CERMES Technical Report N^{o} 18

Impacts of climate change on small-scale fisheries in the eastern Caribbean: a final report to IUCN

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2009

ACKNOWLEDGEMENTS

Sponsorship for this project came mainly from the International Union for Conservation of Nature (IUCN) through a small research grant on the interactions between climate change and small- scale fisheries in the eastern Caribbean. The grant was awarded to the Centre for Resource Management and Environmental Studies (CERMES) at the University of the West Indies (UWI) Cave Hill Campus in Barbados as a pre-programme activity of the IUCN Caribbean Initiative.

Travel sponsorship for the fisher leaders of the Fishers Forum (Anderson Kinch and Mitchell Lay), and coverage of the research and travel costs of the graduate student (Philmore James) came from the IUCN.

Travel of the Forum keynote presenter and research co-supervisor (Leonard Nurse) was sponsored provided through a grant for policy research on Sustainable Aquatic Resource Management (SARM) awarded to CERMES by the International Institute for Sustainable Development (IISD) of Canada.

The Board and Program Committee of the Gulf and Caribbean Fisheries Institute (GCFI) made it possible to hold the Fishers Forum as a session in the main conference programme with simultaneous translation (English, French and Spanish). They provided all facilities and equipment.

Travel and research supervision by Patrick McConney was with the aid of a grant from the International Development Research Centre (IDRC), Ottawa, Canada. The Forum was jointly arranged under the IUCN project and the IDRC-funded Marine Resource Governance in the eastern Caribbean (MarGov) project being executed by CERMES. MarGov private sector sponsors Sol and Island Heritage contributed to the communication aspects of the Forum.

Citation

McConney, P., L. Nurse and P. James. 2009. Impacts of climate change on small-scale fisheries in the eastern Caribbean: a final report to IUCN. CERMES Technical Report No. 18. 36pp.

CONTENTS

1 INTRODUCTION

The Centre for Resource Management and Environmental Studies (CERMES) at the University of the West Indies (UWI) Cave Hill Campus in Barbados has very active teaching, research and outreach programmes in the graduate degree specialisation streams of climate change and of coastal and marine management. Small-scale fisheries (SSF) in the Caribbean feature prominently in the latter, but little emphasis has been placed on the linkages between commercial SSF and climate change either in CERMES or in the several projects concerning both topics that are underway in many parts of the Caribbean. As a consequence, CERMES seized the opportunity to partner with the International Union for Conservation of Nature (IUCN) to investigate aspects of this interaction in some islands of the eastern Caribbean.

The project demand came from questions posed by fishers attending the 60th annual meeting of the Gulf and Caribbean Fisheries Institute (GCFI) in 2007 in the Dominican Republic. They said that they had heard much about climate change generally, and about impacts on coral reef ecology, but little about how it may impact upon the livelihoods associated with small-scale fishing. These livelihoods include fishing, fish processing, fish trade and fisheries technical support services. Although climate change research is in progress by universities, intergovernmental organizations and non-governmental organizations there was not much aimed specifically at SSF. Fishers queried what information regional scientists could supply.

Yves Renard met with Patrick McConney, a senior lecturer at CERMES, while at the Caribbean Natural Resources Institute (CANARI) introducing the draft IUCN Caribbean Initiative. The prospect of answering the fishers' queries through a project of mutual interest was enticing. Leonard Nurse, a senior lecturer who heads the climate change specialisation at CERMES and is a member of the Intergovernmental Panel on Climate Change (IPCC), readily agreed to collaborate. Philmore James, a CERMES graduate student in the climate change stream on study leave from his post of Senior Fisheries Officer in Antigua and Barbuda, was eager to become engaged in the research that spanned his interests. Thus the project proceeded to IUCN approval, then implementation from May 2008 to January 2009.

The project's aims and outputs were oriented towards improving information available to fisheries stakeholders, but especially fishers (Appendix 1). These aims and outputs were to:

1. Provide participants, and especially fishers, at the 61st GCFI meeting in November 2008 with information on the impacts of climate change on small-scale fisheries in the eastern Caribbean in such a way as to stimulate follow-up research and action
2. Initiate a process of enabling fisher folk to interact with scientists and managers so as to reduce vulnerability to climate change and increase options for adaptation
3. Build capacity for the integration of fisheries and climate change research through the graduate studies of one of the sub-region's most experienced fisheries officers
4. Strengthen the interdisciplinary interactions within CERMES by collaboration across two major teaching and research streams offered in MSc specialization
5. Provide advice to IUCN and its members and partners in the region on opportunities for future work on issues related to the impacts of climate change on small-scale fisheries in the eastern Caribbean
6. Identify possible projects and activities for eventual implementation by UWI and other agencies, with IUCN support as appropriate

The next section of this final report addresses the achievement of these aims and outputs in summary fashion. The main focus of the report, however, is on the last two listed aims and

outputs. For easy reference two scientific papers produced as project outputs are appended (Appendices 2 and 3) as well as a research agenda (Appendix 4) developed by a CANARI project on climate change. The IUCN Caribbean Initiative concept note on ecosystems and livelihoods (Appendix 5) is the context for some of the advice and project suggestions.

2 ACHIEVEMENTS

2.1 Information exchange

As a result of the project, both Nurse (Appendix 2 and in press) and James (Appendix 3 and in press) presented papers at the Fishers Forum entitled "Climate change and small-scale fisheries in the Caribbean" held on the first day of the 61st annual meeting of the GCFI in Gosier, Guadeloupe, 10-14 November 2008. IUCN was named as a major sponsor of the Forum and the report (CERMES 2009) is available to download from both the GCFI and CERMES web sites. Several fishers attended the session along with a larger number of fisheries scientists, managers, students and others from around the region. There was interest in follow-up to the Forum as detailed in the report and described in proposals outlined in the next section. The MSc thesis of James should be converted into a CERMES Technical Report and also be made available on the CERMES web site. Students and others seeking research information and ideas are known to consult these reports and this may further stimulate project follow-up.

2.2 Interaction among stakeholders

Chairman of the 2008 GCFI Fishers Forum was Anderson Kinch, who is also a fisher from Barbados, member of the GCFI Board of Directors and the person who raised most of the queries in 2007. Kinch said in the Forum that the research results on fishers' perspectives on climate change reported by James showed that he talked to and understood fishers. He said that more of this type of interaction between fisheries scientists/managers and fishers was needed. The co-chair of the Forum was Mitchell Lay, a fisher and fisherfolk organisation leader from Antigua and Barbuda. He echoed Kinch and the formation of the Caribbean Network of Fisherfolk Organisations (CNFO) that he is coordinating provides additional opportunities for interaction. There was considerable interaction at the GCFI meeting. Both Kinch and Lay participated in the Caribbean regional symposium organised by CERMES and Dalhousie University on "Marine Ecosystem-Based Management in the Caribbean: an essential component of Principled Ocean Governance" held on the Cave Hill Campus, Barbados, December 10-12, 2008 (Fanning et al. 2009). Knowledge of climate change gained from their exposure and interactions at GCFI was evident in their level of participation at the symposium.

2.3 Capacity building

Although James did not complete the write-up of his MSc research report within the project period, his GCFI paper and discussions with fishers, students and fisheries managers attested to the capacity built in this individual. It is expected that he will continue to combine his interests in fisheries and climate change as he returns fully to his professional arena. Since the research was participatory it is likely that it resulted in some increases in the awareness and knowledge of fishers as well through information exchange.

2.4 Interdisciplinary collaboration

The positive outcomes of this small project have reinforced the need for the climate change and coastal and marine management streams at CERMES to collaborate beyond the current sharing of core courses. There is at least one other student presently interested in a research combination similar to James, and co-supervised joint research topics will continue to be

offered in the future. The researchers, McConney and Nurse, are seeking avenues for implementing some of the research outlined in the next section.

3 ADVICE AND PROJECTS

3.1 Scale and scope

The recommendations in this section are oriented to reflect the researcher's particular perspectives and interests concerning climate change and SSF interactions. They should not be taken out of the contexts outlined below without some measure of review or adaptation.

1. The geographic scale is primarily the insular eastern Caribbean. Different considerations apply to some areas of the western Caribbean and to continental areas of the Americas.
2. The socio-economic scale is primarily SSF with a strong livelihoods orientation. Larger-scale fisheries and narrow concentration on business profit-making introduce differences.
3. The governance scope is integrated but emphasises the role of civil society, and especially fisherfolk organisations, in playing a meaningful role in fisheries governance.
4. The scientific scope recognises the importance of ecosystem-based management (EBM) and the ecosystem approach to fisheries (EAF), but also acknowledges that these are new concepts not yet operationalised in the eastern Caribbean.
5. The scale in terms of capacity accepts that these SIDS will be constrained in what is feasible and sustainable, and that applied research must take real limitations into account.

One can further define and delimit the scope, but suffice it to say that the research is intended to closely fit the circumstances and interests of the eastern Caribbean rather than try to attain grander proportions. CERMES has found that benefits accrue from paying attention to scale and scope. This is especially so in cases where the involvement of stakeholders is crucial.

3.2 Approach

The latter point speaks to how the research is approached. We propose participatory action research (PAR). Participation of stakeholders from design to evaluation is intended to ensure that the research is demand driven to ensure relevance and that there is likely to be uptake with application to ensure learning and sustainability of beneficial outcomes. The participatory approach will also provide an opportunity for the researchers to calibrate their model-based projections using the actual observations of fishers. The level and mode of participation, and who the stakeholders are, will differ with the specific research activity. As an integral part of research design, the voices of fisherfolk must clearly be heard in action-oriented communication on the linkages between SSF and climate change in the context of EBM and EAF, and what must be done about them to reduce their vulnerability and increase adaptive capacity. The approach should treat SSF as complex social-ecological systems. Action research contains elements of advocacy and capacity development. We wish to advocate that the research be done in ways that empower stakeholders and promote good governance, using existing institutions where possible. For example, collaborative research involving both fisherfolk organisations and fisheries authorities could be highly beneficial. However, as Nurse points out, adaptation and developing adaptive capacity is a *process*, not a *project.* Although one may integrate a suite of projects into a larger, longer term programme, the requirement is more for the institutionalisation of collaborative approaches in ongoing routine fisheries and climate-related operations than for a collection of project initiatives. As James suggests in compromise, since intervention by project is inevitable, this requires cost-effective approaches that incorporate institutional learning so as to facilitate sustainability.

3.3 Partnerships

The above speaks to partnerships. This reflects the values of both CERMES and IUCN. The latter's interest extend beyond the English-speaking Caribbean in which most of CERMES' current climate change partnerships are forged. The Caribbean Community Climate Change Centre (CCCCC) and CANARI are partners with CERMES and each other. They bring into play a network of local, national, regional and international organisations that IUCN may wish to become familiar with and engage to strengthen existing linkages. Besides GCFI, prominent regional fisheries partners include the Western Central Atlantic Fisheries Commission (WECAFC) and the Caribbean Regional Fisheries Mechanism (CRFM). The Environment and Sustainable Development Unit (ESDU) of the Organisation of Eastern Caribbean States (OECS), Cropper Foundation (a leader of the CARSEA Millennium Ecosystem Assessment study) and Caribbean Large Marine Ecosystem (CLME) Project are just a few of the many that span both fisheries and climate change issues. Working closely with civil society organisations such as the previously mentioned CNFO, and others that are more established, will be crucial in making the research and its application meaningful. The Nature Conservancy (TNC) and other big international NGOs are also working in the region. The point of the above is to emphasise the importance of regional partnerships in developing, implementing and using this research in addition to the prevalent international linkages.

3.4 Research areas

The research areas outlined below draw upon the information in Appendices 2 to 4, and are intended to be compatible with the IUCN initiative in Appendix 5, but not to be limited by it. In most cases the research areas can address several levels on scales of geographic extent, jurisdiction, institutions, time and the like. Multi-level, cross-scale fast and slow variables come into play. The research must be interdisciplinary in most cases. Due to the number of options available we do not attempt to address many details, but provide a coarse resolution general outline. Each brief explanation follows the pattern of addressing:

- What the research idea is about
- Why the research is of interest
- How research may be conducted
- What benefits can be expected

3.4.1 Fisheries ecological relationships

Many of the research recommendations (see the box below) concern investigating ecological relationships between climate change, climate variability and bio-physical aspects of fisheries. They are about better understanding the nature of the issues and possible outcomes.

- How will changing temperature, wind, salinity and circulation regimes affect the spatial and temporal abundance and migration patterns of commercially important species?
- What is the level of understanding of the population dynamics and seasonal availability of non-exploited species? What is the *harvesting threshold* beyond which these stocks might crash?
- How do predators and prey respond under different climate change scenarios? (i.e. what is their sensitivity to *various increments* of warming, acidification, sea-level rise, etc)? What is their 'natural' adaptive capacity?
- Impacts of changes on fisheries ecology; e.g. seasonality, migration patterns, ciguatera, alien invasive species, habitats

- Which fisheries are likely to be most impacted positively or negatively and how?
- Seasonal and local variations of currents: current movement within local areas around the Caribbean and the influence of currents on fishing activities of individual Caribbean countries
- Influence of local habitat on different fish species and how different fish species adapt to different temperature and depth regimes throughout the Caribbean region
- Migratory patterns of fish species: climate change impact on fish migration throughout the Caribbean region
- Migratory patterns of different bird species: investigations into the impacts of climate change on bird migration throughout the Caribbean region and possible relationships with fishing activity
- Climate change and marine invasive species: the appearance of new species of fish and their possible connection to climate change and/or climate variability
- Possible influences of climate change on ciguatera occurrence particularly in the north-eastern Caribbean
- Changes in sea water colour and linkage to climate change: what are the possible relationships between water colour and fish productivity throughout the Caribbean?

Although the precautionary principle warns that information deficiency is not an excuse for not taking immediate responsible management action, there should be sufficient information to reduce the risk of inappropriate management decisions and undesirable outcomes. Some of this research is highly quantitative and technical-scientific, involving the downscaling of climate change models and application of fisheries models as currently being done at UWI. Other aspects require more qualitative assessment of the practices, observations, attitudes and knowledge of resource users. Data, information and knowledge from multiple sources can be both formally and informally combined in models and through participatory processes. This research lends itself to application over several scales in space and time ranging from site-specific, brief graduate student or outreach assignments to large intergovernmental initiatives. How the research is conducted will vary with the details, but much of it is well-suited to UWI and other academic research institutions networked to international scientific expertise. The benefits from such research range from the regional research capacity built in the process to the information products that feed into science, management and policy decision-making.

3.4.2 SIDS-scale appropriate indicators

Related to the suite of questions above, and the means of providing social-ecological system integration, is the challenge of developing indicators appropriate for the sub-region in focus which is characterised by being composed entirely of small island developing states (SIDS).

- Which coastal and marine characteristics are good indicators of climate change
- Which marine and climate features that fishers typically monitor to catch fish will change and how; e.g. sea temperature, water colour and consistency, rainy season, storms, currents, birds

A recent publication (Allison et al. 2009) takes a global look at the vulnerability of national economies to the impacts of climate change on fisheries. Within it the insular Caribbean is conspicuously absent, most countries being categorised as "data deficient". Why is this so? Research is needed to determine if the apparent data deficiency is an artefact of reporting to the particular global databases selected for the constructions of the indicators used. It is also worth investigating whether more SIDS-scale and SIDS-appropriate indicators should be

used even if the apparent data deficiency problem is resolved. Such research is critical given the international trend towards the use of indicator systems as a means of capturing multiple data streams and reducing complexity to sets of composite variables more useful for decision making that the disaggregated spread of information that scientific studies usually produce. An appropriate indicator set could assist in measuring progress towards and meeting the Millennium Development Goals (MDGs) or other important targets. Stakeholders at multiple levels from civil society to governmental and intergovernmental actors would need to participate in the research that should be led by collaborating major regional organisation (e.g. CCCCC and CRFM in this case) assisted by suitable scientific/technical expertise.

3.4.3 Climate impacts on fisheries management models, measures and technology

In the report of the GCFI Fishers Forum (CERMES 2009) a participant points out that good fisheries science and management should not be forsaken due to a new preoccupation with climate change. Yet there is a need to determine what the likely impacts of climate change are on the fisheries models and management measures currently in use. Authors ask:

- Will climate change alter the values of parameters commonly applied in fisheries management models to estimate optimal production, yield, and levels of stock?
- Will there be a need to modify existing fisheries regulations and practices (e.g. extend/reduce closed seasons; issuance of permits for various fisheries), and introduce new technologies?

Research on this topic is first of all a literature review to assess experiences in regions that have already tried to factor climate change into fisheries management models and measures. In many eastern Caribbean countries there is minimal use made of numerical models. Many fisheries management regulations are not as closely linked to scientific models as in larger developed countries. Therefore management measures may be fairly robust and resilient to climate change. One concern, however, may be that new technologies introduced as a means to counter the impacts of climate change will alter patterns of fishing effort, or increase the effective overall effort, so as to increase the vulnerability of ecological and social systems. Another perspective is that new technologies, perhaps to further diversify fishing effort and spread risk over a wider area or number of commercial species, may be warranted by changes in climate. Consequently, in either scenario, there must be mechanisms for offering informed technical information and assistance most likely from fisheries authorities and national or regional fisherfolk organisations. Addressing this topic will assist these organisations to be better prepared, increase their adaptive capacity and perhaps foster institutional re-designs. In addition to their participation, the involvement of specialist consultants in the areas of fishery modelling and technology will be required. This may be an opportunity for technical cooperation between developing countries (TCDC) or south-south SIDS initiatives.

3.4.4 Trade and marketing matters

The countries of the eastern Caribbean engage in both intra-regional and extra-regional seafood trade. As the ranges, behaviours and catchability of existing commercially caught species shift with changing climate, and perhaps new species become commercially important, one can expect changes to occur in trade and marketing.

- Will there be a market for 'new' or non-traditional species? And what would be required to ensure the sustainability of that market?
- How will climate change affect the cost and availability of fishing inputs? e.g. fuel, ice, bait

Since market demand is one of the main drivers of the harvest sector and fisherfolk behaviour it is important to monitor and evaluate market trends closely to be able to adapt accordingly. For example, it may be necessary to promote new species in new markets. Patterns of seafood consumption may change relative to developments in agriculture, tourism or other sectors. Most fisheries authorities and academic institutions in the Caribbean are not accustomed to conducting marketing research. This topic may require specialist consultants to help develop predictive models of trends in trade and marketing and outline the means for seizing these as opportunities where appropriate. Policy level research may be required in relation to trade and food security. Some of the benefits include enhancing socio-economic adaptive capacity and resilience.

3.4.5 Coping strategies, livelihoods and complexity

A feature of poverty and vulnerability research has been to reveal the ingenuity of the coping strategies that people develop and utilise to adapt and remain resilient at several levels. These coping strategies are usually related to livelihoods and means of managing complexity. At the organisational level coping strategies also exist to ensure enterprise survival.

- Which impacts are expected to reduce the viability of fisheries-related livelihoods, including land-based aspects of fishing operations and households dependent upon fishing
- What is the full range of coping and management strategies and whether they are 'good' or 'bad' e.g. increasing fishing effort, decreasing fishing effort, alternative species, alternative livelihoods, seafood price increases, aquaculture, MPAs, changing vessel technology

If individuals or groups have informally or formally developed strategies for coping with climate and fisheries uncertainty it is important to know what these are before advocating any interventions aimed at assisting them. The development literature is full of examples of failed interventions as a result of projects ignoring or failing to utilise existing institutions. The fishers who prompted this research were most keen on obtaining information on linkages between climate change and their livelihoods. This could include examining the sustainable livelihoods framework and approach in the context of Caribbean climate change. Some NGOs such as CANARI are already engaged in this type of applied research and capacity development. James describes the coping strategies of fishers interviewed and it is clear that additional information on their perceptions of options and criteria for decision-making are needed to better understand the choices that they are likely to make when faced with various scenarios. Much of this research involves interdisciplinary social science. Close collaboration among fisherfolk and other NGOs in the region, academic institutions such as UWI and some researchers with experience of similar topics elsewhere (such as in African or Asia-Pacific areas) would be beneficial. Multiple benefits such as pro-poor policies, more appropriate schemes for alternative livelihoods and better structured policy responses could be expected.

3.4.6 Fisheries governance and inter-sectoral linkages

Several of the previously described research areas are relevant to fisheries governance and inter-sectoral linkages. They are part of the EBM/EAF approach identified earlier. Yet it is still customary, globally, to take piecemeal and sectoral approaches to problem-solving despite the compelling arguments for integrated approaches.

- Mainstreaming climate change into national and regional policies and plans.
- Related research agendas incorporated into the plans of universities, regional and national fisheries authorities, user groups, donor and technical assistance agencies etc.

- Private sector partnerships based on products relevant to preparation for climate change impact

Since fishing is often a marginal sector in national economies and policies in the eastern Caribbean special attention must be paid to its integration into policies and plans. Indeed the research of Nurse and James under this project has illustrated that fishing has largely been omitted and overlooked in climate change initiatives in the Caribbean to date when compared to agriculture, tourism and other economic sectors. Implementing applied research to support mainstreaming climate change into fisheries policy and fisheries into an inter-sectoral milieu will require and interdisciplinary effort with a large component of economics. The integration advocated may only occur if the economic advantages are evident. This may entail valuation studies in addition to policy research. An important point to investigate, especially in SIDS, is whether climate change may threaten fisheries less in comparison to currently critical coastal activities such as tourism, and hence elevate the status of the fishing industry as a contributor to national socio-economic resilience. Findings could be particularly relevant to the CRFM Common Fisheries Policy, currently under negotiation, as well as OECS and national policy. As for other topics, this research should be conducted at multiple levels by NGO, academic and governmental partners. Benefits from knowledge gained pertain to informing the entire organisation of fisheries governance in the sub-region.

3.4.7 Communicating with communities

Communication is the subject of the last research area in the CANARI agenda (Appendix 4). James provided observations and recommendations related to communication. The demand for this research project was driven by fishers' perceptions of inadequate communication.

- Limited understanding of the processes of climate variability and climate change
- Uncertainty about the meaning of terms and need for accurate popularisation
- News media, entertainment and outreach interests sensitised to fisher folk and their households as a special segment in the communications market for climate change messages
- Communication research in partnership with fisher folk organisations (FFOs) to understand how knowledge, perceptions, attitudes and behaviours change based on information
- Schools and early education providers involved increasing awareness for future generations
- Communicating climate change to fishers

Communication and communication research (so as to facilitate monitoring, evaluation and improvement) are both important. Understanding of climate change and variability differs among stakeholders. Common understanding and interests are needed to encourage research collaboration and subsequently its results uptake and application in adaptive management. A requirement of any project involving climate change and fisheries is that it includes a large component of communication to multiple target audiences by multiple means that are proven to be effective. UWI and some NGOs have expertise in communication and its research, but it is a field that requires more attention than is typically allocated at present. Communication specialists may need to be sought to assist these partnerships. Schools, media houses and the government education departments should be included. Unless communication is adequately addressed the results of research will go unnoticed. It is one of those areas with a potentially high multiplier effect that is fairly easily sustainable if the demand for outputs persists.

4 CONCLUSION

The possible impacts (positive and negative) of climate change and variability on the small-scale fisheries of the eastern Caribbean were explored mainly via graduate student research in this project, and then combined with information-sharing at a regional fisheries conference. It is suggested that, in the Caribbean, exposure and sensitivity to the climate change threat are high, while adaptive capacity is low (Nurse in press). Applied research and development may contribute to improving the latter if not the former. Fishers in the eastern Caribbean appear to be aware of climate change and variability only generally. Understanding of what these terms mean and perceptions of their impacts on small-scale fisheries vary considerably as do the very preliminary results related to fisherfolk coping strategies (James in press).

The research undertaken only touches the tip of a large iceberg. Several suggestions are made for additional areas of research to be urgently addressed under the IUCN Caribbean Initiative programme of activities related to ecosystems and livelihoods, or through other means. The approach to follow-up research must be interdisciplinary, demand-driven, participatory and communicative. A considerable amount of work is necessary to address the issues raised.

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6 APPENDICES

6.1 Appendix 1: Concept note and terms of reference

Demand-driven research to assess and communicate the likely impacts of climate change on small-scale fisheries in the eastern Caribbean and to identify possible activities in response to these impacts

Outline

Working title	Impacts of climate change on small-scale fisheries in the eastern Caribbean
Applicant organization	Centre for Resource Management and Environmental Studies (CERMES), The University of the West Indies, Cave Hill Campus, Barbados www.cavehill.uwi.edu/cermes
Supervisor and manager	Dr. Patrick McConney, Senior Lecturer, CERMES, UWI patrick.mcconney@cavehill.uwi.edu Tel. 246-417-4725
Co-supervisor	Dr. Leonard Nurse, Senior Lecturer, CERMES, UWI
Field investigator	Mr. Philmore James, CERMES MSc research student
Study area	Eastern Caribbean with emphasis on Antigua and Barbuda, Barbados and St. Kitts Nevis study sites
Funds required	IUCN: US$7,000; Matching: US$7,000 from CERMES
Duration	1 May 2008 to December 31 2008
Project summary	The proposed research responds to a demand from fishers for more information on the likely impacts of climate change on their small-scale fishery livelihoods in order to help them to and reduce their vulnerability. Field research will address the perceptions of fisher folk and the best available scientific information. Results and follow-up recommendations will be shared at a regional conference, and will be used in a concept note – and possible project ideas – to be submitted to IUCN as part of its Caribbean Initiative.

Demand for project

One of the points raised by fishers attending the 60th annual meeting of the Gulf and Caribbean Fisheries Institute (GCFI) in 2007 was that they heard much about climate change generally and about impacts on coral reefs, but little about how it may impact upon the livelihoods associated with small-scale fishing. These include fishing, fish processing, trade and fisheries technical support services. Although much research by universities, intergovernmental organizations and non-governmental organizations is in progress, there has not been much aimed specifically at small-scale fisheries (SSF). The opportunity exists now to integrate SSF into the work of the University of the West Indies (UWI), Caribbean Community Climate Change Centre (CCCCC), Caribbean Natural Resources Institute (CANARI), IUCN and others, both in terms of doing research on impacts, but ultimately also in civil society mobilization for adaptation. It is appropriate to feedback a research response to the forum in which the points were raised and to stimulate the diverse at GCFI meetings to follow-up with further action.

Main aims and outputs

1. Provide participants, and especially fishers, at the 61st GCFI meeting in November 2008 with information on the impacts of climate change on small-scale fisheries in the eastern Caribbean in such a way as to stimulate follow-up research and action
2. Initiate a process of enabling fisher folk to interact with scientists and managers so as to reduce vulnerability to climate change and increase options for adaptation
3. Build capacity for the integration of fisheries and climate change research through the graduate studies of one of the sub-region's most experienced fisheries officers
4. Strengthen the interdisciplinary interactions within CERMES by collaboration across two major teaching and research streams offered in MSc specialization
5. Provide advice to IUCN and its members and partners in the region on opportunities for future work on issues related to the impacts of climate change on small-scale fisheries in the eastern Caribbean
6. Identify possible projects and activities for eventual implementation by UWI and other agencies, with IUCN support as appropriate

Expected IUCN interest

The proposed project cuts across several of the global and regional thematic priority areas outlined in the consultation draft of the IUCN Caribbean Programme 2009-2012. In particular it is relevant to issues of climate, poverty, livelihoods, governance and biodiversity conservation. It would demonstrate the extent of IUCN interest.

Work plan and schedule

The table below provides a rough first draft of the activities and their timing.

Summary description of activity	Schedule
Review literature on impacts of climate change on SSF worldwide and responses of fisheries authorities and fisher folk to these impacts	May –Jun
Prepare final draft of research proposal and arrange field logistics	End of Jun
Obtain information from Caribbean fisheries stakeholders on their perceptions of climate change impacts, including their likely coping strategies (Barbados, Antigua and Barbuda, St Kitts Nevis study sites)	Jul – Aug
Research possible impacts on Caribbean reef and pelagic fisheries at the study sites, paying attention to the impacts and coping strategies that stakeholders identified in order to compare these to the literature	Jul – Aug
Interpret findings in context of vulnerability, mitigation, adaptation etc	Aug – Sep
Make recommendations on how scientists, managers and resource users can endeavour to better understand and cope with the likely impacts	Sep – Oct
Submit the research report for assessment and completion of degree	End of Oct
Present a paper on the research at GCFI 10-14 November 2008 in Guadeloupe, perhaps in a special Fishers' Forum session at which the diverse audience can serve to validate or further interpret the findings	10-14 Nov
Support the participation of key fishers at the GCFI conference, to participate in the Fishers' Forum and assist in leading uptake of results	10-14 Nov
Widely disseminate the research findings and recommendations via the CERMES and other communication networks to raise awareness and stimulate self-organised follow-up action and research on this topic	Oct – Nov
Prepare a final project report and teaching material on lessons learned, including summary advice to IUCN and its members and partners in the region on opportunities for future work on issues arising from the study	Mid-Dec

Draft project budget

Activity	Cost (USD)
Funds requested from IUCN	
Travel and fieldwork for three study sites	2,000.00
1 student participation in GCFI for 6 days	1,425.00
2 fishers participation in GCFI for 6 days	3,000.00
Materials, reporting and communication	575.00
Total requested funds	**7,000.00**
Matching funds from CERMES	
McConney management and co-supervision	4,000.00
Nurse graduate researcher co-supervision	3,000.00
Total matching funds	**7,000.00**

Project management

The project will be managed by Dr. Patrick McConney who will co-supervise the graduate research of Mr. Philmore James along with Dr. Leonard Nurse. Both Nurse and McConney are Senior Lecturers in CERMES with much relevant experience. The former is also a member of the Intergovernmental Panel on Climate Change (IPCC) and the latter is a former fisheries manager. Mr. James is a fishery officer in Antigua.

Useful links

1. Centre for Resource Management and Environmental Studies (CERMES) web pages at www.cavehill.uwi.edu/cermes inform about the organisation and supervisors

2. Gulf and Caribbean Fisheries Institute (GCFI) www.gcfi.org provides information on the conference and a copy of the 2007 Fishers' Forum report can be downloaded

6.2 Appendix 2: GCFI keynote presentation

Incorporating Climate Change Projections into Caribbean Fisheries Management

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Abstract

Concerns over the socio-economic impacts of observed and projected changes of climate have been high on the research agendas of scientists the last several decades. According to the Intergovernmental Panel on Climate Change, the recent observed warming is largely human-induced, and the trend will continue at least into the next century owing to 'thermal inertia', directly related to the concentration of greenhouse gases already emitted to the atmosphere (IPCC, 2001, 2007). While there is a dearth of research on the specific effects of climate change on commercial and artisanal fisheries in the Caribbean, valuable insights can be gleaned from observations and projections in other jurisdictions. In contrast with some projections in middle and higher latitudes, the consequences of climate change on Caribbean fisheries are expected to be mostly negative. Adverse impacts on regional fisheries are likely to manifest themselves through habitat alteration and loss, reduced abundance and diversity, and possibly shifts in distribution induced by changes in ocean currents. In light of these projections, stakeholders in the regional fishing industry might wish to give greater credence to the challenges posed by climate change and climate variability than currently appears to be the case. Appropriate response strategies may not require radical changes in current approaches to management, but rather more effective implementation of existing and proposed arrangements.

The Global Context

Global mean air temperatures have increased by approximately 0.7^0 C during the 100 year period 1906-2005. For the next two decades a warming of about 0.2°C per decade is projected for a range of GHG emission scenarios (IPCC, 2007). In addition, during the 20th Century global sea levels rose at a rate approximately 10 times faster than the average rate for the previous 3000 years (Ibid.). Outputs from a suite of climate models indicate that human-induced warming (approx. 0.1°C per decade) and incremental sea level rise would continue for centuries due to the level of inertia in the climate system, even if greenhouse gas concentrations were to be stabilized at year 2000 levels (Ibid).

Stakeholders in the fisheries sector should equally be concerned about the post-1900 increases in frequency, intensity and persistence of warm (El Niño) phases of El Niño Southern Oscillation (ENSO), as well as an observed trend of increasing sea-surface temperatures. Before the end of the current Century mean global sea-surface temperatures are expected to be approximately 1.0-2.0^{o}C higher than the 1990 mean (IPCC, 2001). In the specific case of the tropical oceans, temperatures are projected to be 2^o C by the 2050s and 3^{o}C higher by the 2080s, relative to the same 1990 baseline (Lal *et al.* 2002). The link between ocean warming, El Niño occurrences and coral bleaching is now well-established, and there is considerable observational evidence to show that the most intense bleaching events since 1900 have all occurred in those years when the El Niño signal has been strongest (Glynn, 1984; Goreau et al., 2000; Wilkinson, 2000; McWilliams et al., 2005)

Ever since publication of the First Assessment Report of the Intergovernmental Panel on Climate Change in 1990, a large volume of literature has emerged on the observed and projected impacts of climate change and climate variability on terrestrial and marine habitats, and their associated assemblages of flora and fauna. The literature provides an abundance of evidence of a wide spectrum of responses from the species to the community level in all latitudes, and documents observed as well as projected climate change impacts on all socio-economic sectors, including fisheries (IPCC 1990, 2001, 2007; Walther et al, 2002; Edwards and Richardson, 2004; Winder and Schindler, 2004; Garpe et al., 2006). Regrettably, focused investigations on the impacts of climate change and climate variability on Caribbean fisheries has lagged considerably behind the work conducted in other regions. However, notwithstanding the dearth of region-specific research, there is both an opportunity and a need for Caribbean fisheries stakeholders to build upon the existing global knowledge base, as they become increasingly confronted with the inevitability of designing mitigation and adaptation strategies to global climate change.

Linking Climate Change and Fisheries: What Do We Know?

While there is a need for considerably more research especially at the species level, there already exists a good generic understanding of the *potential* impacts of climate change and climate variability on key factors and processes that influence recruitment, abundance, migration, and the spatial and temporal distribution of many

fish stocks. For instance, the consequences of greenhouse gas emissions on the seasonality and intensity coastal upwelling and the implications for fish and other marine organisms has occupied the attention of scientists for many decades (Bakun, 1990; Wiafe et al., 2008). This is well demonstrated in the case of the California Current, where both intensification of upwelling and seasonality changes in the phenomenon have been documented (Diffenbaugh et al, 2004). The impact of CO_2-induced warming is equally well documented for the upwelling region of the Gulf of Guinea, where zooplankton biomass decreased by approximately 6.33 ml per 1000 m^3 yr^{-1} between 1969 and 1992, in phase with sea surface warming (Wiafe et. al., 2008). Coincidentally, *Calanoides carinatus*, a crustacean whose appearance is observed only in the major upwelling season (July-September) and known to be highly sensitive to temperatures > 23°C, also decreased in abundance (Wiafe, op.cit). Similar observations have been noted at various other upwelling locations including South Africa (Schumann, 1999), Northwest Africa (McGregor et al., 2007), Chile (Arcos et al., 2001; Escribano and Schneider, 2007) and India (Krishna, 2008).

Equally well documented is a noticeable poleward shift in the range of various marine species, in response to ocean warming both at surface and at depth (Fields et al., 1993; Sagarin et al., 1999). Murawski (1993) has shown that a number of pelagic species including Atlantic mackerel and Atlantic herring tend to migrate poleward by approximately 0.5-0.8 degrees of latitude for every 1^0C increase in mean sea surface temperature. Similarly, Perry et al. (2004) have demonstrated that almost two-thirds of exploited and non-exploited North Sea fishes have shifted either poleward or to greater depth as a response to elevated sea water temperature over the last 25 to 30 years. This is further supported by the findings of Field et al (2006) who documented a significant increase in the number of tropical and sub-tropical species of planktonic foraminifera in the California Current, but a decline in abundance of temperate and sub-polar species during the 20^{th} Century. Barry et al. (1995) have also noted a northward shift in the range of eight 'southern' invertebrate fauna along the California coast between 1931 and 1994, when mean temperatures in the bay rose by 0.75°C.

These findings corroborate the conclusions of Roemmich and McGowan (1995), who had earlier noted an 80 % decrease in macrozooplankton biomass off the coast of southern California since 1951. This was linked to ocean surface warming which exceeded 1.5°C in some localities, reduced upwelling and a smaller volume of inorganic nutrients to support the zooplankton population. These changes correlate well with 20^{th} Century anthropogenic warming at depth, a phenomenon not manifested in earlier centuries. Similar findings are documented for the northeast Atlantic where a decline in phytoplankton abundance has accompanied sea surface warming, with the reverse occurring in cooler regions to the north (Richardson and Schoeman, 2004). It is projected that with the continued warming trend, the spatial distribution of primary and secondary pelagic production would be affected to the extent that it would contribute to further depletion of north Atlantic fish stocks.

The sensitivity of tuna stocks to temperature changes, especially during ENSO, and the spatial variation in catch has been studied in the Pacific, and Maldives in the Indian Ocean. In the Pacific, there is a tendency for both skipjack and yellow fin tuna to move eastward during the El Nino phase, resulting in a significantly reduced catch. This is associated with the zonal displacement of the Pacific '*warm pool*' where these species are dominant (Lehodey et al., 2003). In the case of the Maldives, skipjack catches tend to decline in El Nino years, while the yellow fin harvest increases. Contrastingly, during La Nina years, skipjack catches increase, while there is a decrease in other tuna species (MOHA, 2001). Overall, the IPCC (2007) projects that climate change is likely to lead to migration and ultimately decline of these tuna stocks.

Research indicates that climate change will also lead to other more complex biological changes and responses in marine organisms, including fish. For example, it has been shown that patterns of larval transport and population dynamics are being affected by observed changes in ocean circulation. It is also suggested that climatic impacts on a few '*leverage species*' could ultimately lead to far-reaching community level changes (Harley et al., 2008). In addition, there is evidence which suggests that the development and survival of many fish species may be impacted more by changes in ocean chemistry (linked to climate change) than by elevated sea surface temperatures *per se*. While the effects of such changes are not yet fully understood, early evidence suggests that the impacts on fisheries will be overwhelmingly negative. Moreover, these climate-induced changes are likely to be exacerbated by other well-documented anthropogenic stresses, including overfishing (Harley, et al., 2008).

What are the key climate change projections of relevance to the Caribbean fisheries sector?
Apart from the obvious implications of the global observations highlighted above, there are additional avenues via which climate change will impact the Caribbean fisheries sector, directly and indirectly. The discussion that follows is not intended to be exhaustive, it merely seeks to highlight issues of relevance to the region's fisheries sector for which sound, scientific consensus is emerging. It is also anticipated that the analysis will contribute to

the development of a clearer understanding of the range of climate-related risks to which the sector will be exposed.

Of critical significance is the fact that the pattern of observed temperature changes in the region is consistent with the global trend (IPCC, 2007; Hayes and Goreau, 2008). Regional temperatures increased in the 20th Century with the1990s being the warmest decade since 1900. Outputs from a suite of global climate models (GCMs) suggest that surface air temperatures in the Caribbean will continue to increase in the present Century by between 0.5^0-$1.^0$ C during the period 2010-2039, 0.8^0-2.5^0 C in the decades 2040-2069 and 0.94^0-4.8^0 C between 2070 and 2099. Recent climate model runs for the Eastern and Southern Caribbean show that a similar trend in sea surface temperatures can also be expected. This is shown in figures 1 and 2 which are outputs from the HADCM 3 and ECHAM GCM, downscaled to 25 km resolution using the PRECIS model[1]. These results clearly suggest that that sea-surface temperatures will not only increase during the summer (JJA), but also during the traditional 'cool' season (DJF). Of equal interest is the indication that both the diurnal and seasonal temperature ranges will also decrease. This has particularly severe implications for Caribbean corals which would, under such circumstances, be consistently exposed to even higher minimum and maximum temperatures that at present.

There is strong support from the observational records that elevated sea surface temperatures are a primary cause of coral bleaching. The most severe episodes in the past have coincided with years when the El Niño signal was strongest, for instance in 1983, 1985, 1997/98, 2005/2006. (Glynn, 1984; Hoegh-Guldberg, 1999; Goreau et al, 2000). In the 1997/98 event, more 95% of Pacific corals were bleached, and approximately 25-30% in Caribbean (Wilkinson, 2000). The most recent intense bleaching episode in the Caribbean occurred during the summer of 2005, when bleaching occurred in an area extending from Mexico in the north, to Tobago in the south. A detailed case study of the event at Barbados revealed that throughout the summer, sea surface temperatures were consistently between 1^0-2^0 C above seasonal maxima, and all nearshore and offshore habitats were affected (Oxenford et al., 2008). The situation in Barbados was not unique to the Eastern Caribbean, since many other islands also reported significant bleaching. Certainly, fishers will find no comfort in these events, particularly since they are projected to become more frequent in the future.

Another emerging issue that could be potentially worrisome for fisheries stakeholders is the observed and projected change in the level of acidity of the world's oceans, associated with increasing anthropogenic emissions of CO_2. Research has shown that the world's oceans have become approximately 30% more acidic (i.e. a reduction in pH from 8.2 to 8.1 units) since 1750 - the start of the Industrial Revolution (IPCC, 1990, 2001, 2007). Although the effects on marine organisms are not yet fully understood, ocean acidification is expected to be a limiting factor in the development of corals and other organisms, which use carbonate ions in sea water to build calcium carbonate shells and exoskeletons. With rising CO_2 emissions, more CO_2 is absorbed by the oceans, sea water becomes more acidic by stripping out carbonate ions, thus making it more difficult for organisms to form shells (Kleypas et. al, 2005; Fabry et. al, 2008). With global CO_2 emissions continuing to increase at a rapid rate, the threat to reef habitats and associated fauna, including fish assemblages, will become more pronounced. Since the reef fishery constitutes a vital component of small-scale activity, this sector of the industry is likely to be most affected.

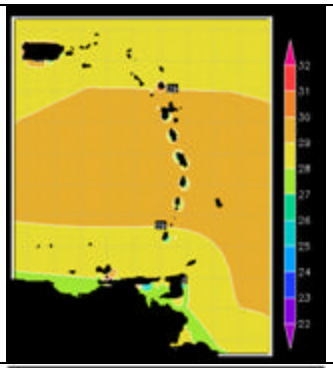
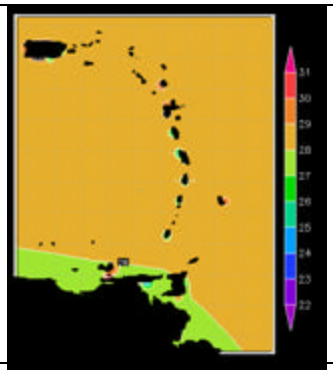
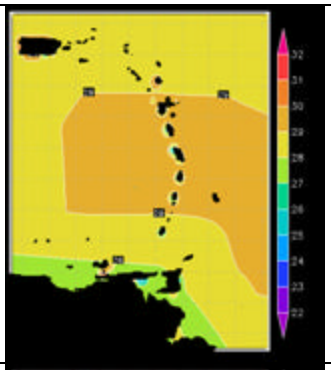
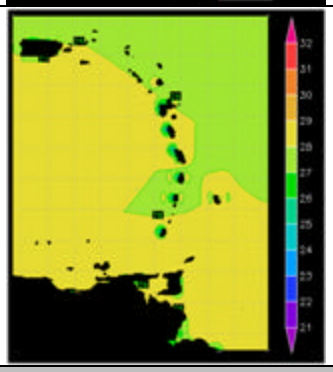
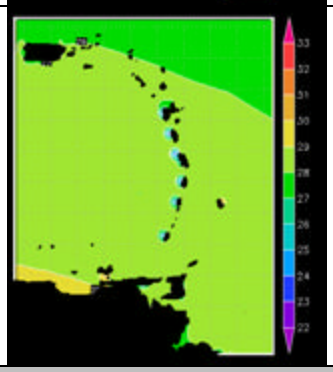
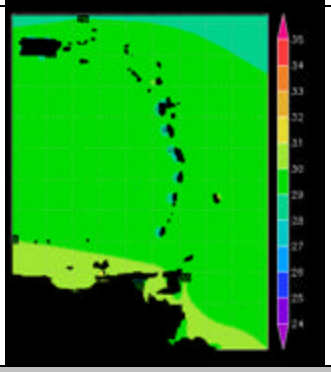
Table 1: Category 5 Atlantic Hurricanes, 2001-2007

Hurricane	Year	Maximum Winds, km/hr (mph)
Isabel	2003	266 (165)
Ivan	2004	266 (165)
Emily	2005	290 (180)
Katrina	2005	282 (175)
Rita	2005	290 (180)
Wilma	2005	298 (185)
Dean	2007	266 (165)
Felix	2007	266 (165)

Source: NOAA, 2008

[1] This work focuses on the Eastern and Southern Caribbean, and is being conducted by the Climate Modeling Studies Group at the Cave Hill campus of the University of the West Indies in Barbados. Similar modeling experiments are ongoing at the Mona campus in Jamaica, where the focus is on the Northern and Western Caribbean.

Figure 1: Modeled Decadal Sea Surface Temperatures - Eastern Caribbean

	2010s	2020s	2030s
JJA			
DJF			

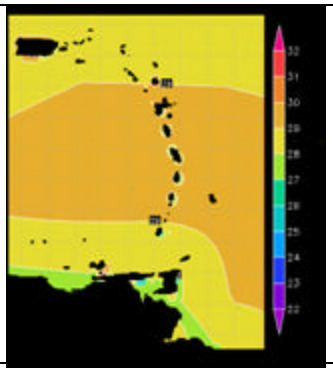
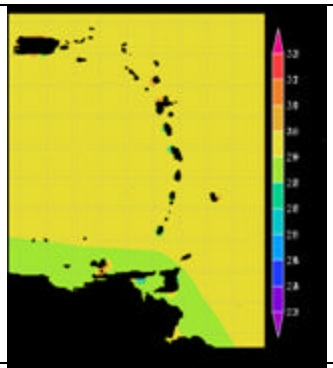
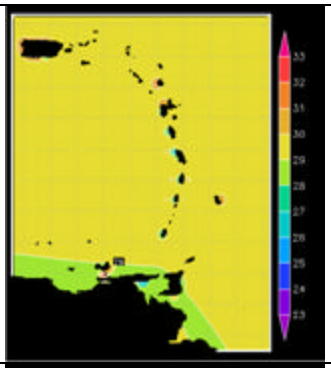
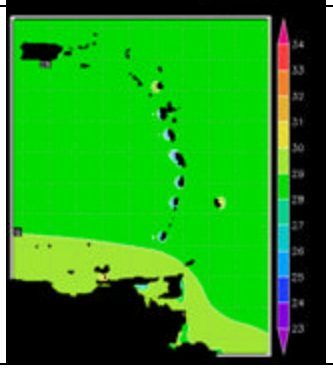
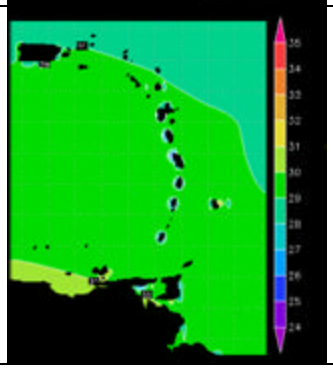
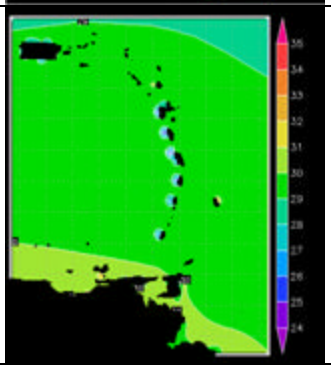
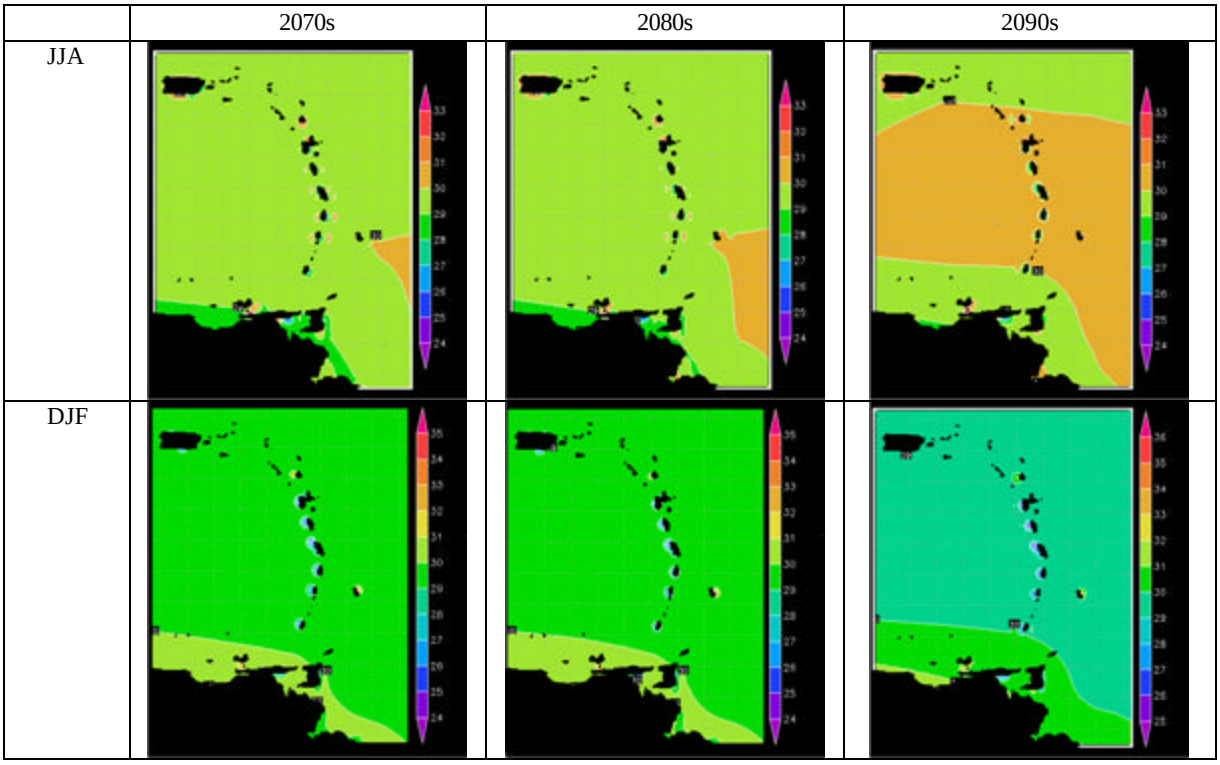
	2040s	2050s	2060s
JJA			
DJF			

Figure 2: Modeled Decadal Sea Surface Temperatures - Eastern Caribbean



While there is as yet no clear indication that tropical cyclones (hurricane) frequency will change, modeled data indicate that peak wind intensities are expected to increase by approximately 5-10% by the 2050s (Emanuel, 2006; IPCC, 2007). Moreover, of those systems that reach hurricane status, a greater number appears to be attaining a status of category 3 and above than in prior decades. For instance, in the first seven years of the present decade (2001-2010) eight category 5 hurricanes have already developed, compared with a total of twenty-three recorded between 1928 and 2000[2] (Table 1). In addition, it is already being hypothesized that these systems may be reaching high intensity over a shorter duration than previously observed. This is exemplified by hurricanes Wilma (2005) and Gustav (2008), which moved from tropical depression status to category 5 and 4 hurricanes in less than 24 hours. Should this become a trend, fishers will be faced with the prospect of having greatly reduced time frames for securing boats, gear and other equipment. Similarly, the expected increase in maximum wind speeds combined with currently projected increments of sea-level rise for the region, would amplify storm surge effects, and accelerate coastal erosion and loss. Apart from damage to equipment, critical infrastructure such as wharves, jetties and other fish landing sites would be at very high risk under this likely scenario.

Vulnerability of Caribbean Small-Scale Fisheries to Climate Change

There is universal agreement that the vulnerability of any sector to climate change is a function of (a) the degree of exposure to the threat (b) the sector's sensitivity to the risk and (c) the capacity of the sector to cope with or adapt to the threat (IPCC, 1995, 2001, 2007; FAO 2005). Any objective assessment of small-scale fisheries in the Caribbean's would conclude that exposure and sensitivity to the climate change threat are *high*, while adaptive capacity is *low* (see for example FAO, 2005; Salas et al., 2007). Among the reasons for this conclusion are:

- Observed and projected negative impacts (direct and indirect) on the sector, e.g. through habitat and ecosystem damage, e.g. bleaching of corals, additional stress on mangroves and seagrasses;

[2] Since official hurricane records have been kept, no category 5 systems have been identified prior to 1928.

- Linkage between ocean warming as a *triggering mechanism* in the proliferation of harmful algal blooms and various diseases;
- Dependence of fisher folk on sector for employment, revenue generation and human well-being;
- In the Caribbean many fisher folk tend to reside in vulnerable, low-lying coastal areas which exposes their physical assets (e.g. boats, gear, homes) to climate-related events such as hurricanes, storm surge and sea-level rise;
- While the sector has demonstrated considerable resilience to climate variability in the past, factors such as lack of consistent governmental, access to capital on reasonable terms, weak fisher folk organizations and consequently low bargaining power will compromise adaptation capacity in the future;
- Lack of insurance and other institutional support to enable the sector to rebound in the aftermath of extreme events, which are projected to become more frequent and/or intense in the future.

While the list of factors presented above is not exhaustive, it provides a reasonable indication of the issues confronting the fisheries sector in the Caribbean. Since it is widely anticipated that climate change will amplify these challenges, appropriate and timely interventions will be required in order to minimize the adverse effects on stakeholders. Some possible approaches are offered for consideration in the ensuing section of this paper.

How May the Caribbean Fisheries Sector Respond to Climate Change?

Like other sectors, the fis hing industry in the Caribbean, in particular its small-scale sector, is already experiencing some of the negative impacts of anthropogenic climate change. Since elimination of the source of the problem is practically unachievable, adaptation is the only option. Given the range of impacts and challenges posed by global climate change, any meaningful response will inevitably require a suite of practical measures aimed, *inter alia*, at building resilience in the sector, exploiting available opportunities and minimizing the economic and social dislocation of fishers. At the very minimum, the design of an adaptation package should reflect the status of the science, it should be flexible in order to benefit from new research findings, it should exploit the rich knowledge base of key actors i.e. the fishers, while at the same time being cost-effective, and socially and culturally acceptable to stakeholders.

It should be emphasized from the outset that adaptation must be regarded as a *process* not a project. It s hould also be stressed that the process does not necessarily imply the abandonment of existing management practices and the implementation of new, high-cost strategies. While some new initiatives may be required, stakeholders may wish to begin the process by simply strengthening existing management structures and *mainstreaming* 'adaptation thinking' into these arrangements. Fortunately for the Caribbean, there is already a basic platform (e.g. legislation, advisory committees, a regional coordinating mechanism) in place which can be adjusted, as required, to accommodate sound adaptation practice.

First, there should be an ongoing commitment to implement those actions that will improve the resilience and therefore the sustainability of the sector (See f or instance Charles, 2003; IPCC, 2007). In this regard the strategy should be guided by pragmatism, so that the emphasis should be on activities over which countries have some control and which, if implemented, will have a positive impact. Thus, while the region can do little to reverse the trend of global greenhouse gas emissions and higher sea water temperatures, actions can be taken to improve the resilience of habitats and targeted species to the adverse effects of climate change. Such actions would include (i) strict enforcement of existing marine pollution control protocols and abatement of contamination from land-based sources (ii) reactivation and expansion of habitat protection and restoration programmes and (iii) control of non-sustainable practices such as overharvesting, and the use of inappropriate harvesting methods.

The benefits of applying good governance and *co-management* principles in the small-scale fisheries sector have been widely discussed in the literature (Pomeroy and Berkes, 1997; McConney et al., 2003). Governance and co-management systems that are based, *inter alia*, on an understanding of ecosystem health and thresholds, partnership, stakeholder inclusiveness, equity and sustainable livelihoods should also be regarded as vital ele ments of climate change adaptation planning.

As part of the adjustment to changing conditions, stakeholders may also wish to consider whether opportunities exist for targeting presently unexploited species, in a sustainable manner. Evidently, acceptance of 'new' or 'non-traditional' species will be affected by factors such as consumer perception, culture and taste, but such impediments may be overcome with the implementation of aggressive, innovative marketing programmes, education and outreach. The harvesting of non-exploited species, if found to be feasible, would not only

diversify the options available to fishers for maintaining their livelihood, but might simultaneously alleviate the pressure on heavily exploited stocks. This would also make a positive contribution to the building of resilience into the sector. Agencies such as the Caribbean Regional Fisheries Mechanism (CRFM) and the OECS Fisheries Unit, whose missions already embody notions of adaptation, diversification and resilience building (though not explicitly defined in these terms), can play lead roles in such initiatives, in collaboration with other key stakeholders.

Since it is likely that climate change will impact negatively on the future availability of stocks, an overriding direct concern for fishers is the extent to which alternative forms of employment (seasonal or otherwise) can be pursued as an adaptation option. The pursuit of alternatives would help to compensate for expected reductions in revenues and livelihood support caused by climate change. However, it would require the intervention and assistance of Government and the Private sector, working in close collaboration with the fishing community and affiliates. In this regard, organizations such as fisheries cooperatives could play a significant role in assisting with the creation and sourcing of opportunities, as well as the 'retooling' of fishers with new skills.

Notwithstanding the above, the reality is that although local adaptation strategies will help to 'cushion' some present and future effects of climate change, global anthropogenic greenhouse gas emissions must be abated and stabilized urgently. There is a positive correlation between greenhouse gas forcing of the atmosphere and the severity of the impacts. The efficacy of adaptation also diminishes as the severity of impacts increase (IPCC, 2001, 2007; Nurse and Moore, 2007). It is therefore regrettable that stakeholders in the fisheries sector have not engaged in the global debate with the same vigour as interest groups in other sectors. Since the adverse effects of climate change are expected to be greatest on low-lying small islands (Nurse and Sem, 2001; Mimura et al., 2007), the fisheries constituency must invest in its own self-interest and join the global lobby to for steep emission reductions and swift implementation of agreed protocols.

The international community is currently negotiating successor arrangements to the Kyoto Protocol, with a view to reaching agreement at the 15th Conference of the Parties (CoP) to the United Nations Framework Convention on Climate Change, scheduled for Copenhagen in 2009. Fisheries stakeholders should immediately seize the opportunity to have an effective voice at the remaining preparatory meetings and at the final decision-making forum. At the same time, the Caribbean fisheries sector must seek to equip itself to access the various climate change adaptation facilities that currently exists. The climate change Adaptation fund, established under the Kyoto Protocol, should be a prime target. The Fund was created specifically to assist vulnerable countries and communities adapt to the adverse effects of climate change, provided that certain conditions of eligibility are met.

Ongoing, focused research should also constitute a vital component of the adaptation package. While it is possible to learn and apply the lessons from observations and research conducted elsewhere, more effective adaptation programmes can be designed if there is robust, region-specific information available. In this context, key research questions such as the sample listed below, readily come to mind:

- How will changing temperature, wind, salinity and circulation regimes affect the spatial and temporal abundance and migration patterns of commercially important species?
- What is the level of understanding of the population dynamics and seasonal availability of non-exploited species? What is the *harvesting threshold* beyond which these stocks might crash?
- Will there be a market for 'new' or non-traditional species? And what would be required to ensure the sustainability of that market?
- How do predators and prey respond under different climate change scenarios? (i.e. what is their sensitivity to *various increments* of warming, acidification, sea-level rise, etc)? What is their 'natural' adaptive capacity?
- Will climate change alter the values of parameters commonly applied in fisheries management models to estimate optimal production, yield, and levels of stock?
- Will there be a need to modify existing fisheries regulations and practices (e.g. extend/reduce closed seasons; issuance of permits for various fisheries), and introduce new technologies?

Full or even partial answers to these and other questions would provide valuable guidance on key issues including the optimization of catch effort, the relative vulnerability of various fisheries, the structuring of bilateral and other fishing agreements with neighbouring states, and types of behavioural changes that stakeholders may be required to effect in the interest of minimizing livelihood dislocation as a result of climate change. Such information could also be used effectively for purposes of stakeholder training and awareness.

Conclusion

The observations presented above should provide a compelling reason for stakeholders in the Caribbean to accelerate the process of '*mainstreaming*' climate change considerations into ongoing fisheries management programmes. While climate change may be regarded simply as an '*additional stressor*', the difference is that it is one which the most vulnerable countries and communities have not invited upon themselves, and which they are poorly equipped to solve. Global and regional climate change assessments indicate that some of the Caribbean's most important economic and social sectors, including fisheries, are already being adversely impacted by climate change. Based on the current trend of increasing global greenhouse gas emissions and robust climate model projections, practically all sectors are likely to be severely affected in the future.

The solution to the climate change challenge is a global one, and the basis of that solution will emanate largely from outside the fisheries constituency[3]. Yet, industry stakeholders in the Caribbean need to become more actively engaged in the global and regional debate, which hopefully will provide the consensus for a solution that is lasting and equitable. Only then are the legitimate concerns of the fisheries constituency likely to be fully ventilated, and access to available adaptation funding and other resources maximized. Such action must be regarded as a priority, if the Caribbean fisheries sector is to properly equip itself to adapt to the adverse consequences of a changing climate, with which it will be confronted for the foreseeable future.

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6.3 Appendix 3: GCFI research presentation

An Assessment of Potential Impacts of Climate Change and Climate Variability on Small-scale Fisheries in the Eastern Caribbean

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Abstract

Small-scale fisheries can play an important role with respect to key development issues such as poverty alleviation, food security and pro-poor growth especially in small island developing states (SIDS). The ecosystems in which fisheries operate are very vulnerable to several factors including climate change and climate variability. This paper focuses on potential impacts of climate change and climate variability on small scale fisheries in the Eastern Caribbean (EC). In response to a demand for more information on the likely impacts of climate change on small-scale fisheries particularly the livelihoods of Fishers the perceptions of fishers were assessed in three selected Eastern Caribbean island countries: Antigua and Barbuda, Barbados, and St. Kitts and Nevis. Rising sea surface temperatures, variable currents and rising fuel cost were among the main factors that affected the fisheries. The perceptions of fishers based on observations at sea were compared to available scientific information on climate change and climate variability. Fishers throughout the Eastern Caribbean have various perceptions of climate change and climate variability. They have also identified climate and other factors that impact fisheries . Based on the findings, suggestions were made of coping strategies that facilitate adaptation of small scale fisheries to climate change and climate variability. Possible areas for further research were also suggested. It is anticipated that these can assist in shaping future climate change adaptation strategies and project ideas for fisheries in the Caribbean.

Keywords: Small-scale fisheries, impacts of climate change, perceptions of fishers.

Introduction

There is a paucity of shared scientific information on the likely impacts of climate change on fisheries in the Eastern Caribbean. Within the region, fishers generally hear of climate change impacting the natural environment but little about how it may impact the livelihoods associated with small-scale fisheries. These include the actual fishing activity, fish processing, trade and fisheries technical support services. Although some climate change research by universities, intergovernmental organizations and non-governmental organizations is in progress, there has not been much aimed specifically at small-scale fisheries (SSF) in the Caribbean. For example, the Cuban Institute of Meteorology (INSMET) in collaboration with the University of the West Indies (UWI Cave Hill and Mona campuses) is producing downscaled climate models for the Caribbean Community Climate Change Centre (CCCCC). Scientists and students at the Discovery Bay Marine Laboratory (UWI, Jamaica) and the Centre for Resource Management and Environmental Studies (CERMES) have conducted extensive marine research including climate and fisheries ecological studies, but not on livelihoods.

The fisheries sector has particular significance for small island states since fish is one of the world's most widely traded foodstuffs and a key source of export earnings for many poorer countries (APO 2008). Fishers are particularly vulnerable to the direct and indirect impacts of predicted climatic changes, including changes in physical environments and ecosystems, fluctuating fish stocks, infrastructure located in high risk (coastal) areas, reduced fishing operations and unstable livelihoods (FAO 2008, Béné 2006). The fisheries sector is a major food provider and income generator with some 42 million people working directly in the sector (the great majority in developing countries (APO 2008). When those who work in associated processing, marketing, distribution and supply industries are considered the sector supports several hundred million livelihoods (APO 2008). Local supplies of fish can be highly unpredictable given the nature of the resource.

Caribbean fishers have observed changes within their natural work environment, some of which may be due to impacts from climate change and climate variability. The central theme of this research paper is to: assess the potential impacts of climate change and/or climate variability on small-scale fisheries in the Eastern Caribbean. It adds to the information on sectoral climate change impact studies (here the Fisheries Sector). This information will be important for increasing awareness among the stakeholders, especially those involved in the primary (harvesting) stage of the industry.

The paper focuses on the perceptions of fishers in the Eastern Caribbean in relation to how they see climate change/ climate variability affecting their fishing activities and consequently their livelihoods. Efforts were made to relate perceptions of fishers (based mainly on observations at sea) and available (published) scientific information on climate change and climate variability.

While this paper provides a general overview, it serves as a basis for identifying possible future climate change adaptation strategies and project ideas for fisheries in the Caribbean, in light of the international requirements under the United Nations Framework Convention on Climate Change (UNFCCC). It is also an opportunity to integrate SSF into the work on climate change being done at the University of the West Indies (UWI), Caribbean Community Climate Change Centre (CCCCC), Caribbean Natural Resources Institute (CANARI) and other regional organizations, both in terms of doing research on impacts, but ultimately also in civil society mobilization for adaptation. It is also proposed that appropriate information will be made available for dissemination throughout the region on the linkages between fisheries and climate change**.**

Methods

The study sites were Antigua and Barbuda, Barbados, and St. Kitts and Nevis. Findings and general trends may be cautiously considered relevant throughout the entire Eastern Caribbean based on similarities in fishing methods and the scale of operations, noting however that even within the Eastern Caribbean, there may be distinct differences between the fisheries of the islands in the north and those in the south. In recognition of the need for more information on the likely impacts of climate change on small-scale fisheries, particularly the livelihoods of fishers, several research methods were utilised to achieve the stated focus. However, the main methods were a literature search and informal interviews with fishers. Where available, fish landing data for the selected countries were analysed to identify possible trends. The interviews included fishers whose livelihoods are hinged directly on harvesting of fish. Interviews were done individually or in groups of three to six fishers. The setting was generally a well relaxed atmosphere to encourage fishers to share freely and openly. Where possible, historical fisheries data were related to recognised climate change events.

Primary data were collected mainly through interviews with fishers in the selected countries at landing sites or in homes. A total of 111 fishers were interviewed: Antigua – (26), Barbados – (25), Barbuda – (24), Nevis – (17), St. Kitts – (19). The on-site time limitation for primary data collection biased selection to a convenience sample of most available fishers. The fishers who were interviewed may not be representative, and in a group interview true perceptions may not always be revealed. In some cases, where inexperienced fishers have given abnormal responses when compared with others in the group the interview data were edited to remove errors. Secondary data were retrieved mainly from the FAO on-line database, in order to ensure consistency of data based on the assumption that the commonality in data collection results in similar quality data from different countries.

Fishers were interviewed to get their perceptions of how climate change may impact their livelihoods especially fishing activities. Although there were organised groups at fish landing sites, fishers involvement in interviews were at random. It was evident that fishers with more (>10 years) fishing experience could better compare present conditions with those of the past. Additionally, increased success of the process of selecting respondents and interviewing them was due mainly to the guidance of Fisheries Officers from each island.

The field survey, designed to get fishers' perceptions of climate change and the impact(s) of change on fisheries, targeted the main landing sites in each country. Interviews were either with individuals or groups. In addition, information was also gathered from a few selected Fisheries Officers who have considerable fishing (sea) experience and knowledge of fishing activities and can even be considered as part-time fishers. Conclusions were based mainly on the modal responses from the interviews. However, outlier responses were not ignored. Prior to interviews, a literature search was used to obtain data from relevant studies on climate change and fisheries. Base reference (historic) data on fisheries and climate events within the Caribbean were also important sources of information. The information from the literature search was useful in the assessment of changes over a specific time period, whether for climatic conditions or fisheries-related human activity.

Most of the secondary data were collected from published sources, and from the Fisheries Divisions within the specific countries. The FAO database provided the most comprehensive set of data on fish landings. Tabular or graphical data for individual species or specific time periods were also derived from various websites and workshop or conference reports. However, there were various gaps within the data for fisheries of the Eastern Caribbean.

Since the study was limited to the perceptions of fishers especially in relation to fishing activities, potential impacts of climate change and climate variability on many other aspects of the fisheries sector may have been neglected. Even among the fishermen, different fishing methods (diving, trapping, trolling, etc.) may be under-represented as the research emphasis was on pelagic fisheries. The impacts of changes in climate parameters may be different for pelagic and demersal fish species. The study also tended to seek general rather than specific observations given the timeframe and scope of the research. Since not all perceptions fit closely to what are considered established scientific facts, further studies will be necessary to confirm or test the various conclusions derived from this study.

Other limitations include the technical level of acceptability of conclusions of this study. It is recognised that models used in the prediction of climate trends have associated uncertainties. In addition, the lack of adequate time series fisheries data is a major factor. Trends are more easily recognised over long periods but most records for the Eastern Caribbean (fisheries and climate change) fall within the last 50 years. The recent 50 year period of climate records may be less reliable compared to century or longer time-scale records available elsewhere (Sharp 2003).

Results

Some characteristics of the small-scale fisheries in the selected countries are outlined in Table 1. Small-scale fisheries are scattered around the seashores of the islands, especially within sheltered bays near settlements or areas of economic activity. Their development may be hampered by inadequate infrastructure. They are generally exposed to natural calamities like floods, inundation, sea erosion and storms. However, small-scale fisheries in the Caribbean are generally open access with fishers having high geographic mobility. They may migrate over considerable distances and operate from different landing sites.

Table 1 General Characteristics of Selected Eastern Caribbean Countries

Country	Location	Characteristics
Antigua and Barbuda	North	Well developed demersal fishery (mainly reef fish, lobster and conch); Pelagic fisheries undeveloped.
Barbados	South	Well developed pelagic fisheries (longliners and ice-boats); Demersal fishery is minor in importance.
St. Kitts and Nevis	North	Expanding pelagic fishery (both coastal and offshore). Important demersal fisheries exist (mainly finfish and lobster with some conchs as well).

Table 2 presents a summary of the main results of the study based on the perceptions of fishers. It is generally perceived that climate is changing and climate change has affected the fisheries sector. While the Fisheries Authorities of CARICOM countries collect catch and effort and biological data it bears no relationship to climatic or weather information collected by Meteorological Departments. It is therefore difficult to compare scientific data with the perceptions of fishers.

Table 2 Perceptions of Fishers

Characteristic Feature related to Fisheries or Climate Change	Perceptions of Fishers
Understanding of Climate Change	Generally, it is perceived that there is global warming causing melting of polar ice sheets. Stronger and more frequent storms, effects of sea swells and impacts on the amount of fish being caught are also linked to climate change.
Fishing Distance/Depth/Time	Varies from country to country, depending on type of fishing, size and type of fishing vessel used and the general bathymetric conditions around the islands.
Fishing Activities	The type and extent of fishing activities vary from island to island. Trap fishing and different types and techniques of net and line fishing are common. Depending on the area, focus is on catching fin fish, lobster or conch.
Characteristic of Sea (Surface) Temperature	Few fishermen quoted specific sea surface temperatures but the majority believe that there is a general increase in SST. Increasing temperatures are perceived as causing a general decrease in fish catch.
Effects of Rain/Rainy Season	Some fishermen believe that there is a tendency to catch more fish during the rainy season. This is mainly attributed to more nutrients reaching the sea as well as mixing of fresh water.
Effects of tropical storms/hurricanes	Tropical storms are recognised as being destructive to fishing vessels, fishing gear and the physical environment in which fish survive. However, most fishermen take necessary precautions to weather the effects of storms.

Characteristic Feature related to Fisheries or Climate Change	Perceptions of Fishers
Observance of Currents/ Upwelling currents and winter swells	There is a general perception that currents are getting stronger. Winter swells or ground swells are perceived to be more unpredictable and therefore may occur any time of the year.
Moon Phases and Fishing	Some fishermen, using hook and lines/trolling, believe in fishing according to moon phases. Other fishing methods in most cases occur independently of moon phases
Observed Water Colour	Fishermen perceive that sea water colour varies throughout the region from clear or light blue to green or even brown. They believe that more fish is caught in the clear or blue water. Some relate the water colour to nutrients, volcanic activity or even dust from the Sahara.
Migratory Sea Birds	While different species of migratory seabirds are observed, there is no real recognition of changes in populations and migration patterns.
General Marine life around Island	Many fishermen are unable to comment on general marine life. Divers, however recognise a general decline in the condition of coral reefs and sea grass in particular.
Sea Level Rise	Surprisingly, sea level rise is not considered a major issue. Most fishermen perceive that it will not have much effect on fishing activities.
Economics of Fishing	The cost of fuel, ice and bait seems to be the main elements for a fishing trip. This cost varies from island to island based on the type of fishing, distance of operation and the local price of fuel and engine oil. The price of fish also varies from country to country.
Fish Landings	In the south-Eastern Caribbean, the landings tend to be species specific and generally include more pelagic species while there is more 'mixed fish' in the northern Eastern Caribbean with a higher percentage of demersals. In general, it is perceived by fishermen that there is a recognisable decline in fish landings.

Available information for large pelagic fish species in CARICOM countries, mainly from the south-eastern Caribbean where there are well established fisheries for pelagics show that the availability of large pelagic fishes, both coastal and oceanic, is highly seasonal (Mahon 2002). Additional information, for example, reports on catch and effort produced by the Fisheries Division also substantiated this point.

The following is a list summarising the impacts of climate change on fisheries and oceans, generally at the global level and specifically for small-scale fisheries of the Eastern Caribbean:

- Impacts fisheries including (freshwater, saltwater) aquaculture
- Changes in fish abundance, fishery areas and species mix
- Subsistence/small scale fishers are more vulnerable in some cases due to restricted mobility and fewer options being available
- Loss of income to fishers
- Destruction of /damage to critical fisheries habitats (mangroves, seagrass beds, coral reefs) Destruction of/damage to fisheries infrastructure such as landing sites and fishing complexes
- Climate change impacts may contribute to overfishing, natural variation, pollution, UV-B and loss of wetlands and nurseries
- Inherent uncertainties in fisheries worldwide are expected to be exacerbated by a changing climate
- Reduction in/disruption of the production of fish, and therefore, food supply; Globally, economic and food supply impacts should vary but may increase the population at risk to hunger and other symptoms of poverty
- Increased coral bleaching as a result of a 2°C increase in average global atmospheric temperature by 2050
- Sea-level change will occur with regional variations, impacts including loss of coastal wetlands
- Changes in coastal pollutants will occur with changes in precipitation and runoff eventually affecting fisheries.
- Changes in circulation and vertical mixing influence nutrient availability, primary productivity, fish yields
- Reduced yields of desirable fish species will occur if primary productivity decreases
- Damage to/loss of fishing vessels and gear
- In extreme conditions, the loss of a livelihood, and
- General economic losses to the country

Sources: (APO, 2008; Creary 2003; Crocker, 2008; Delaney *et al*. 2000; Everett, 2007; IPCC, 2007a; IPCC, 2007b; Mahon 1990; Mahon 2002; Yohe, et al., 2007)

Generally, fishers have heard that global warming is occurring and has caused increased melting of polar ice sheets. Stronger and more frequent storms, effects of ground swells and impacts on the amount of fish being caught are also expected linkages to climate change.

According to the IPCC Fourth Assessment Report, the observed average temperatures for all small-island regions are showing consistent warming trends over the 1901 to 2004 period (IPCC 2007b). For the Caribbean region, analyses show warming ranging from 0 to 0.5°C per decade for the 1971 to 2004 period. It is projected that atmosphere and ocean temperatures will continue to rise through to the next century. Incidences of temperature extremes in the Caribbean have increased since the 1950s (Peterson et al. 2002). Temperature and other variations resulting from climate change will have a strong impact on fisheries. Since most marine species used for human consumption are poikilothermic, any changes in habitat temperatures can significantly influence their metabolism, growth rate, productivity, seasonal reproduction, and susceptibility to diseases and toxins (APO 2008). Research has shown that while fish may take refuge from rough conditions through minor changes in distribution, most fish species have a fairly narrow range of optimum temperatures related both to the species basic metabolism and the availability of food organisms that have their own optimum temperature ranges (NOAA a n.d.). Researchers believe this decline in zooplankton may be the result of increased warming of the surface layer that reduces the nutrient enrichment of this layer by reducing upwelling from below the thermocline (NOAA a n.d.). While species, particularly those with shorter life spans, will change the timing of their life cycle, some plankton species will bloom earlier, resulting in mismatches between the early life stages of fish and their prey, and therefore cause declines in abundance (FAO n.d.). Studies have also shown that there is a similar decline in the abundance of seabirds which rely upon the fish as prey and this overall decline of fish species correlated to the decline in zooplankton abundance, as shown in Figure 1. Reduced Abundance of Zooplankton and Temperate Fish during Two Decades of Figure 1 (NOAA a n.d.). The different fish species will vary in their abundance based on their optimum temperature ranges.

Increased temperatures will not only affect the productivity of some marine areas but will also have a negative impact on associated marine ecosystems such as coral reefs (Murray 2005, Van der Meerin1998). It is widely recognised that extensive coral bleaching occurred in the Eastern Caribbean over the last 25 years (Donner et al. 2007, Everett 2007). However, there are significant local and regional variations in the scale and type of threats to coral reefs especially in small-island situations. It is difficult to measure direct impacts of climate change as against other elements such as misuse or overuse of coral reefs or other habitats. Ocean acidification on the marine biosphere can add stress to coral reefs as progressive acidification of oceans is expected to have negative impacts on marine shell-forming organisms and their dependent species (IPCC 2007b). Air temperatures are projected to continue to rise further as depicted in Table 3.

Table 3 Projected increase in air temperature (°C) and change in precipitation (%) in the Caribbean, relative to the 1961–1990 period.

Period	2010 - 2039	2040 - 2069	2070 - 2099
Temperature Increase(°C)	0.48 - 1.06	0.79 - 2.45	0.94 - 4.1
Precipitation Change (%)	-14.2 to +13.7	-36.3 to +34.2	-49.3 to +28.9

Source: (Mimura et al. 2007)

Most fishing vessels in the Eastern Caribbean are not equipped to measure sea surface temperatures. However, while a few fishermen quoted specific sea surface temperatures the majority believe that there is a general increase in SST contributing to a general decrease in fish catch. According to Figure 1, the catch may be dominated by species that can tolerate much higher temperature ranges. Fishermen have also reported seeing new or unaccustomed species in their catch. This could also be a result of changes in temperature ranges thus varying the (thermal) tolerance levels of the different fish species.

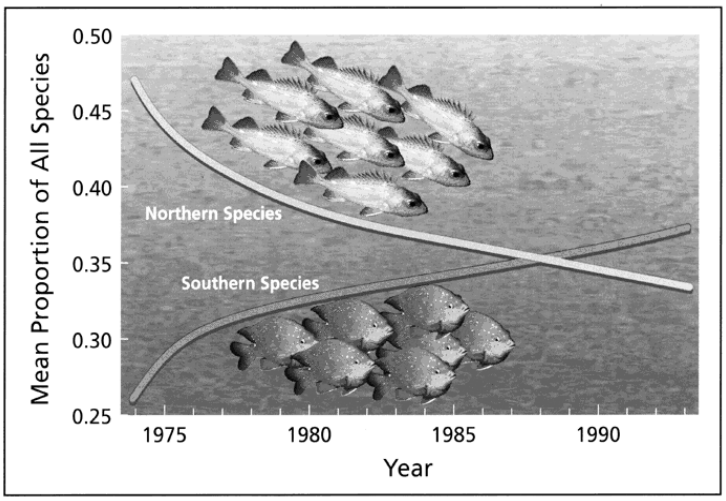

Figure 1. Reduced Abundance of Zooplankton and Temperate Fish during Two Decades of Warming
Source: Adapted from http://www.pfel.noaa.gov/research/climatemarine/cmffish/cmffishery5.html

Precipitation patterns are also changing in the Caribbean. The maximum number of consecutive dry days is decreasing and the number of heavy rainfall events is increasing (Mimura, et al. 2007, Peterson, et al. 2002). As illustrated in Table 3, it is anticipated that precipitation will become more variable (extreme dryness to extreme wetness). Interannual variability in rainfall in the Caribbean is influenced strongly by anomalies in sea surface temperatures of the tropical North Atlantic and it is suggested that the spatial pattern of rainfall is influenced by the El Nino/La Nina phenomenon (Taylor, Enfield and Chen 2002, Chen and Taylor 2002). Fishermen tend to believe that more fish is caught during rainy periods. There is an association between rains, the transport of sediments in rivers and the supply of nutrients as a source of food for fish. This applies mainly to 'surface' fishing. The influence of the Orinoco plume across the entire Eastern Caribbean is affected mainly by winds and currents and increased precipitation, in addition to intensification of the typical seasonal pattern of winds could lead to the Orinoco River discharge reaching east of the Eastern Caribbean during periods when the westerly winds are relaxed (Mahon 2002). A fish kill that affected several countries in the south-eastern Caribbean was also linked to increased water temperatures and the transport of a pathogen thought to be in the Orinoco discharge (Mahon 2002).

The movement and amount of particles within the sea or ocean depends on the supply of sediments and the operation of currents within the water column. Fishermen noted that generally currents are getting stronger and surges which usually occur between November and May are now more unpredictable. The presence or absence of sediments could influence water colour and could either have a positive effect on productivity depending on the type of species.

Storm activity is also on the rise in the Caribbean. According to the IPCC First Assessment Report, except for two El Nino years (1997 and 2002)[4], hurricane activity was greater from the 1930s to the 1960s, in comparison with the 1970s and 1980s and the first half of the 1990s. After 1995, all but two Atlantic hurricane seasons have been above normal relative to the 1981-2000 baselines. There was a generally below-normal hurricane season observed during the previous 25-year period, 1975 to 1994. The EC falls within the Main Development Region (MDR) for hurricanes where during 1949-2002 Tropical Systems accounted for 71% of the 53-year total activity measured, 55% of all hurricanes and 79% of all major hurricanes (Knutson 2006, Saunders and Rockett 2001). During that period there was a nine-fold drop in activity in MDR between above- and below-normal seasons. Most fishermen noted an increase in the frequency of storm or hurricane activity. Potential impact could be damage to fishing vessels and gear as well as the physical environment. Upon notification of an approaching storm, fishermen would normally take necessary precautions by storing their vessels in a safe place on land. In most instances, fish traps, especially those set at a distance, would be left in the water. Based on the dominant type of fishing activity and the distance of operation, a country such as Antigua and Barbuda would suffer more loss to damage of fish traps from a hurricane than say St. Lucia or Barbados.

[4] El Niño acts to reduce storm activity and La Niña acts to increase activity in the North Atlantic.

It is anticipated that increased hurricane activity could cause widespread physical damage to habits such as coral reefs and mangroves areas. In addition, there could be considerable losses in incomes due to fewer fishing days due to unfavorable weather conditions (Mahon 2002). Several fishermen have also recorded increased lobster catches following storm activity. Without knowing the full implications, this can be regarded as a positive effect of increased storm activity.

According to the IPCC Third Assessment Report, the projected globally averaged sea-level rise at the end of the 21st century (2090 to 2099), relative to 1980 to 1999 for the six SRES scenarios, ranges from 0.19 to 0.58 m (Mimura, et al. 2007). Slight changes in sea level rise may not affect fishing activities but can have severe impacts on the natural environment associated with fishing. However, the Caribbean region experienced, on average, a mean relative sea-level rise (SLR) of 1 mm/yr during the 20th century (Mimura, et al. 2007). It was also recognised that there were considerable regional variations in sea level observed in the records due to large-scale oceanographic phenomena such as El Niño coupled with volcanic and tectonic crustal motions of the Caribbean Basin rim, which affect the land levels on which tide gauges are located. Locally, difference in the response to tectonic movements have caused recent variations in sea level, such as on the west coast of Trinidad where there are indications that sea level in the north is rising at a rate of about 1 mm/yr, while in the south the rate is about 4 mm/yr (Mimura, et al. 2007).

Discussion and Conclusions

The main questions used to guide the research are shown in Table 4. A summary of the related findings is also given. The analysis of the perceptions of fishermen did not fully identify potential coping strategies and mitigation measures against impacts of climate change and climate variation on small-scale fisheries in the Eastern Caribbean. However, the findings support the following measures:

1. The development of appropriate alternatives to present fishing gear and methods: There is a need to develop more innovative and cost effective technologies for fishing. This could involve not only changing fishing gear and methods as well as fishing for new species and the expansion of fishing activities in time and space.
2. Utilisation of the fisheries resources using an integrated management approach: Fishing as a livelihood should be seen in a broader environmental and socio-economic context. The fisheries resources should be managed based on the best available scientific information. This information should be shared among all resource users.
3. Fishing activity should be treated as a business: Fishermen need to plan adequately and prepare for climate change and even climate variation. This calls for mainstreaming of climate change into the entire fisheries sector.

Table 4 Research Questions and Summary of Related Findings

Research Questions	Summary of Related Findings
What do fishers consider to be the main features of climate change and variability?	Major elements stressed include global warming as experienced by rising air and sea temperatures, more variable rainfall patterns and totals and increased frequency and severity of tropical storms.
What do fishers perceive as the likely impacts of climate change and/or climate variability on small-scale fisheries at selected sites in the Eastern Caribbean?	The main perceptions are that there is a general decline in fish catch while the cost of fishing continues to rise as a result of increasing fuel prices. Natural fisheries habitats such as coral reefs and mangroves are also adversely affected.
Does scientific evidence support or refute the climate change and variability impacts on small-scale fisheries perceived by fishers?	Some of the perceptions are corroborated by facts. However, it may be still unsure what proportion of impacts may be attributed directly to climate change.
How can fishers cope with changes resulting from likely climate change impacts?	There are wide variations in responses. Shifting to other areas of economic activity, improved technology and fishing methods, more integrated management of fishing operations and abandoning fishing are some of the proposed solutions.
What future research is needed on issues related to the impacts of climate change and variability on small-scale fisheries in the Eastern Caribbean?	Several areas were suggested including: seasonal and local variations of currents around the Caribbean, the influence of local habitat on different fish species, migratory patterns of fish and bird species throughout the Caribbean region, possible impacts of climate change on marine invasive species and the occurrence of ciguatera in the north-eastern Caribbean, the relationship , if any, existing between sea level rise and fishing activity and possible linkages between changes in sea water colour and climate change.

Most fisheries-related climate change studies for the region tend to be more qualitative in nature rather than quantitative. The lack of specific information and data for this study have demonstrated a need for more detailed research on issues related to small-scale fisheries and climate change. These could include but not limited to the following:

- Seasonal and local variations of currents: current movement within local areas around the Caribbean and the influence of currents on fishing activities of individual Caribbean countries could be very useful
- Influence of local habitat on different fish species and how different fish species adapt to different temperature and depth regimes throughout the Caribbean region.
- Migratory patterns of fish species: Climate change impact on fish migration throughout the Caribbean region needs to be investigated.
- Migratory patterns of different bird species: Investigations into the impacts of climate change on bird migration throughout the Caribbean region and possible relationships with fishing activity could be a useful area of research.
- Climate change and marine invasive species: The appearance of new species of fish and their possible connection to climate change and/or climate variability may be useful for further studies.
- Possible influences of climate change on ciguatera occurrence particularly in the north-eastern Caribbean
- Does sea level rise matters when it comes to fishing?
- Changes in sea water colour and linkage to climate change: What are the possible relationships between water colour and fish productivity throughout the Caribbean?
- Communicating climate change to fishers and
- Mainstreaming climate change into both national and regional policies and plans.

The themes and research emphases are presented in Table 5. While fishing activities occur within a natural physical environment, general research should be placed in the context of socio-ecological systems. This is necessary, considering the many complex relationships that exist between the different systems. Figure 2 indicates some proposed criteria and approaches that could be followed.

Table 5 Potential topics for future research

Theme	Research Emphases
Climate change indicators	What are fisher-relevant indicators of climate change?
Currents	Variations in fisher-observed seasonal and local currents
Habitats	Influence of local habitat changes on 'indicator' fisheries
Fish migration	What determines change in migratory patterns of fishes?
Sea Birds	Behaviour, etc. pattern changes of 'indicator' sea birds
Ciguatera	Climate change impacts on occurrence of ciguatera
Marine invasive species	Climate change impacts on marine invasive species
Sea water colour	Changes in sea water colour linkage to climate change
Communicating climate change	How to communicate climate change issues to fishers?
Mainstreaming climate change	How to include fisher climate issues in policies plans?
Socio-economic change	What market, technology, livelihood changes to prepare for?
Sea level rise	Does sea level rise matter when it comes to fisheries?

Figure 2 Proposed Research Criteria and Approaches

Based on scientific evidence, we are certain that climate will continue to change and fisheries distributions and abundances within the Caribbean will continue to be impacted even though we are unsure of the extent of the influences due to our lack of adequate quantitative evidence. There are many interconnected environmental, social and economic factors that affect the fishing industry making it very difficult to pinpoint direct linkages between climate change and fisheries. The problem is exaggerated further when the dynamic nature of climate and elements such as the migratory nature of some fish species are considered. Although the study focuses on the Eastern Caribbean, fisheries and climate change should always be studied in a broader global context. Future research should focus on key ecosystem and other linkages we need to understand in order to wisely manage our fisheries. Several fisheries–related areas and possible relationships with long term changes and natural climate variability have been identified for further study. Results and implications of research must reach primary stakeholders. Fishers must know.

Acknowledgements
Thanks to Dr. Patrick McConney and Dr. Leonard Nurse for their expert advice, guidance and support throughout my research. Funds for this study were provided by a grant from IUCN. Thanks for your assistance, especially in supporting my attendance at GCFI. This paper is dedicated to Carmen and Terrencia, my wife and daughter and presented in honour of my mother who recently transitioned into another realm.

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6.4 Appendix 4: CANARI draft research agenda

Climate Change and Biodiversity in the Insular Caribbean Research Agenda for Marine, Coastal and Terrestrial Biodiversity

(Working Groups 2 and 3)

DRAFT

Introduction

This research agenda was developed by a group of Caribbean experts as part of the *Climate Change and Biodiversity in the Insular Caribbean* (CCBIC) project implemented by CANARI under funding from the John D. and Catherine T. MacArthur Foundation. The CCBIC project was designed to summarise the status of existing research on the impacts of climate change on biodiversity[5] and identify research priorities and capacity needs for the conservation of the Caribbean's terrestrial, coastal and marine biodiversity in the context of increasing impacts from climate change. The research agenda is based on discussions held at a workshop in Port-Of-Spain, Trinidad, on the 24th and 25th September 2008, during which detailed working group reports were presented and discussed.

It is important to note that the proposed research agenda coincides with the following priority actions already listed in the Convention on Biological Diversity (CBD);

1. Create viable networks of protected areas (PAs) that are resilient to climate change.
2. Identify species, e.g. coral, that are resilient to climate change in order to use those species for restoration projects.
3. Implement adaptation and mitigation measures in land-use and coastal zone planning and strategies to strengthen local level resilience to climate change.

This overlap reinforces both the urgency and opportunity for Caribbean islands to meet their obligations under the CBD while simultaneously pursuing national climate change adaptation strategies.

Research Agenda

The research agenda is divided into six thematic areas listed below. Within these thematic areas priority will be given to research that is multi-disciplinary and that builds capacity of project actors and communities if they are involved. When possible, research should also include an assessment of the application of research findings and help develop good practices based on lessons learned.

1 Linkages between ecosystem services, human well-being and climate change
2 Resilience and restoration
3 Agro-biodiversity
4 Protected areas
5 Vulnerability assessments
6 Communication and outreach

1 Linkages between ecosystem services, human well-being and climate change

Multi-disciplinary studies that examine the linkages between climate change, human well-being and ecosystem services are identified as a priority thematic area of research. An understanding of these linkages is critical for the formulation of balanced and cost-effective adaptation strategies, and for a better appreciation of the often undervalued role of biodiversity conservation in maintaining the ecosystem services which are vital for human well-being (e.g. soil fertility, clean water supplies, micro-climate regulation, fisheries productivity, coastal protection). The following topics are considered particularly important:

[5] The reports of the three expert working groups (Climate change trends and scenarios; Impacts of climate change on marine and coastal biodiversity; and Impacts of climate change on terrestrial biodiversity) can be found at http://www.canari.org/macarthurclimatechange.html

1.1 Innovative pilot projects on the economic valuation of environmental goods and services, which include the development of models that estimate the value of regulating and cultural services of biodiversity. Such models should include an analysis of the effects of climate change on these values.

1.2 Analysis of case studies that demonstrate good practice in terms of the nexus between conservation and human well-being. The analysis should include how the projected impacts of climate change will affect their respective socio-economic and environmental conditions, with recommendations for what adaptation strategy may be required.

1.3 Analysis of the impacts of climate change on tourism, in particular tourism dependent on natural resources (e.g. reefs, beaches, turtles) and research tourism.

1.4 Analysis of the impacts of climate change on the ecosystem services that support human settlement in the coastal zone. This could be, for instance, an analysis of the changes in the ability of coral reefs and/or mangroves to protect coastal areas, as well as a cost-benefit study of various adaptation strategies.

2 Resilience and restoration

This thematic area focuses on applied research targeted at selected sites, which may benefit from specific interventions that strengthen the resilience of the ecosystems and restore biodiversity. The research should build on existing case studies, as well as exploring innovative approaches, in order to develop replicable solutions for the Caribbean region. The following research topics were identified as particularly important:

2.1 Research aimed at increasing the resilience of beaches

Rising sea levels and intensifying storm events will increase beach-erosion in many areas. One particular concern is the negative impact this will have on the availability of suitable nesting sites for marine turtles. Turtles are considered to be an important indicator species for climate change impacts and have a Caribbean-wide interest.

2.2 Research aimed at increasing the resilience of coral reefs

Coral reefs are particularly important to the Caribbean region because of their high value to fisheries, tourism and coastal protection. They are also particularly vulnerable to the effects of climate change and therefore research is needed to determine the best strategies for building their resilience and capacity for adaptation.

2.3 Research aimed at increasing the resilience of mangroves and other coastal ecosystems.

Mangroves are essential nursery habitats for many species and play a critical role in coastal protection during storm events. As with beaches, they are threatened by increasing development on the landward side and rising-sea levels on the seaward side. To address this phenomenon, known as "coastal squeeze", targeted research linked to land-use planning and policy will be required.

2.4 Research aimed at increasing the resilience of forests.

Projected changes in the temperature and rainfall in the Caribbean will have profound effects on soil moisture and the incidence of forest fires, disease, and invasive pests. In order to strengthen the resilience of Caribbean forests and their associated biodiversity, research is required that addresses opportunities from reforestation, watershed management and appropriate land-use planning

3 Agro-biodiversity

Agricultural biodiversity is a subset of biodiversity and underpins the development of all food production. Agro-biodiversity includes domesticated crops and animals as well as their wild relatives. It also includes non-harvested species that support agriculture, such as pollinators and soil bacteria. Research priorities for the conservation of agro-biodiversity include:

3.1 Capturing traditional knowledge relevant to agro-biodiversity.

3.2 Developing *in-* and *ex-situ* conservation activities and systems of access that produce economic and livelihood benefits for the local community.

3.3 Developing national protocols for protecting the intellectual property associated with traditional knowledge and practices in agro-biodiversity.

4 Protected areas

The creation of protected areas (PAs) is potentially one of the most effective approaches for the conservation of biodiversity and is generally included as an important component of national environmental management plans. Climate change has strengthened the arguments for PAs, on the basis that ecosystems inside PAs are likely to be more resilient than unprotected ones, and therefore better able to adapt to a changing environment. Climate change also strengthens the need for networks of PAs that take into account the ecological connectivity that exists across geographic regions as well as the potential migrations of species and ecosystems in the future.

Research in this thematic area should use a multi-disciplinary approach to examine the social, economic, political and ecological factors that contribute to the effectiveness of PAs in meeting their objectives. Research should also try to integrate with existing regional projects (e,g. Integrating Watershed and Coastal Area Management [IWCAM] and Caribbean Large Marine Ecosystem [CLME] projects) and with commitments under international agreements (e.g. CBD, Ramsar). The research priorities that have been identified are:

4.1 Identification of ecosystems that have high natural resilience.

4.2 Assessment of existing protected areas to see to what extent they are vulnerable.

4.3 Assessment of existing protected areas to see to what extent they are addressing climate change issues.

4.4 Assessment of effectiveness of current protected areas, and analysis of the factors that make some more successful than others in achieving their objectives, using a multi-disciplinary approach.

4.5 Application of the findings to improving the management of selected terrestrial and marine protected areas.

5 Vulnerability assessments of selected species and ecosystems to climate change

The vulnerability to climate change of many species and ecosystems is unknown, and therefore is a key area of concern for both the conservation of biodiversity and the security of livelihoods, human-health and food production in the Caribbean. Research targeted at assessing the vulnerability of selected species is therefore a priority thematic area, with the following topics being of particular concern;

5.1 Vulnerability assessments of keystone species critical to the provision of ecosystem services (e.g. pollinators, corals).

5.2 Vulnerability assessments of indicator species of climate change such as turtles, amphibians and mosquitoes.

5.3 Vulnerability assessments of commercially important species in agriculture and fisheries.

6 Communication and Outreach Research

Effective communication is a prerequisite for effective climate change adaptation, and strategies are needed both for the "adaptation community" and the wider public. It has been identified as a key thematic area in this research agenda because little is currently known about what types of communication are most effective in bringing about the desired changes of opinion and behaviour in the key target audiences. Effective outreach will necessitate increased dialogue between scientists and communication specialists with the ability to "translate" what is often technical and complex information to target audiences who may currently be misinformed, sceptical or disinterested. Regional communication strategies face the additional challenge of linguistic and cultural diversity. The following research is therefore considered a high priority:

6.1 Testing different messages, channels and media to a range of target audiences and analysing the outcomes. This approach will require multi-disciplinary teams, including climate and social scientists, as well as specialists in marketing and communications.

6.2 Analysing the effectiveness of past communication strategies linked to increasing awareness of biodiversity, climate change and their impacts on human wellbeing.

6.5 Appendix 5: IUCN Caribbean Initiative ecosystems and livelihoods concept

Ecosystems and livelihoods: sustainability, adaptation and resilience
Outline of a programme of activities

Summary
This programme of activities is one of three main components in the first phase of implementation of the IUCN Caribbean Initiative launched at the World Conservation Congress in October 2008. Its focus will be on policies and practical instruments of integrated management, in order to build the capacity of the region to meet critical development and resource management challenges and to strengthen the role of ecosystems and ecosystem services in helping meet these challenges, especially those provoked by natural disasters, climate change and transformations in the main economic sectors. This programme of activities will contribute to the integration of protected areas and other conservation instruments within wider planning and management frameworks, and will identify and strengthen the contribution of ecosystems to resilience and adaptation to the main changes that impact negatively on Caribbean livelihoods and human development.

Issues and needs
This programme is based on the recognition of the many linkages that exist between biological diversity, livelihoods and national economies in the small islands of the Caribbean. Natural ecosystems and the services they provide support a wide range of human activities, production systems and economic sectors, but they are threatened by a number of factors, including climate change. This represents a major obstacle on the road towards sustainable development, especially since biodiversity and ecosystem services could play a significant role in disaster risk reduction (flood control, buffer zones, etc.), while their destruction only serves to increase negative impacts on people, economies and the environment. At the same time, sustainable and equitable patterns of resource use can bring tangible economic, social and cultural benefits to people while contributing to the maintenance of vital ecosystem services. There is therefore a need for a more active promotion of the ecosystems approach and of integrated management in the insular Caribbean, and there is an urgency to build the resilience of both human and natural systems, in an integrated fashion.

IUCN value proposition
While these issues and needs are at the heart of the challenge of conservation and sustainable development in the insular Caribbean, they are insufficiently addressed by present efforts. While the region has made significant advances in a number of areas (creation and management of protected areas; establishment and strengthening of physical planning systems and institutions; introduction of risk identification, assessment, monitoring and early warning systems for natural disasters), two critical needs remain largely unmet:

- the need to integrate biodiversity and ecosystem services into development planning, disaster risk reduction and climate change adaptation;
- the need to integrate livelihood issues by looking at the positive relationship that can be developed between sustainable livelihoods, biodiversity and ecosystem services.

In order to address these needs, IUCN proposes to strengthen and expand regional processes by bringing:

- its experience and strength in ecosystem management and its understanding of the linkages between diversity, disaster risk reduction and climate change;
- its regional membership and constituency in conservation, natural resource management and sustainable development.

Objectives
The objectives of this programme will be to:

- understand and enhance the main, present and potential contribution of biodiversity to adaptation, resilience building and sustainable livelihoods;
- build the region's capacity to integrate biodiversity concerns and ecosystem management approaches into disaster risk reduction and, more generally, into poverty reduction, development planning and integrated resource management.

Approach
This programme of activities will be characterised by the following features:

- it will promote a "learning by doing" approach, with collaborative field testing of responses and instruments;

- it will promote the collective formulation of planning and management instruments;
- it will involve government agencies (in planning, natural resource management, disaster risk reduction and conservation), non-governmental and community organisations, academic and research institutions, and local experts;
- it will contribute the expertise and experience of similar work undertaken by IUCN in other regions, such as the Mangroves for the Future project in Asia, and it will encourage communication and collaboration with other regions, especially Oceania;
- it will be truly regional in scope, working with all countries of the insular Caribbean, across linguistic and political groupings (including the member states of the Caribbean Community, Cuba, the Dominican Republic and Haiti as well as the dependent territories of European countries and the United States).

Activities

Activities will include:

- national, regional and thematic assessments of the contribution of ecosystems to disaster risk reduction and resilience at community and national levels;
- facilitation and implementation, in close collaboration with local partners, of pilot projects that will identify ways in which ecosystems can contribute optimally to sustainable livelihoods, adaptation to change, disaster risk reduction and sustainable energy production and consumption;
- participatory analysis of the experience gained and lessons learned;
- preparation of tools, guidelines and studies and dissemination to government agencies, regional organisations and local actors in a targeted fashion (presentation to conferences and inter-governmental meetings, integration into curricula of training institutions, conduct of workshops and other training activities, etc.);
- facilitation of and provision of support to policy reform processes that allow for the integration of ecosystem management into disaster risk reduction and poverty reduction strategies and into energy policy.

Main partners

The main partners in this programme will include the inter-governmental and regional organisations active in these areas, the governments of participating countries, selected civil society organisations (including IUCN members), and key regional experts (including IUCN Commission members). The programme will be implemented by the IUCN Caribbean Initiative with support from and in collaboration with the IUCN Global Islands Initiative, GLISPA and the IUCN Programme in Oceania.

October 2008