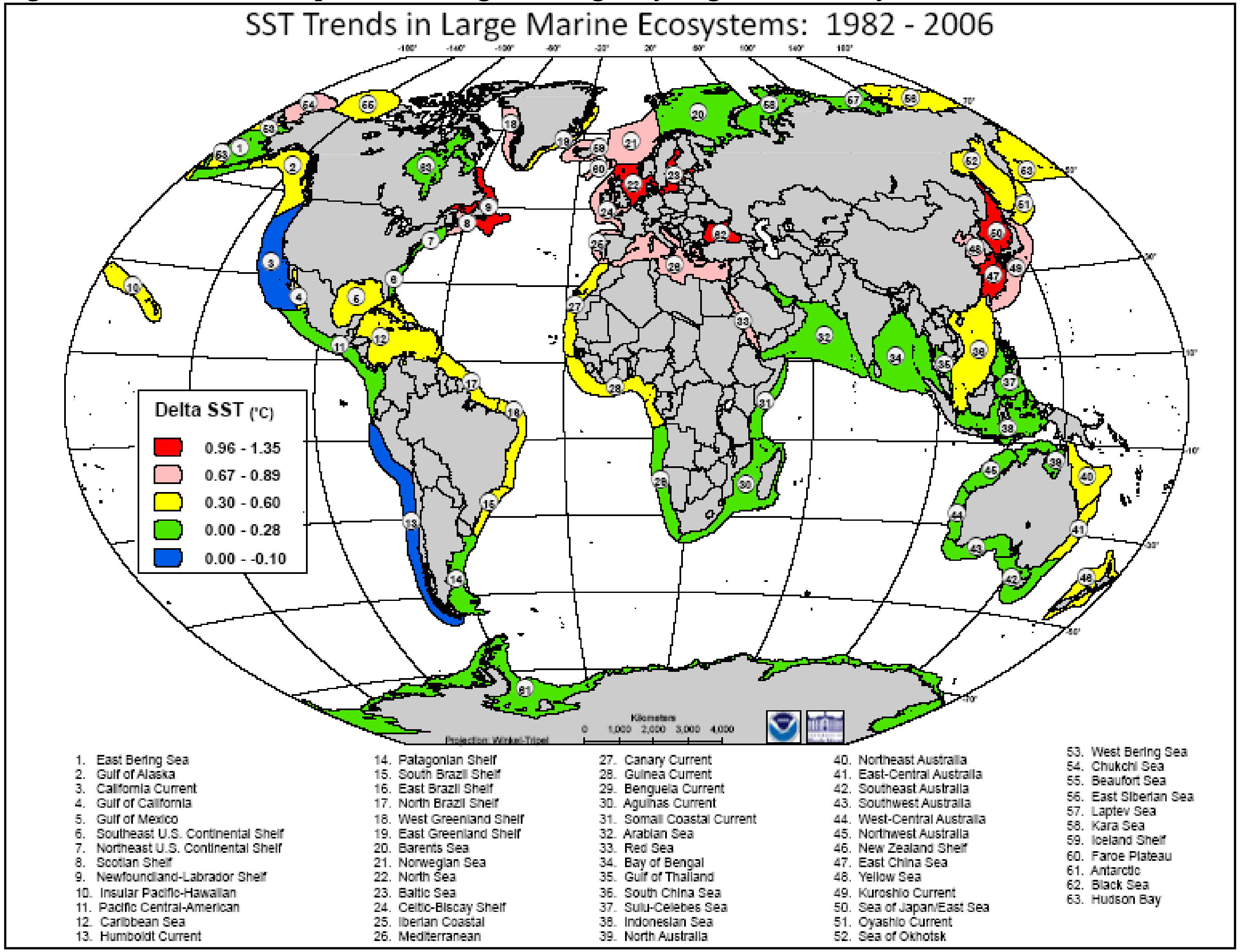
Species invasions and diseases

Pathogens are spreading to higher latitudes and harmful algal blooms are becoming more common (although these may also be due to localized nutrient enrichment). Ecosystems may become more liable to invasive species as they change conditions from those that may have prevented warmer water species from breeding, for example. Thermally stressed fish in aquaculture systems may become more liable to viral, fungal and bacterial infection (Handisyde et al., 2006).

Regime shifts and extreme events

Gradual and variable climate changes can provoke sudden and perhaps irreversible biological responses as ecosystems shift from one state to another (de Young et al., 2008). The altered state may provide an alternative fishery, or it may simply be less productive. Examples of regime shifts are the alternations between sardine and anchovy-dominated pelagic fisheries in some upwelling areas, and, arguably, the collapse of the Newfoundland cod fishery signaled a regime shift driven by the combined stressors of over-fishing and climate variability.

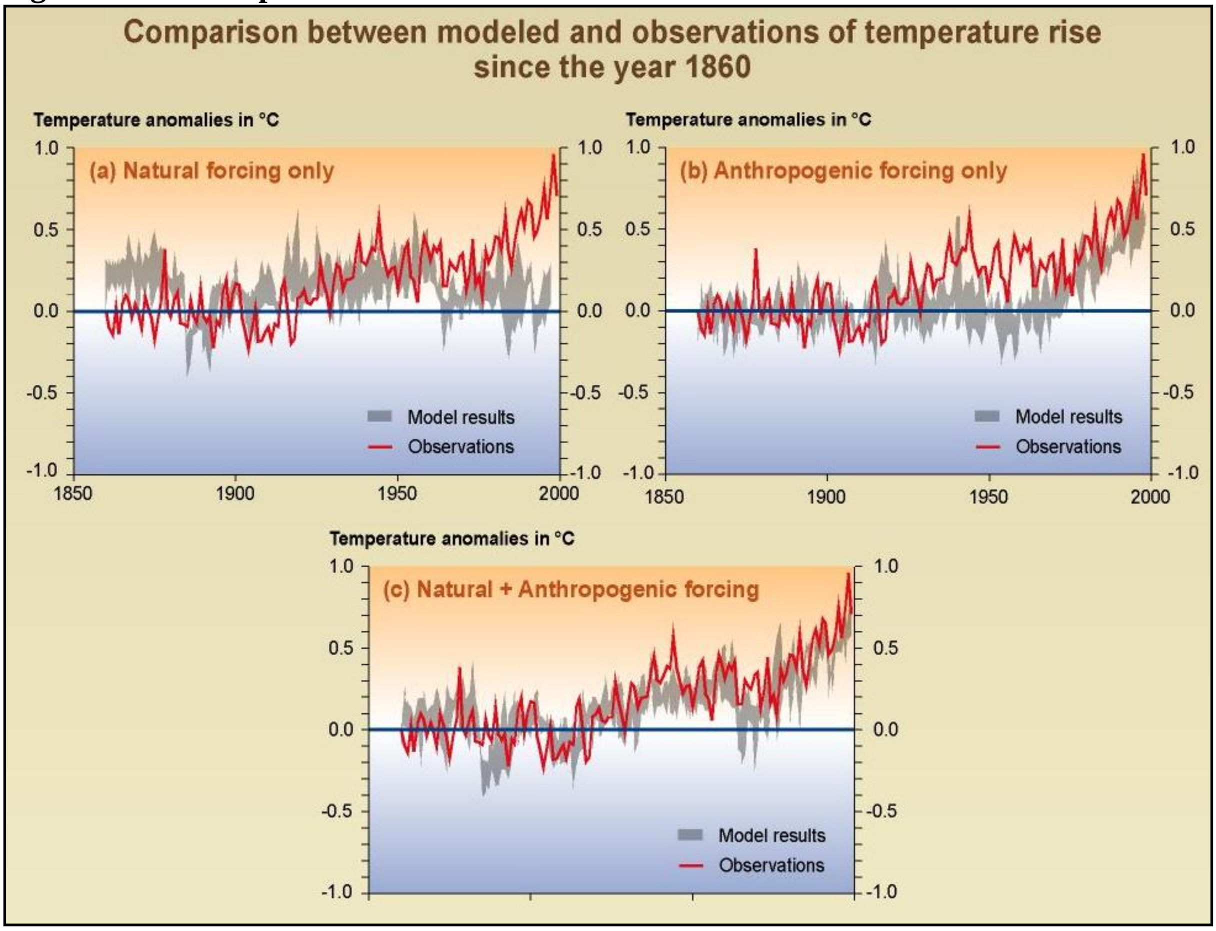
Figure 10: Sea Surface temperature changes, averaged by large marine ecosystem, 1992-2006.



Source: UNEP/NOAA

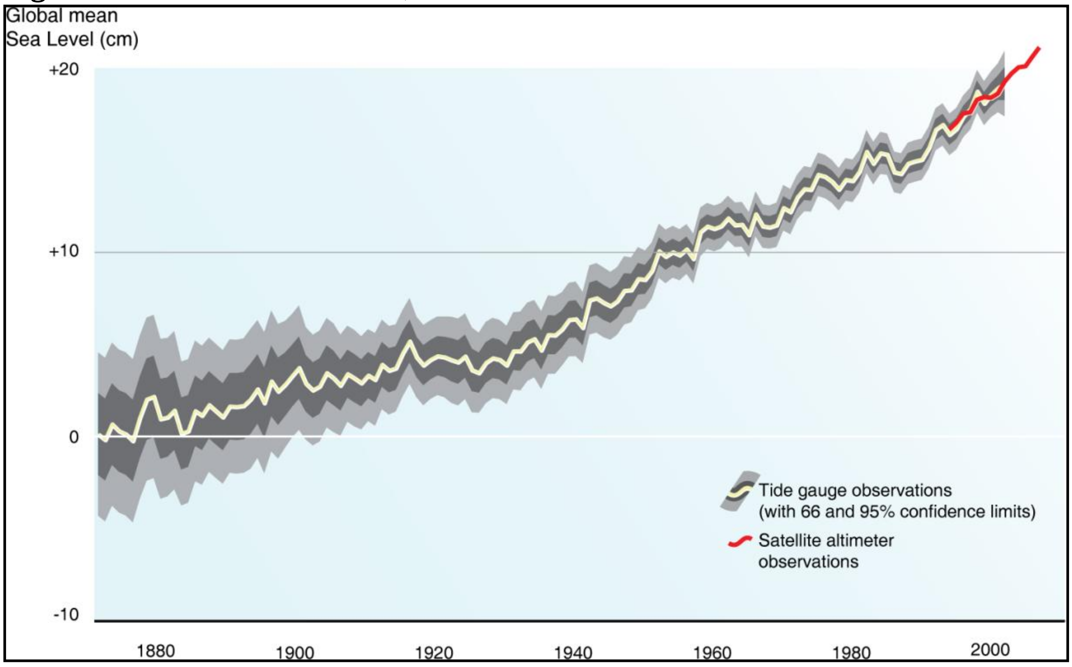
Figure 11 shows that although ocean temperatures undergo natural variations, recent ocean temperature rises (anomalies from an average from 1860-2000) can only be well explained (good fit between observations and model results) when both natural and anthropogenic changes ('forcings') are included in coupled ocean and climate models of the type that have been used to predict further temperature increases and sea-level rise.

Figure 11: Sea temperature rise since 1860



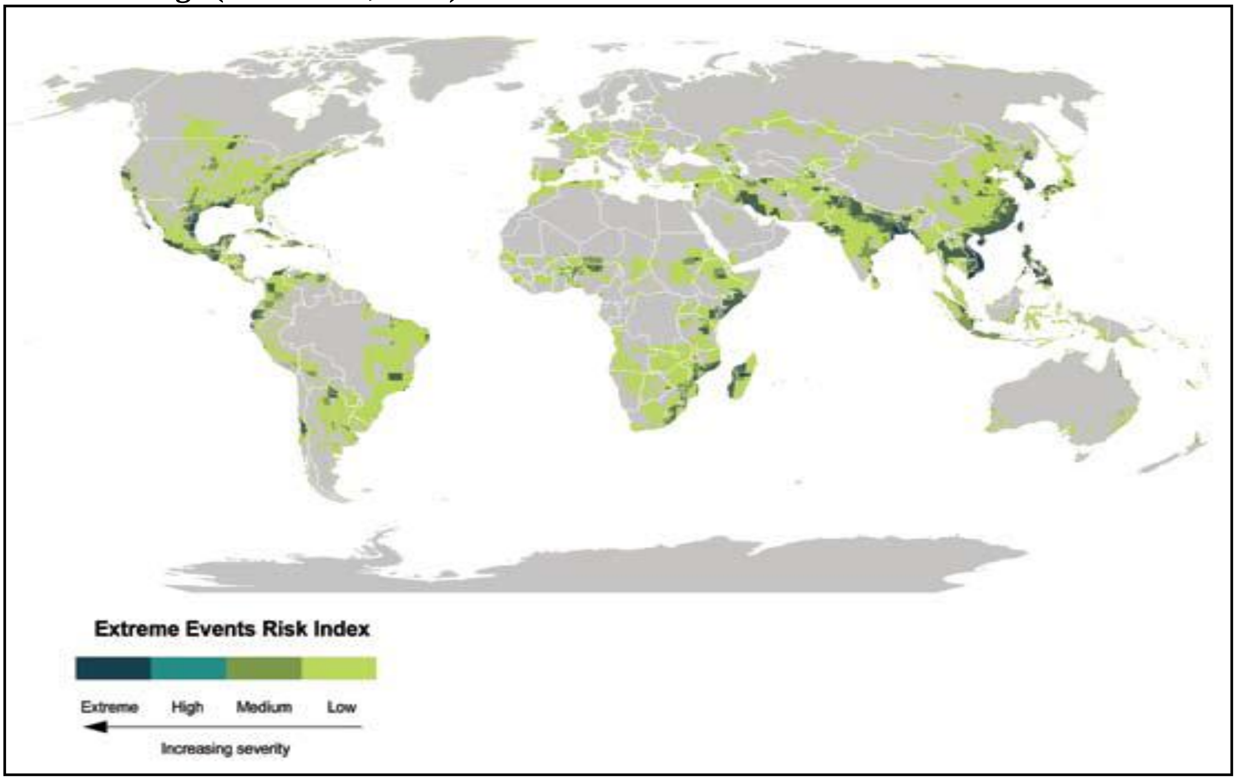
Source: IPCC, 2007

Figure 12: Trends in sea level, 1870-2006.



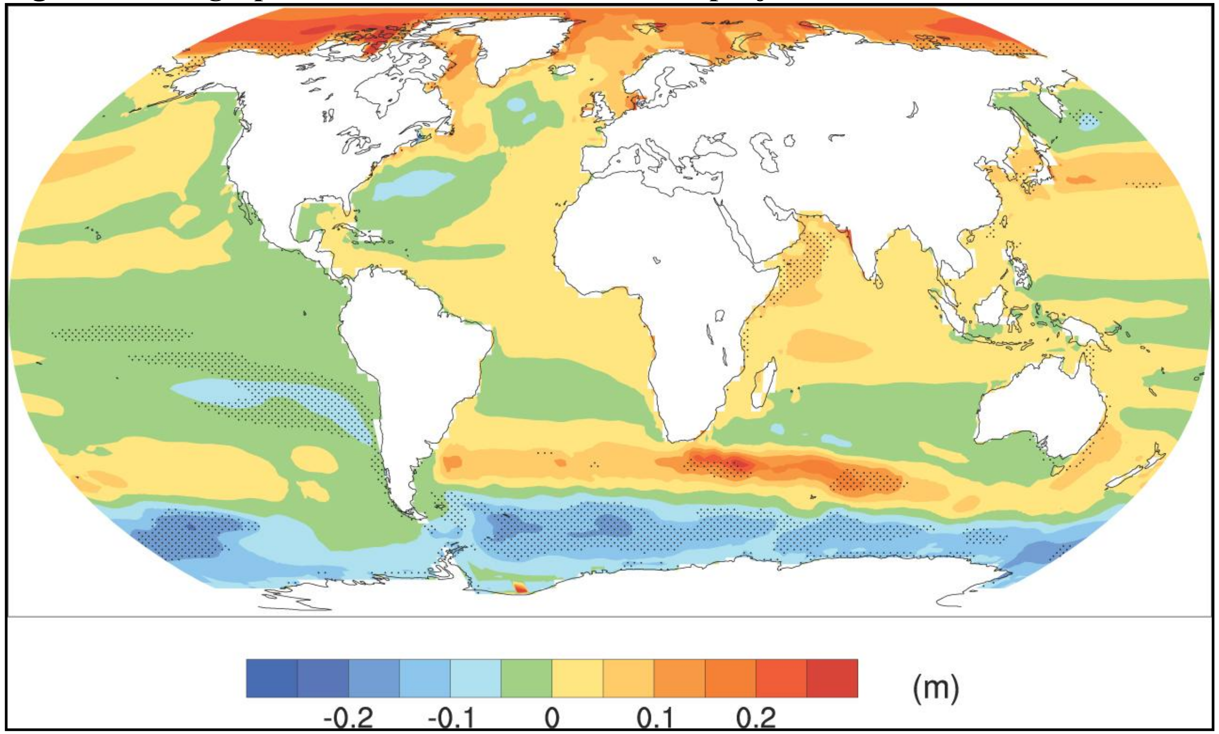
Source: Church, J.A. and White, N.J. (2006)

Figure 13: Areas at risk from floods, droughts, storms and sea level rise associated with climate change (from GHF, 2009)



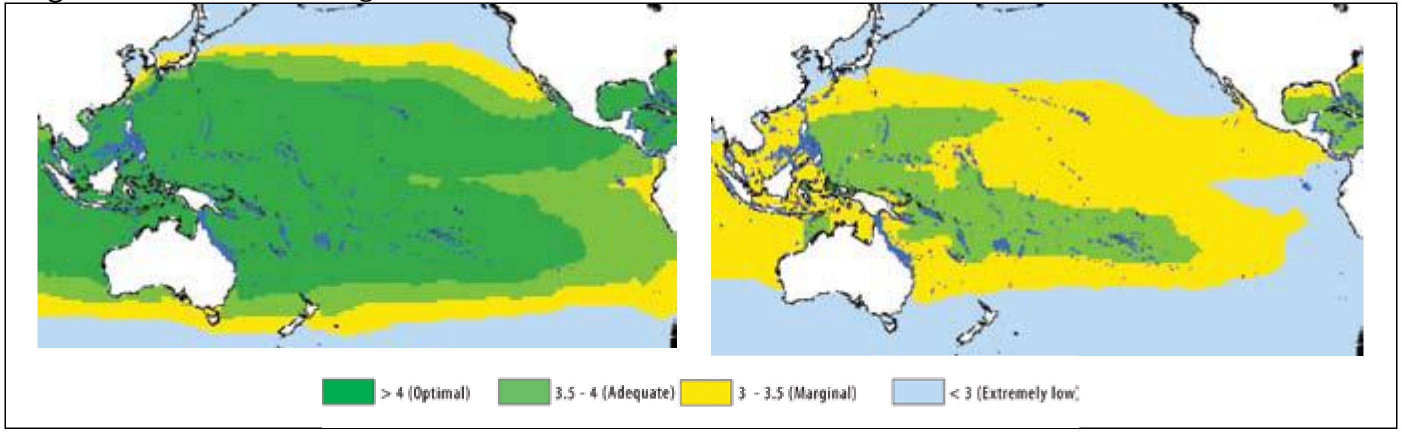
Source: Center for Hazards and Risk Research, Center for International Earth Science Information Network, Columbia University, International Bank of Reconstruction/World Bank, United Nations Environment Programme. Global Resource Information Database Geneva, 2009

Figure 14: Geographical variations in Sea level rise projected to 2050 under 'business as usual' scenarios



Source IPCC 2007

Figure 15: Global warming and reef formation

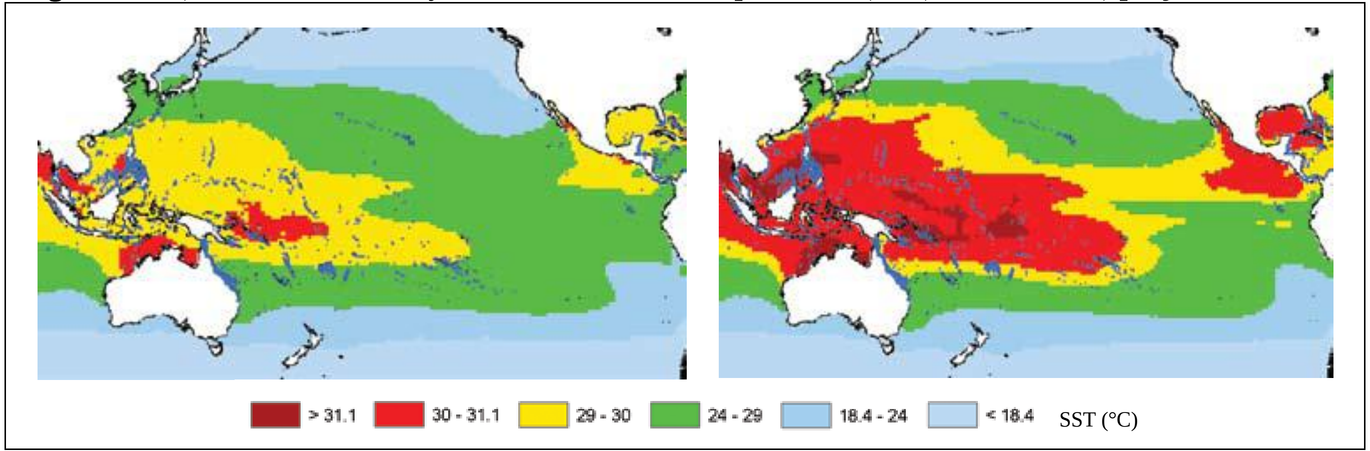


Source: Maps based on information in Guinotte et al. (2003)

The two maps above indicate availability (supersaturation levels) of the carbonate mineral, aragonite, needed by corals to build their skeletons and form structurally complex reefs, which protect coasts and sustain reef-dependent fisheries. The map on the left shows calculated pre-industrial aragonite levels c. 1870, CO_2 = 280 ppm. The map on the right shows projected aragonite levels in 2050, CO_2 = 465 ppm. Together they indicate that reef formation will become more geographically restricted, leading to erosion and loss of existing reefs. Note that increasing atmospheric CO_2 results in more acidic oceans, which in turn blocks the availability of aragonite, and that temperature increases lead to more frequent coral bleaching effects (due to physiological stress on corals), so that these processes reinforce one another and increase the likelihood of major coral reef fishery decline or collapse in large areas of tropical and sub-tropical oceans.

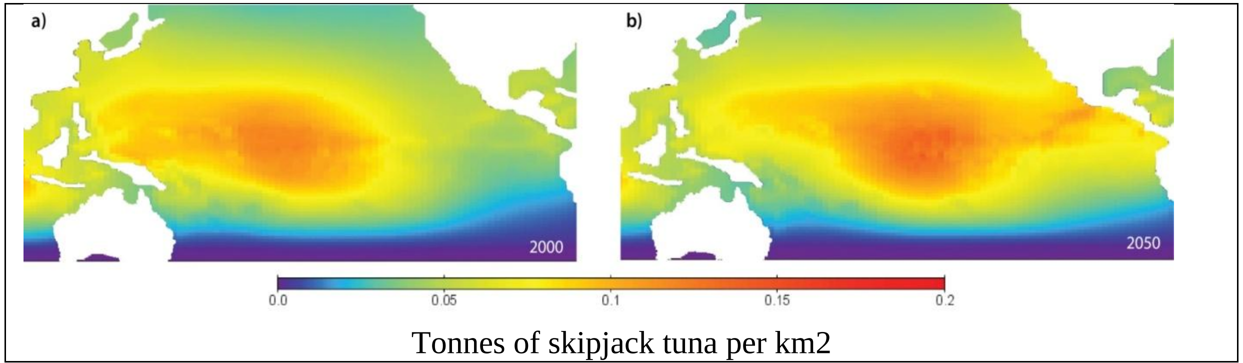
Less oxygen dissolves in warm water than cold. The oxygen concentration of the ventilated 100 to 1,000 m of the world's ocean has been decreasing since 1970, driven by a reduced rate of renewal of intermediate water. Together with eutrophication due to nutrient pollution, the size and persistence of oceanic 'dead zones' - areas where anoxia means no aerobic life can survive - is increasing (Brewer and Peltzer, 2009). Of the 400 such dead-zones identified so far, most are in developed countries and their distribution matches the global human footprint on the terrestrial environment, although such zones are probably under-reported in the southern hemisphere (Diaz and Rosenberg, 2008). Of the Commonwealth developing countries, such dead zones have only so far been reported off the coasts of Belize, Ghana, Mauritius, and SE India.

Figure 16: a) Maximum monthly Pacific sea surface temperatures (SST) 1982-1991; b) projected sea surface temperatures by 2050



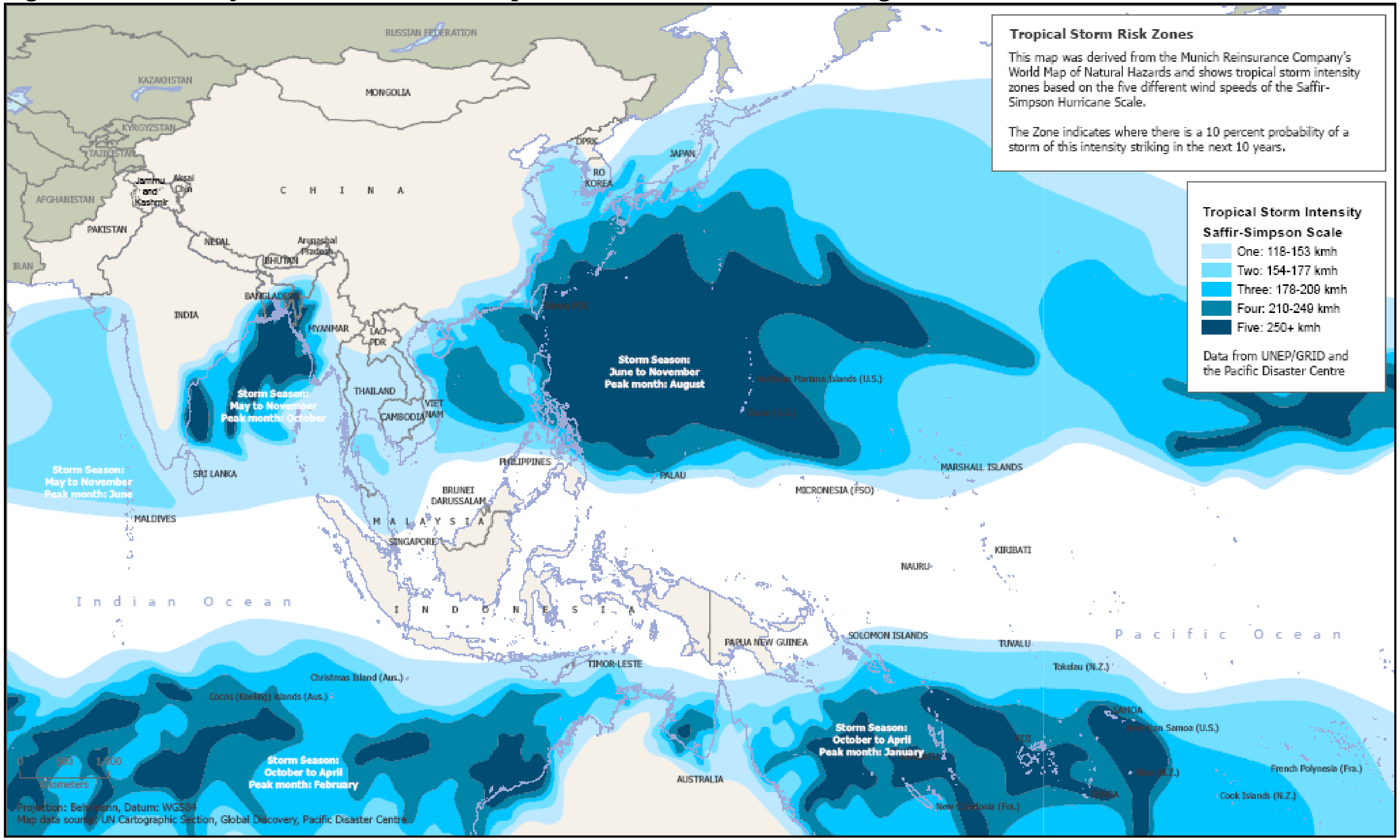
Source: derived from Guinotte et al. (2003) Coral Reefs Vol. 22, pp. 551-558.

Figure 17: a) Estimated distribution and abundance of skipjack tuna in the Pacific in 2000; and b) preliminary modeling of skipjack tuna distribution in 2050



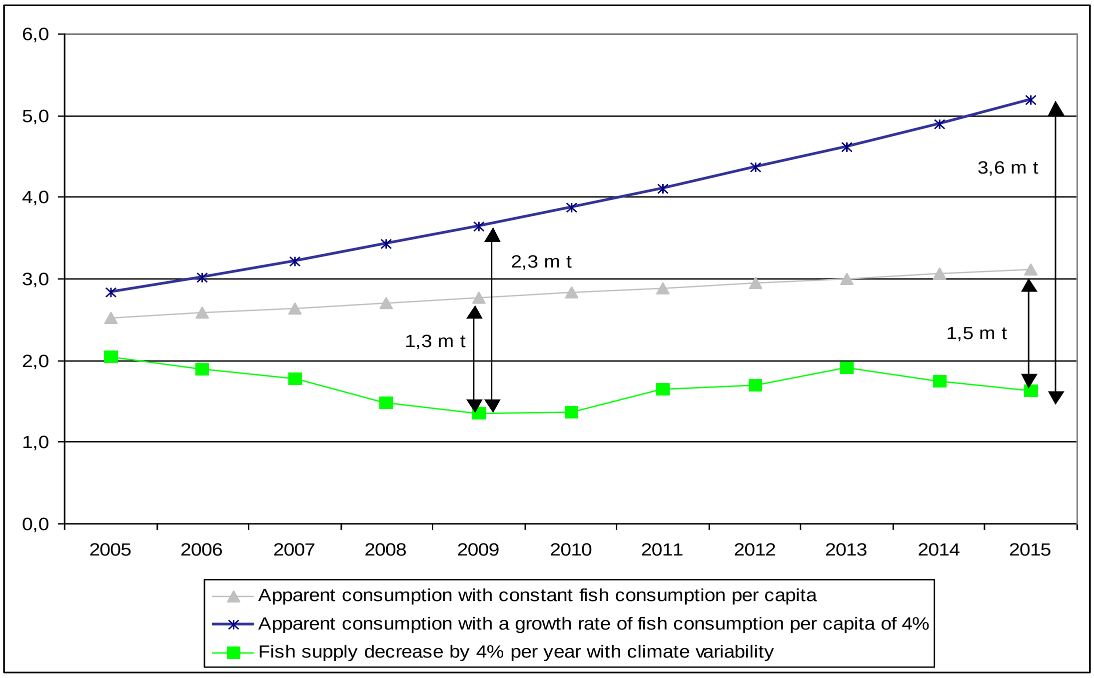
Source: based on the study 'Forecasts of population trends for two species of tuna under an IPCC scenario' presented by Lehodey et al. at the international symposium "Effects of Climate Change on World's Oceans", Gijon, Spain, 19-23 May 2008

Figure 18: Areas subject to the most severe tropical storms in the Asia-Pacific region.



Source: OCHA regional office for Asia and the Pacific

Figure 19: Projected fish availability (catches) and consumer demand with climate variability (2005-2015) in West Africa



Source: Failler, P. & B. Samb (2006)

Appendix 3: Additional baseline information on Kenya

Inland fisheries

More than 90% of Kenyan fisheries production (in both volume and value terms) originates from inland fisheries, and the majority from Lake Victoria, which Kenya shares with Tanzania and Uganda. The lake produces around 1 million tonnes of fish a year with a landed value in 2007 of US$337 million and an export value of US$308 million. The fisheries provide almost 2 million people with their household income and provide much of the protein needed by almost 22 million people in the region. (Macfadyen, 2008) In Kenya, and the lake more widely, all fishing takes place using small-scale vessels, a very high proportion of which are non-motorized. Catches comprise a mix of Nile Perch (almost exclusively for export), and tilapia, dagaa, and haplochromines (all for local and regional consumption). Around 60,000 people are employed in activities related to inland fisheries, around 30,000 in catching, and the balance in processing, distribution and retail activities.

The volume and value of catches for Lake Victoria over recent years are provided in Table 25, and show that catches of Nile Perch have been declining for the lake as a whole, with associated rises in catches of other lower value species. However, there are variations between the three countries, and recorded production volumes for Kenya increased in 2007 compared to 2006[35]. Declining values of landings are explained by the fact that while *total* biomass estimates are reported to be relatively constant over recent years, falling biomass and declines in average fish size for Nile perch (the most valuable of the lake's resources but not the most important from a food security perspective) point to potential problems with the sustainability of catches of this species, and possibly also to climate change impacts on ecosystems that are already being experienced (although there is no evidence at present to support this hypothesis). A pattern appears to be emerging where stocks of other less valuable species (e.g. haplochromines and *dagaa*) are recovering due to recent heavy/over fishing of Nile Perch (see Figure 20).

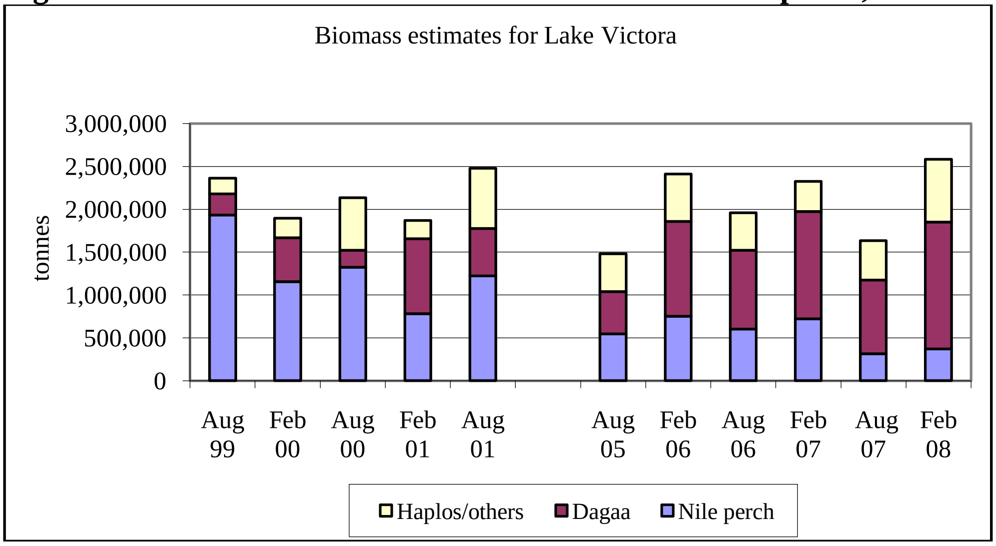
[35] Production is based on recorded landings, and it is likely that a proportion of fish landed in Kenya originates from Tanzanian and Ugandan waters.

Table 25: Summary of landed volumes and values from Lake Victoria, 2005-2007 (tonnes, $)

	Uganda		Kenya		Tanzania		Total	
	volume	**value**	**volume**	**value**	**volume**	**value**	**volume**	**value**
2005								
Nile perch	94,900	104	50,700	56.60	141,100	144.93	286,700	306
Tilapia	29,300	16	17,900	12.56	24,300	10.48	71,500	39
Dagaa	106,400	12	81,000	15.08	306,100	39.98	493,500	67
Haplochromines	*		3,900	0.86	128,900	15.78	132,800	17
Others	7,800	5			2,000	1.23	9,800	6
Total	238,400	137	153,500	85.10	602,400	212.40	994,300	435
2006								
Nile perch	91,350	89	31,600	35.30	107,500	110.43	230,450	235
Tilapia	27,600	14	10,800	7.55	28,400	12.27	66,800	34
Dagaa	107,900	11	74,000	13.76	472,600	61.73	654,500	87
Haplochromines	*		900	0.23	142,600	17.46	143,500	18
Others	2,300	1	1600	0.98	3,900	2.38	7,800	4
Total	229,150	116	118,900	57.82	755,000	204.27	1,103,050	378
2007								
Nile perch	82,100	83	57,900	45.50	119,600	111.08	259,600	240
Tilapia	23,000	13	10,300	5.50	18,000	9.12	51,300	28
Dagaa	111,900	10	121,800	11.92	329,300	38.81	563,000	61
Haplochromines	*		2,000	0.52	61,200	2.11	63,200	3
Others	2,900	1	1600	3.07	2,800	1.23	7,300	6
Total	219,900	108	193,600	67	530,900	162.35	944,400	337

Source: LVFO catch assessment survey records, and Fisheries Departments and research institutions.

Figure 20: Lake Victoria biomass estimates for selected species, 1998 - 2006



Source: LVFO/IFMP records

Government revenue generation from the fisheries sector in Kenya is primarily derived from export levies and generates $0.35 million per year. Potential changes in the near future include the introduction of an export levy of 2%, and the establishment of a Fisheries Development Authority which would have control over these levies. However as demonstrated in Table 27 the lake also provides for rent extraction of $0.75 million per year by local government and the private sector in Kenya, in addition to profits made in fishing and processing. Government revenue from the issuing of foreign licences in the marine sector are not known.

Table 26: Annual revenue collected in Kenya from Lake Victoria fisheries, 2007/08 (Ksh)

Source of revenue	Amount paid to			
	National treasury	**Non-government**	**Local Government**	**Rate (Sh)**
Export duty	17,730,935			0.5% of value
Licences to fish, have boats, move fish, traders licence	5,000,000			See notes
Processing licence	6,000			1,000/year
Processing hygiene compliance fee	420,000			70,000
Processing association payments to AFIPEK		1,440,000		240,000/year
Industry self-monitoring		2,880,000		480,000/year
BMU charges		17,562,500		Various see notes
Fish landings fee			30,000,000	Sh1/kg
Total	23,156,935	21,882,500	30,000,000	

Source: Macfadyen 2008

Table 27: Revenue/resource rents collected from Lake Victoria fisheries, 2007/08 ($)

	Amount paid by the private sector to			
	National treasury	**Local/ district government**	**Non-government (Beach Management Units, tenderers, self-regulation**	**Total**
Uganda	n/a	n/a	n/a	n/a
Kenya	**345,626**	**447,761**	**326,604**	**1,119,992**
Tanzania	5,324,142	1,933,122	1,357,541	8,614,805

Source: Macfadyen 2008.

In order to protect the livelihoods of those dependent on Lake Victoria, government already faces considerable expenditure burdens on management and research activities. For Kenya these amount to more than $1 million per year (see Table 28), and could be expected to increase with requirements for a better understanding of climate change impacts and associated adaptive strategies.

Table 28: Fisheries management and research expenditure on Lake Victoria, 2007/08

	Management	Research	Total
Uganda	n/a	286,126	286,126 + management
Kenya	**745,152**	**392,000**	**1,137,152**
Tanzania	3,027,695	351,563	3,379,257
Total	3,772,847	1,029,688	4,802,535 + Uganda management

Source: Macfadyen 2008

Marine fisheries

The tropical Western Indian Ocean (WIO) is a nutrient poor ecosystem that is characterized by clear warm waters that provide an ideal habitat for coral reef formation and their associated fish communities. The tropical WIO lies between the productive, nutrient rich upwelling systems to the north off Somalia and the Agulhas current to the south which are the primary production sources for the highly migratory fish stocks.

The area of Kenya's EEZ is 116,000 km^2. Kenya's continental shelf is relatively narrow, extending to approximately 60km on the North Kenya Banks (Figure 1). The total area of the continental shelf is 19,100 km^2 (14,400 km^2 to the 200 m isobath), of which 11,000 km^2 is considered trawlable. The reef drop-off is usually between 0.5 and 2 km from the shore and the 200m isobath is well within territorial waters along the southern half of the coast.

Table 29: Kenyan marine fisheries production, 2000-2007 (tonnes)

Species	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Albacore	-	-	-	-	-	-	-	-
Amberjacks nei	71	92	31	61	107	111	81	21
Barracudas nei	83	99	88	158	125	171	246	248
Bigeye tuna	-	-	-	-	-	-	-	-
Black marlin	-	-	-	-	-	-	-	-
Carangids nei	85	119	144	163	189	187	157	176
Clupeoids nei	119	164	101	119	108	112	138	147
Demersal percomorphs nei	1,224	2,060	1,450	1,099	1,103	1,211	1,286	2,196
Emperors(=Scavengers) nei	334	466	414	421	434	412	477	431
Grunts, sweetlips nei	63	85	90	79	112	65	88	94
Indo-Pacific sailfish	-	-	-	-	-	-	-	-
Marine fishes nei	474	667	874	1,418	1,646	1,401	1,297	678
Marlins,sailfishes,etc. nei	80	78	55	44	75	111	148	83
Mullets nei	181	199	164	188	237	248	221	201
Narrow-barred Spanish mackerel	94	136	150	215	151	124	145	197
Pelagic percomorphs nei	378	1,003	982	793	897	875	792	937
Sharks, rays, skates, etc. nei	115	175	134	208	197	253	189	165
Skipjack tuna	86	183	116	267	307	337	233	185
Snappers, jobfishes nei	120	177	177	118	137	171	193	220
Spinefeet(=Rabbitfishes) nei	299	403	469	382	388	423	412	420
Swordfish	-	-	-	-	-	-	-	-
Tuna-like fishes nei	-	-	-	-	-	-	-	-
Yellowfin tuna	-	-	-	-	-	-	-	-
Total	**3806**	**6106**	**5439**	**5733**	**6213**	**6212**	**6103**	**6399**

Source: FAO

Commercial marine fisheries are of minor importance compared to the inland fishery on Lake Victoria described above. 90% of the marine catch is attributable to artisanal fisheries. There are around 1,750 coastal artisanal vessels and 4,000 fishers, a decrease from an estimated 15,000 fishers in the early 1990s. Full-time fishermen operate about 64% of total vessel numbers. Vessels are mostly dugout canoes propelled by sail, or paddle. Few are motorised, and many fishers do not own their boats or gear but work as labourers for non-fisher vessel owners, who may not be fishers. The Coast Province is deficient in food supply and has the second highest poverty rating of Kenya's provinces.

The industrial shrimp fishery and the sport fishery catch the remainder of Kenya's marine catch. Kenya's marine recreational fishery attracts a large tourist trade, and anglers target amongst other things shark, marlin and other game fish.

The shrimp fishery is Kenya's only domestic industrial fishery, with four industrial trawlers operated by two companies. The shrimp is sea frozen and mostly exported to the EU and the Middle East. Several attempts have been made over the years to establish a domestic tuna fishing industry in Kenya. In the 1973 – 1979 period catches by longliners operated by Kenya Fishing Industries Ltd. (a joint venture with Japanese interests) ranged from over 7,000 tonnes to just under 300 tonnes. The catch comprised mainly yellowfin and bigeye. For a number of reasons, including political interference and poor catches these endeavours were not successful. The largest concentrations of tuna on the Kenyan coast occur during the 'kusi', or Southeast monsoon, during which period the strong winds make fishing difficult. In 1993 the Korean-built company longliners were sold to SECO, which landed 428 tonnes in 1995. Poor catches led to a closure of the fishing operations.

Processing of species other than shrimp and tuna accounts for around 2,000 jobs, while the retail and distribution sector for marine fish is thought to provide employment for around 3,000 people.

Table 30 : Exports of processed marine products from Kenya by company in 2003 (tonnes)

Product	Wanainchi Marine Products Ltd	Transafrica Fisheries Ltd	Sea Harvest Ltd	Crustacean Processors	Alpha 3 vessels	Venture II 1 vessel	Totals
Tuna loins	4,291						4,291
Octopus		256	350		1		603
Whole lobsters		135	12	1	1		149
Lobster tails		26	2	1			30
Squids		6					6
Cuttlefish					4		4
Prawns					162	10	172
Total (tonnes)	**4,291**	**420**	**364**	**2**	**167**	**10**	**5,255**

Source: DoF, Mombasa

The only offshore fisheries at present are the foreign-flag longline and purse seine fisheries for tuna and highly migratory species.

In 2003 Kenya issued licenses 53 foreign tuna vessel licences: 37 to purse seiners and 16 to longliners. Licence income was income was more than $0.5 million (Table 31). Many of the purse seine licences are issued to Spanish vessels, while long line interest is dominated by Korea and China. Mombasa is the only major Kenyan port and acknowledged to be the best deepwater port on the entire East African coast with extensive berthing, cargo handling, bunkering and supply facilities. The port has a modern container terminal (loins are exported by freezer container), 16 deepwater berths (13.5 m) with a total length of over 3 km. Kilindini Harbour is the location of the tuna loining plant, the dry dock and slipway and vessel repair yards.

Table 31 : Numbers of foreign licences issued by Kenya and fees paid

Year	Longliners	Purse seiners	Licence fees paid (€)
2003	16	37	585,763
2003		37	429,154
2002		13	184,413
2001		36	325,926
2000		25	134,409
1999		16	299,065
1998		28	500,000
1997		30	526,316
1996		35	551,181

Source: Department of Fisheries

Appendix 4: Additional baseline information on Maldives

The Republic of Maldives is an archipelago of 26 natural atolls, consisting of 1,190 coral reef islands in the Indian Ocean. There are around 200 islands which are inhabited, 89 islands used exclusively as tourist resorts and the rest of the islands are uninhabited and mostly used for industrial and agricultural purposes. The 1,190 islands are grouped into 20 atolls for administrative purposes. The islands are scattered over an area of 750 km from north to south and 120 km from east to west covering around 90,000 sq km and about 99% of the country’s territory consists of ocean (DPND, 2009). Mean elevation above sea level is around 1m, and the highest elevation in the country only 2.4m above sea level.

Almost all of the natural resources of the country are marine in nature, and these natural resources forms the basis of the country’s two most important economic activities - fisheries and tourism. For many of the country’s island communities, fisheries provide by far the most important economic activity.

The fisheries sector has traditionally been the major contributor to the country’s economy. Nevertheless, since 1978, the fisheries contribution to the GDP has shown a continual declining trend. This is mainly due to the introduction and rapid growth of the tourism sector in the economy and diversification of the fishery related businesses into other economic sectors such as export and labour. However, “the fisheries sector’s contribution to the GDP has remained significant, both in terms of employment, value added production and export returns” (MPND, 2004).

Table 32: Maldivian fish production 2000-2007 (tonnes)

Species	2000	2001	2002	2003	2004	2005	2006	2007
Bigeye tuna	560	923	1,323	1,284	1,190	1,047	1,111	932
Dogtooth tuna	451	647	789	746	615	542	512	499
Freshwater fishes nei	<0.5	<0.5	<0.5	-	-	-	-	-
Frigate and bullet tunas	3,991	3,981	4,187	4,357	3,638	5,057	3,532	3,802
Kawakawa	1,898	2,150	2,241	2,406	2,290	2,702	1,674	2,790
Marine fishes nei	6,156	5,610	7,211	7,686	9,607	22,989	16,104	17,158
Marine molluscs nei	866	-	-	-	-	-	-	-
Sea cucumbers nei	205	226	191	239	182	117	75	75
Sharks, rays, skates. nei	13,523	11,935	11,498	11,522	9,475	896	900	800
Skipjack tuna	79,682	88,043	115,321	108,329	109,749	132,061	138,458	96,860
Tropical spiny lobsters nei	7	13	.	.	.	.	20	20
Tuna-like fishes nei	-	-	24	21	24	-	-	-
Yellowfin tuna	11,624	13,656	20,603	18,825	21,394	20,512	21,772	20,661
Total	118,963	127,184	163,388	155,415	158,164	185,923	184,158	143,597

Source: FAO

Catches by the domestic fleet are all artisanal in nature, primarily using pole and line methods for skipjack tuna and handlines for Yellowfin (and reef fish), however it should be noted that many of vessels in the mechanized fishing fleet are large dhonis of more than 20-25m in length and are equipped with satellite navigation systems, hydraulic line haulers, fish finders, sonars and other such technological equipment.

The fishing fleet has been declining over the years, partly in response to increases in vessel size. Mechanized Masdhonis accounted for more than 95% of the annual catch in 2008.

Table 33: Maldivian fishing vessels by type (2000-2008)

Vessel types	2000	2001	2002	2003	2004	2005	2006	2007	2008
Mechanized Masdhoni	1137	1128	1102	1104	1092	1002	923	894	867
Mechanized Vadhudhoni	58	49	59	46	67	56	44	42	40
Sailing Vadhudhoni	72	40	9	4	17	22	17	16	17
Sailing Masdhoni	41	66	90	115	8	5	3	10	34
Row boats (Bokkura)	19	13	16	18	26	18	14	16	7
Total	**1376**	**1316**	**1319**	**1318**	**1246**	**1142**	**1026**	**1005**	**979**

Source: Ministry of Fisheries and Agriculture

Catches are very seasonal in nature, and vary significantly between atolls, as shown in the following table. Tuna catches peaking around April and November; at the onset and offset of Northwest monsoon. However, the fishing seasonal has followed irregular trends in the past few years. This may be due to the change in global climate change and its impact on seawater temperature.

Table 34: Maldivian catches by atoll and month in tonnes (2006)

Atoll	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
AA	970	644	765	834	741	805	641	607	461	710	556	501	**8,234**
AD	579	639	697	884	674	605	783	785	593	524	503	582	**7,849**
BA	235	265	240	152	74	135	297	355	262	280	153	139	**2,588**
DH	81	44	67	417	272	170	100	139	562	424	190	95	**2,562**
EEZ	161	158	599	392	237	193	227	231	232	259	210	279	**3,177**
FA	84	105	120	202	273	169	161	146	158	147	159	133	**1,857**
GA	2,289	2,654	972	4,761	5,225	3,136	432	1,643	1,363	1,394	776	364	**25,009**
GD	2,653	2,127	933	3,205	1,339	1,308	149	823	1,322	1,898	989	649	**17,395**
GN	84	85	86	126	148	99	49	42	27	22	35	18	**821**
HA	2,270	2,338	2,119	1,296	1,012	551	260	482	740	1,648	1,250	1,888	**15,855**
HD	895	1,084	559	313	333	404	464	629	588	646	774	782	**7,471**
KA	592	482	442	374	345	356	381	694	385	628	515	272	**5,465**
LA	1,077	618	592	1,048	1,419	1,772	597	786	1,021	1,273	1,272	1,395	**12,870**
LH	1,591	1,929	1,387	439	434	448	472	884	1,123	1,155	837	204	**10,902**
ME	563	233	244	225	356	612	329	245	139	326	360	355	**3,987**
MLE	1,055	1,040	1,026	734	710	654	1,022	970	1,144	1,022	1,266	1,343	**11,987**
NO	444	484	296	33	65	74	76	83	80	96	165	152	**2,049**
RA	494	662	1,519	1,389	378	878	1,389	1,441	980	1,331	1,103	1,206	**12,770**
SE	1,739	1,213	893	1,559	1,274	1,037	287	1,325	460	1,238	897	461	**12,383**
SH	1,256	1,529	885	613	283	259	458	577	785	1,117	1,269	1,659	**10,690**
TH	665	486	898	1,216	1,206	740	321	257	443	806	690	394	**8,123**
VA	75	49	75	43	88	103	81	67	65	29	53	43	**771**
Total	19,851	18,868	15,416	20,255	16,886	14,508	8,979	13,211	12,934	16,974	14,020	12,914	184,816

Source: Ministry of Fisheries and Agriculture

The fisheries sector provides employment for 13,980 fishermen (2006), as well as around 6,000 artisanal fish processors of 'Maldive fish' and workers employed by processing and export companies. Related ancillary activities include boat building, provision of fishing gear/inputs, and engine maintenance.

The following table provides detail on a project specifically focusing on building resilience in the fisheries sector, as proposed at the recent Maldives Partnership Forum III (23-24 March 2009)

Table 35: Building resilience of the fisheries sector to climate change

PROJECT SUMMARY

<table>
<tr><td colspan="3">Project Title:
Build Resilience of Fisheries</td></tr>
<tr><td colspan="3">Executing Agency:
Ministry of Fisheries and Agriculture</td></tr>
<tr><td>Geographic Coverage:
National</td><td>Start Date:
Immediate</td><td>Target Groups:
Fishermen</td></tr>
<tr><td colspan="3">Goal:
Better bait fishery management and exploration of alternative techniques of live bait catching, culture and storage.</td></tr>
<tr><td>Objectives</td><td colspan="2">Activities</td></tr>
<tr><td>1: Enhance the knowledge on bait use and utilization, alternative live bait, catching methods and improved holding techniques.</td><td colspan="2">1. Undertake a comprehensive review of bait biology, bait use and bait utilization in the Maldives.
2. Identify, catalogue and map popular bait fishing grounds in each atoll
3. Undertake scientific and technical evaluations for alternatives to bait and alternative species
4. Study and evaluate the potential for mariculture of alternative species of bait.
5. Conduct bait fishing trails in various regions of the Maldives in different periods to investigate efficacy of attracting live bait using different methods
6. Conduct bait fishing trails using submersible lights in the open ocean to investigate the potential for use of mycophids as live bait
7. Evaluate the cost effectiveness of alternatives to bait and alternative methods of bait catching
8. Identify and rank the practical solutions to bait fishery in the Maldives</td></tr>
<tr><td>2: Strengthen the policy, regulatory and institutional framework for bait fishery management</td><td colspan="2">1. Develop manuals and guidelines for best practice on bait fishery
2. Develop the policies, rules and standards to regulate bait fishery in the Maldives
3. Prepare a stakeholder and public participation plan for bait fishery management
4. Conduct education and outreach programmes for fishermen on rational utilization of live bait
5. Develop a bait fishery research implementation strategy
6. Undertake training on research methods to investigate bait catching options</td></tr>
</table>

	7. Training on mariculture for the existing research staff; establish collaborative research programme with appropriate overseas institutions 8. Identify methods/techniques for measuring bait catch and utilization
3. *Demonstrate innovative, appropriate and cost-effective mariculture for breeding alternative live bait species*	1. Undertake in-depth assessment of mariculture technology focusing on the specific needs of the fishermen and the future vulnerabilities of coral reef ecosystems to climate change and human induced stresses. 2. Develop criteria for the selection of mariculture demonstration species and sites 3. Select species and sites for mariculture demonstration based on selection criteria, and national priorities. 4. Implement mariculture demonstration projects in the existing fisheries extension service centres
Financial Resources: US$ 2.92 million	

Appendix 5: Additional baseline information on Solomon Islands

Background and oceanographic conditions[36]

The Solomon Islands is the third largest archipelago in the South Pacific and consists of almost 1,000 islands. The main islands vary in length from 140 to 200 km and in width from 30 to 50 km, and in types from high islands to raised atolls and low lying islands, sand cays and rock outcrops. These islands can be divided into groups, and the Delimitation of Marine Waters Act 1978 (Legal Notice 40/79) defines five archipelagos:

- The Main Group Archipelago (by far the largest of these island groups)
- The Ontong Java Group Archipelago
- The Rennell, Bellona and Indispensable Reef Atoll Archipelago
- The Santa Cruz Islands Archipelago
- The Duff Islands Archipelago

Sea surface temperatures in the Solomons are consistently in the high twenties with little annual variation. The South Equatorial Current and the South Subtropical Current are the most important surface current systems in the area. In general, the surface currents flow to the west in the southern winter but considerable easterly flow is experienced during the southern summer. Local current variations near islands are common. The vertical structure of the ocean in the Solomon Islands varies from north to south, with the mixed layer deeper in the north (north of 9^{o} S). The 15^{o} isotherm is generally deeper than 250 metres.

The Solomon Islands generally lies within the Western Pacific Warm Pool, which has the warmest surface waters of the world's oceans. The Pool sometimes extends over 80° of longitude and produces virtually 100% of the purse-seine catch, 90% of the pole-and-line catch and 60% of the longline catch of tunas in the Pacific Islands region. The Pool's boundaries are dynamic, moving in response to oceanographic features. It can undergo spectacular displacements of over 40° of longitude (nearly 4,000 km) in less than 6 months. Tuna abundance and yields are also displaced east-west by the same phenomena, and the geographic location of catches of purse-seine fleets can to some extent be predicted by the movement of the Pool. During El Niño periods, the Solomon Islands continue to experience the warm water of the Pool but the eastern boundary of the Pool usually extends much further to the east, well into the waters of Kiribati.

Domestic activity

The marine resources of the Solomon Islands can be broadly split into two main categories:

- Coastal resources which include many groups of fish and invertebrates, such as finfish (scarids, lethrinids, lutjanids, and carangids), beche de mer, trochus, giant clam, lobster, and turbo. They are characterised by their shallow water habitats or demersal life-styles. Because of their relative accessibility, these resources form the basis of most of the small-scale fisheries in the Solomon Islands.
- Oceanic resources which include tunas, billfish and allied species. They are characterised by an open-water pelagic habitat, potentially extensive movements of individuals, and wide larval dispersal. These resources form the basis of the industrial fisheries of the Solomon Islands (pole and line, purse seine, and longline).

[36] Much of the text in this Chapter is based on a previous ex-ante evaluation of an EC Fisheries Partnership Agreement, to which one of the authors contributed in 2004.

As can be seen from Table 36, Solomon Islands' fish production is strongly dominated by tuna species (primarily skipjack and yellowfin). Although logsheet data from the industrial scale tuna fisheries in the Solomon Islands is compiled by the Department of Fisheries and Marine Resources, the analysis of the information and associated stock assessment is carried out for the Solomon Islands and other Pacific Island countries by SPC's Oceanic Fisheries Programme (OFP). The OFP collaborates with regional and international scientists through a regional forum known as the Standing Committee on Tuna and Billfish (SCTB). Recent OFP/SCTB assessment of tuna in the Pacific Islands region indicates:

- Skipjack: The available fishery indicators suggest that, while skipjack tuna stock biomass in the WCPO shows considerable inter-annual variation, the fisheries have had little measurable impact on the stock. Current levels of stock biomass are high and recent catch levels are sustainable under current stock productivity conditions.
- Yellowfin tuna: The yellowfin stock in the WCPO is presently not being overfished, but the stock is likely to be nearing full exploitation and any future increases in fishing mortality would not result in any long-term increase in yield and may move the yellowfin stock to an overfished state.
- Bigeye tuna: The current bigeye assessment indicates that overfishing is occurring and the current level of exploitation appears not to be sustainable in the long term, unless the high recent recruitment is maintained in the future.
- Albacore: The South Pacific albacore tuna stock declined moderately since the early 1980s. This decline in stock biomass was mainly recruitment driven, as was the slight recovery in the mid-1990s. The impact of the fishery on the overall stock is estimated to be small, and higher levels of catch could likely be sustained.

Table 36: Solomon Islands fish production 2000-2007 (tonnes)

Catches	2000	2001	2002	2003	2004	2005	2006	2007
Albacore	224	54	121	95	207	.	-	-
Banana prawn	10	10	10	10	10	15	15	15
Bigeye tuna	706	810	889	1,185	1,503	748	1,353	817
Clams. nei	5	5	5	5	5	5	5	5
Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Marine fishes nei	6,000	6,000	7,000	9,000	10,000	10,000	10,000	10,000
Marine shells nei	0	0	0	0	0	0	0	0
Marlins,sailfishes,etc. nei	51	9	12	23	12	15	15	15
Pacific bluefin tuna	-	-	-	-	-	6	.	.
Sea cucumbers nei	161	375	174	409	17	20	20	20
Sharks, rays, skates. nei	19	10	5	2	9	10	10	10
Skipjack tuna	8,791	11,943	13,998	18,653	13,122	12,605	18,557	13,743
Trochus shells	54.3	146.3	126.5	43.1	17.6	18	18	18
Yellowfin tuna	3,208	4,410	3,529	6,431	7,881	6,670	9,361	6,647
Total	19,229	23,772	25,870	35,856	32,784	30,112	39,354	31,290

Source: FAO

Information on catch distribution is provided in the following Figures.

Figure 21: Longline Effort in WCPO, 1999

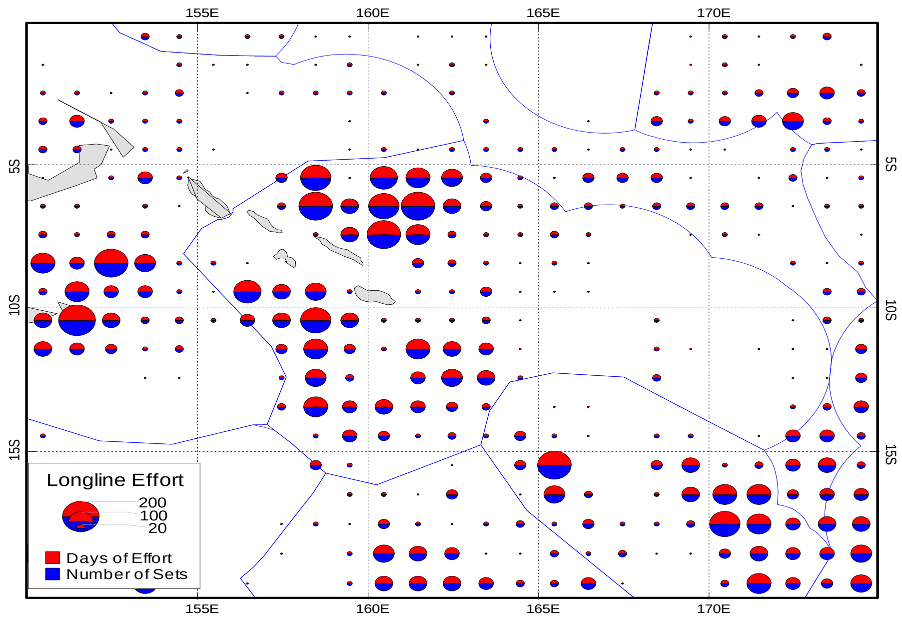


Figure 22: Purse Seine Effort in WCPO, 1999

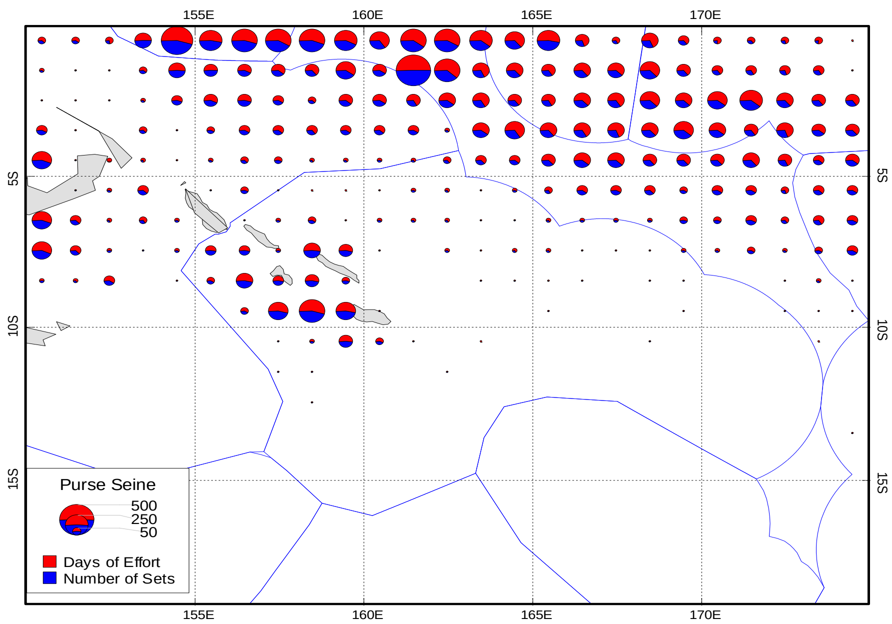
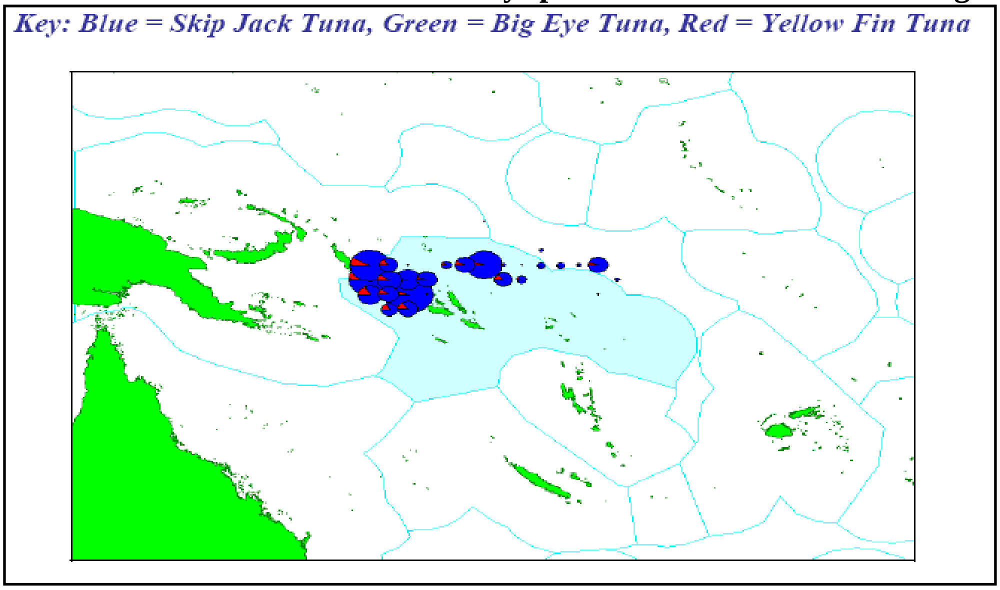
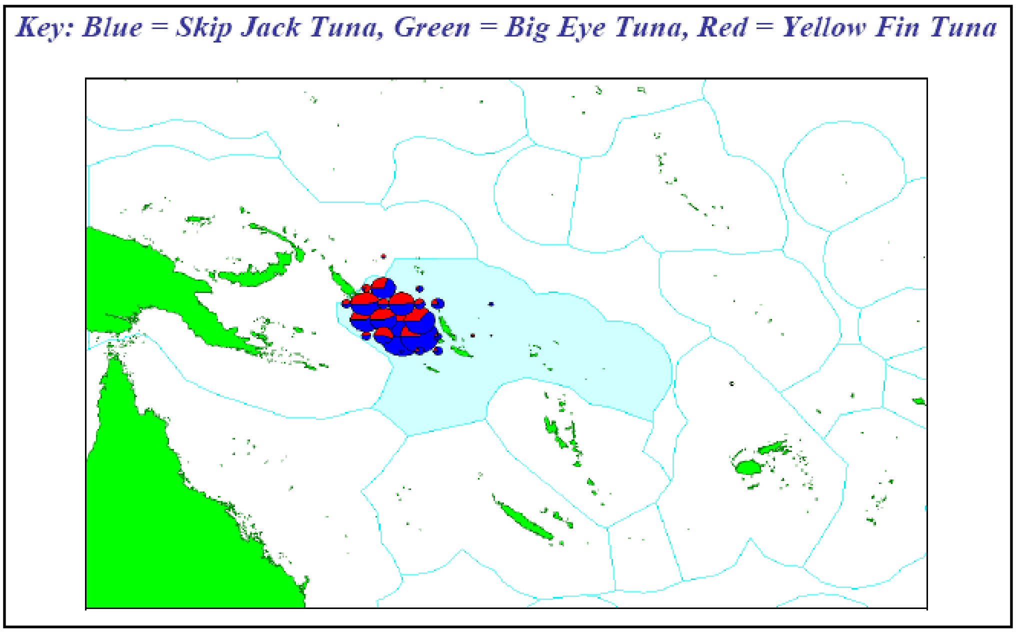


Figure 23: 2007 annual catch distributions by species for Solomon Islands longline fleet



Source: WCPCF, based on raised logsheets data collected and provided by fishing companies

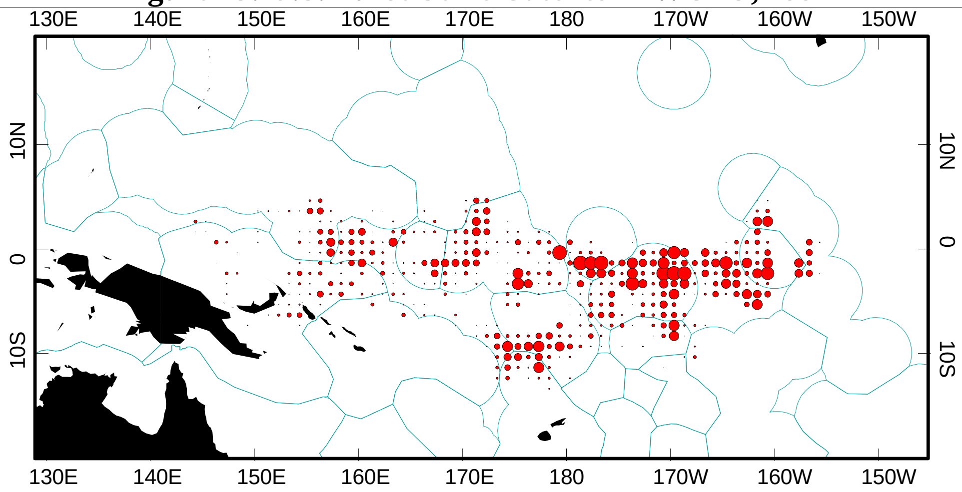
Figure 24: 2007 annual catch distributions by species for Solomon Islands Purse Seine fleet



Source: WCPCF, based on raised logsheets data collected and provided by fishing companies

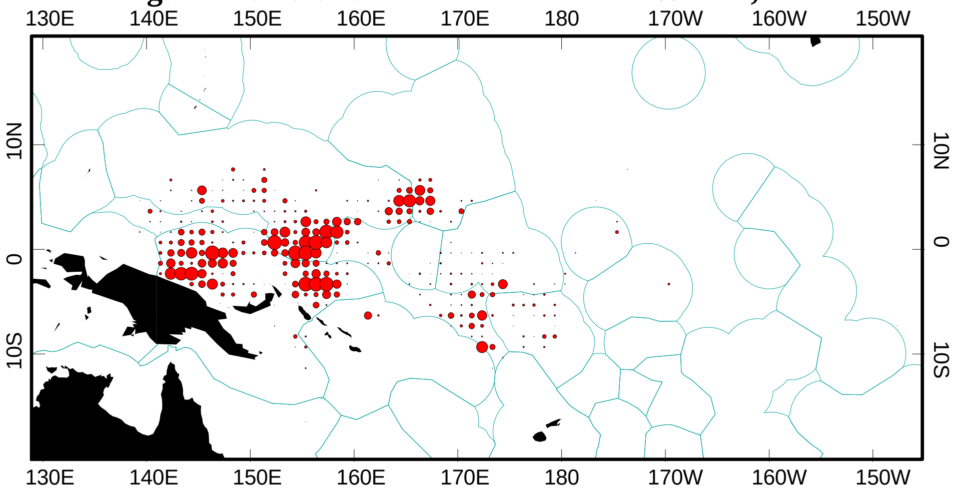
The activities of the foreign fleets are more dispersed than the local tuna vessels, and many vessels have the option of fishing the zones of other countries. For longlining, clear patterns are often not discernable for a variety of reasons (various target species, gear configurations). For purse seining, oceanographic conditions have a large effect on which sub-regions in the WCPO area have favourable fishing conditions. In general, during El Niño periods the conditions tend to be better in the areas to the east of the Solomons zone. This is demonstrated quite clearly by the shift in activity of the US purse seine fleet (which has the option of fishing in most areas of the region) between an El Niño year (1994) and a non-El Niño year (1995). Figure 25 and Figure 26 show this movement.

Figure 25: U.S. Purse Seine Catches in WCPO, 1994



Source: SPC Oceanic Fisheries Programme

Figure 26: U.S. Purse Seine Catches in WCPO, 1995



Government revenues

Chapter 5 provides information on government trade in fishing licences, and resulting revenues.

The scheme whereby purse seiners from the USA obtain access to fish in the Solomon Islands is on a multilateral basis. Under a single arrangement, vessels in the US fleet obtain access to the waters of the Solomon Islands and that of 15 other countries in exchange for an annual payment to all countries[37]. The Pacific Island countries share 15% of the total equally, with the remainder allocated according to the location of the catch.

The Solomon Islands also now has a Fisheries Partnership Agreement with the EU (2006 to 2009), and the Solomon Islands receives €400 000 each year from the EC, out of which 30 % has been earmarked for the support of the Solomon Islands sectoral fisheries policy in order to promote sustainability in its waters. The agreement provides for 4 purse seine vessels (from Spain and France) and 10 surface longline vessels (6 from Spain and 4 from Portugal) to fish in the waters of the Solomon Islands.

[37] US$21 million in 2004 ($3million from vessel owners; $18million from the US Government)

In addition to the foreign revenue sources, Soltai spent SBD122 million in the domestic economy and paid SBD1.25 million to the government (in taxes and fees), for a catch of 7,254mt. In the same year domestic company NFD spent SBD62 million in the domestic economy and paid SBD8.7 million to the government for a catch of 22,343mt. So local companies are thought to provide at least $1.5 million in revenue to the Government.

Socio-economic issues associated with upstream and downstream activities

Very little employment data is available to determine the relative importance of employment associated with the tuna industry. For example Grynberg et al. (1995) state that in Western Province (where Noro is located), 37.6% of all employment is associated with fisheries. However, estimations on employment in the domestic tuna industry of the Solomon Islands are provided in Table 37.

Table 37: Summary of Domestic Tuna Industry Employment

	Solomon Taiyo/Soltai	NFD	Solgreen
1999	2 200	-	-
2001	748	45	85
2005	850	75	0
2008	600	120	0

Sources: (Gillett 2003); Department of Fisheries and Marine Resources (interviews conducted 2005); Solomon Taiyo Ltd (interviews conducted 1999); NFD (interviews conducted 2005, 2008).

Source: Solomon Islands Diagnostic Trade Integration Study, 2008

Table 38: Summary of domestic fleet

	2002	2003	2004	2005	2006	2007
Purse seine	2	3	3	3	4	5
Longline	11	9	8	5	0[a]	0
Pole-and-line	12	12	10	7	11	9[b]
Total	**25**	**26**	**19**	**13**	**13**	**14**

Source: Ministry of Fisheries and Marine Resources, Statistics Department

Notes: a. In 2005 the tuna longlining company Solgreen/Solco ceased operations. Global has a shark longlining operation, so there have been longliners (just not targeting tuna) in Solomon Islands' fleet in recent years, but these are not included in MFMR statistics.

b. These figures are based on the numbers of vessels licensed. In 2007 not all of Soltai's nine pole-and-line licensed vessels were actually fishing.

Source: Solomon Islands Diagnostic Trade Integration Study, 2008

About 43% of the jobs in the tuna industry of the Solomon Islands are at the Soltai cannery in Noro. The number of people employed has decreased in recent years as cannery production has tapered off. In recent years, the Soltai cannery has been having difficulty competing with the more efficient overseas tuna canneries, with the cost of importing the cans being a major problem.

Major socio-economic issues associated with upstream activities are:

- Unemployment is a major problem in the Solomon Islands. While the local fleets employ a substantial number of Solomon Islanders, employment on foreign vessels and in transshipping operations is limited.
- The pole-and-line fishing technique is labour intensive and in many respects ideal for the Solomon Islands. The ageing Solomon pole/line fleet is suffering considerable

attrition and there is little likelihood for new vessel acquisition. A typical Soltai pole/line vessel uses 30 to 32 crew, of which almost all are Solomon Islanders. On the other hand, the much larger NFD purse seine vessels use about 26 crew of which 18 or 19 are Solomon Islanders. The future labour requirements for tuna fishing in the Solomon Islands are likely to be less than at present.
- With the exception of labour, some local food, and water supplies, virtually all of the inputs into the domestic tuna industry are imported. The country obtains benefits from the imported inputs by its taxation system. The local tuna companies stress, however, that the domestic tuna industry cannot compete in the international marketplace due to the high import duties.
- For a variety of reasons (high cost of supplies, difficult investment conditions.), foreign fishing vessel access agreements which intend to produce local benefits through spin-off economic activity do not greatly do so.

The major socio-economic issues associated with downstream activities are:
- The local disposal of by-catch and discards has both positive and negative repercussions. On the positive side, the supply of fish to consumers in the Honiara and Noro areas is enhanced by this activity, but the livelihoods of small-scale commercial fishers and fishworkers in those areas is often disrupted due to periodic flooding of the market.
- The employment provided at the cannery is substantial, provides opportunities outside the major urban areas, and is one the country's major employers of women.
- The low-grade canned product (which now utilizes the by-product of loining) has become a staple food in the country.
- A small tuna cannery located in an isolated area of an isolated country has great difficulty in competing in the international tuna marketplace with modern well-capitalized canneries that are located in low wage countries with efficient access to world markets.

Bell et al (2008) suggest that 64% of per capita consumption on a national basis and 73% in rural areas comes from subsistence fishing rather than being purchased commercially, and that forecasts of fish required in Solomons (tonnes) to meet per capita consumption of fish for good nutrition based on population growth are as follows:

Table 39: Forecasts of fish required in Solomons (tonnes) to meet per capita consumption of fish for good nutrition

	2010	**2020**	**2030**
National	18,000	25,500	29,900
Urban	3,400	5,400	8,700
Rural	14,600	18,100	21,200

Source: Bell et al (2008)

Sector Governance[38]

Fisheries and aquaculture governance in Solomon Islands suffers a lack of capacity that inhibits Solomon Islanders from enjoying the full potential of their fisheries resources. The main difficulties are:

- Failure to meet obligations for ensuring sustainable tuna fisheries by collecting and reporting data on tuna catches in the Solomon Islands EEZ, cross checking effective observer data against fishing company data.
- Political involvement in directorship and management of Soltai Fishing and processing inhibiting company financial viability thus restricting the economic benefits of employment and spin-off businesses.
- Failure to provide a macroeconomic and political environment that encourages private sector development.
- Failure to maximize revenue from fishing access agreements from international fleets
- Failure to work with communities for local level monitoring and enforcement for sustainable use of reef resources.
- Failure to provide rural communities with the political environment and infrastructure for education, communications, finance and transport that would enable more private sector development by villagers and reduce the necessity for patron-client relations in attempts for private sector development.

One of the chronic problems with MFMR capacity is a lack of effective information systems. There have been no properly published annual reports on the sector from the Ministry since the late 1980s. There have been *ad hoc* reports available upon asking from Fisheries staff, but these have not provided comprehensive and consistent annual snapshots of the sector. Reports to the WCPFC Scientific Committee from Solomon Islands have provided some information about the tuna sector, but the Solomon Islands government failed to provide the Scientific Committee with proper country reports in 2006 and 2007. Up until 2000 the fisheries information gap was to some extent covered by the CBSI Annual Reports, which included breakdowns of different kinds of tuna product exports (canned, frozen and smoke, which all have very different prices), as well as marine shell and sea cucumber exports. Since 2004, however, the CBSI Annual Reports include only ‘fish’ and the only price they usually mention is price for frozen tuna. In the absence of fisheries annual reports it is difficult to find production and export information about the sector to track progress. Furthermore, production figures for two of the main tuna companies, Soltai and NFD have been contained in the CBSI annual reports, but there is no information about the other large domestically based tuna company, Global. Technical assistance reports on fisheries and aquaculture even from the last few years were not kept in MFMR in hard copy or electronically.

As well as internal information problems, fisheries and aquaculture have suffered from a lack of cross-Ministry coordination. For example, the 2008 draft Medium Term Development Strategy (MTDS) had minimal input from MFMR. The various scales of governance also present a challenge in fisheries and aquaculture. While the MFMR is quite dysfunctional, it has far more capacity than the Provincial level fisheries offices. Apart from ice provision from Fisheries Centres, there is no effective government fisheries presence outside Honiara and the fishing port of Noro.

[38] Text from recent DTIS study, 2008