Seminar 1

Oceans at Risk:
Protecting the oceans and marine resources

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Confronting Climate Change in the Pacific: Knowledge-action approaches and the Association of Pacific Rim Universities Sustainability and Climate Change research program

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Abstract

Representing almost half of the world's ocean area, the Pacific Ocean is both a major control system of climate change, and as a physical, social and economic system (including the Pacific Rim), highly vulnerable to it. This presentation was set within an overview of the current state of these vulnerabilities and the challenges they present, especially in the context of the vital role of marine resources.

Human societies within the Pacific Rim and on the land interact both through economic relationships and through the climate system and hydrological cycle, which in turn all together form a system with the sea. Effective mitigation and adaptation approaches will require policies which understand and regulate human impacts on this system and its impacts on human societies. Whilst it is useful to form mitigation and adaptation policy at national, regional and even global scale, the specific circumstances of local communities interacting with the water system condition the challenges which must be faced. The challenges are technical, economic, cultural, and political and it frequently is far from obvious at local scale what information is needed to even determine adaptation and mitigation challenges, let alone to shape higher level policy to meet local capacities and needs.

A project for meeting these combined issues, which harmonizes approaches and needs across scales to provide effective responses through an integrated system framework, has been developed over the last five years by the Association of Pacific Rim Universities Sustainability and Climate Change (APRU-SCC) research program. The APRU-SCC approach involves an international collaboration of researchers working together around an integrated model which combines both the social and technical dimensions of a community in interaction with a water system. The approach developed heavily stresses interactive processes of engagement with subject local communities and solution finding. Whilst the process itself has been limited by the need to attract resources it has produced significant outcomes. The relevance of approaches taken by APRU-SCC and their potential for assisting Pacific communities at different scales to meet the challenges of changes to marine and associated systems under the impacts of climate change will be discussed and opportunities for collaboration and participation will be explored.

1. The view from the Pacific

The Pacific constitutes an area of 18,000 km by 15,000 km with an average depth of 4.2 km. In a similar fashion, this paper aims for breadth rather than depth, bringing together a range of issues, somewhat in the manner of what Ernest Boyer has characterized as "the scholarship of integration".[1]

The Pacific Ocean is an important part of the Earth's climate system. It mediates carbon dioxide

[1] Boyer, E.L., *Scholarship Reconsidered: Priorities of the Professoriate*, The Carnegie Foundation for the Advancement of Teaching, 1990

absorption and release, heat storage and transportation, storm and wind, and the vulnerabilities of the crucial coastal land masses of the Pacific and its Rim.

The Pacific and Asia (the "Asia-Pacific region") is home to over 3.9 billion people – some 58% of the world's population.[2] As elsewhere, there is a consistent tendency for that population to increasingly concentrate along the coastline. Worldwide coastal population density is about twice the average, and the urbanization of coastlines has grown dramatically with the development of large to huge (10-20 m) coastal cities. While population growth has slowed, population size and density in the coastal population has steadily grown. The Pacific coastal region encompasses many of the largest coastal cities in the world including Tokyo, Shanghai, Beijing, Jakarta, Manila, Osaka, and Seoul. These put enormous pressure on the marine coastal system as well as linking more and more people to it.

The Asia-Pacific region is also the centre of global consumption and production growth. As UNEP points out, with almost 60% of the world's population and agricultural land the Asia-Pacific region has become the largest single user of materials including biomass, fossil fuels, ores, industrial and construction materials, with a huge potential for future growth.[3]

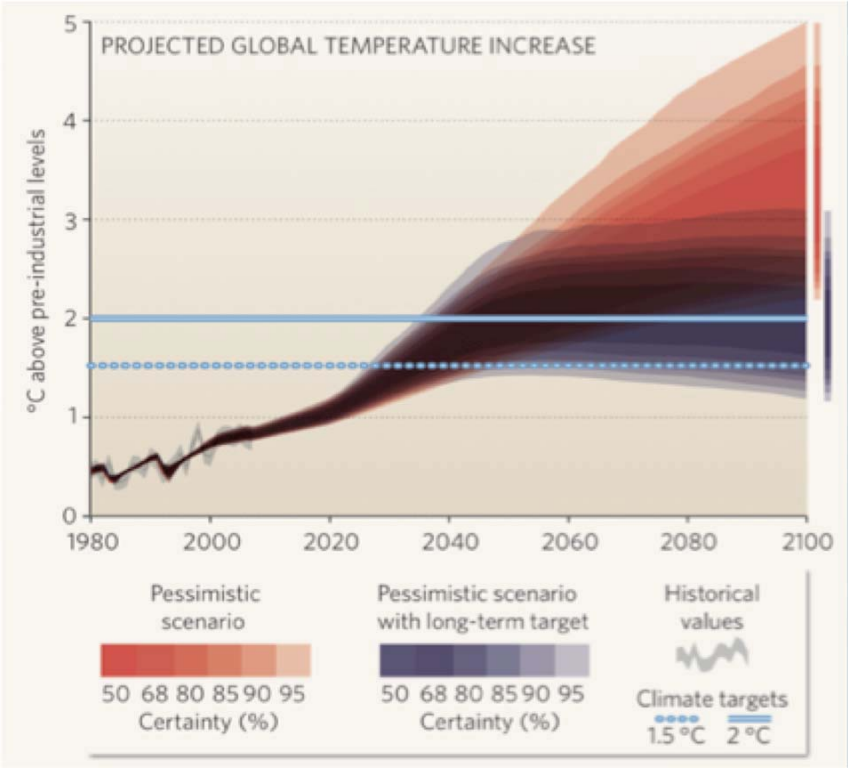
The Asia-Pacific region is also the largest consumer of water, with withdrawal rates of 2,268,726 GL/year over 1995-2002, which, as UNEP reports, is far more than the consumption of the rest of the world.[4] This heavy usage of water reflects its central role in agriculture, to which, on average more than 80% of this usage is directed.[5] As this suggests, and as UNEP comments, "In coming decades, the Asia-Pacific region will be the most important driver of global resource use and related environmental impacts, including resource scarcity, pollution, and climate change."[6]

With high water usage and a strong reliance on marine and terrestrial food production, and its large and growing population, the Asia-Pacific region is also one of the most vulnerable regions to climate change. Not only are the impacts likely to become more intense in the future but the time developing "arrow of knowledge" on climate change points overwhelmingly to a worsening prospect.

Despite all the international negotiations, claims of concern, and innovations, the concentration of greenhouse gases in the global atmosphere continues to increase (allowing for the economic slow-down during the global financial crisis) at what is broadly an accelerating pace. In February 2013, the carbon dioxide concentration had reached 396ppm compared to 319ppm in February 1963,[7] and a pre-industrial level of 260-270ppm. As a result the window is closing very rapidly for any prospect of containing global mean temperature rise to 2°C (as set at COP-15 and the subsequent meeting at Cancun) and in fact the rise by the end of this century seems likely to be more like 3-4 degrees, or quite possibly higher. The graph from Meinshausen, produced in 2011, is now, if anything, an understatement of the potential for temperature rise.

[2] UNEP, *GEO5: Global Environment Outlook for Asia and the Pacific Region*, 6 June 2012, p. 2
[3] UNEP, *Resource Efficiency: Economics and Outlook (REEO) for Asia and the Pacific*, United Nations Environment Programme, Bangkok, October 2011, p. 88
[4] Ibid
[5] Ibid
[6] Ibid. p. 1
[7] Scripps Institution of Oceanography, Monthly CO2, http://scrippsco2.ucsd.edu/data/in_situ_co2/monthly_mlo.csv, viewed 24 March 2013

Figure 1. *Range of potential global temperature increase trajectories to 2100 plotted against time, color-coded against calculated likelihood.* [8]



Source: Rogelj, Meinhausen, et al. *Nature,* 2011

Climate Interactive's *Climate Scoreboard* puts the effect of current proposals for emissions reductions (June 19, 2012) as producing a 4.4°C rise in mean temperature by 2010 and if business as usual is followed, a rise of 4.9°C.[9]

Despite the steady increase in the assessment of global temperature rise over the rest of this century, still much of the planning, where it is in place, rests on old outdated projections. Planning (for example for the flood barriers being constructed on the Venice Lagoon) has been designed around expectations shaped by the IPCC Fourth Assessment Report scenarios, where (although rises up to 6.4°C were raised as possible in the report)[10] most of the attention focused on lower emission scenarios and warming of around 2°C with corresponding sea level rises of perhaps half a meter.[11] Taking into account what has since begun to be understood about the much more rapid melt of the polar ice caps and glaciers, together with possible temperature rises of four or more degrees rather more dramatic sea level rise ought now to be considered. As the World Bank now reports: **"**Even with the current mitigation commitments and pledges fully implemented, there is roughly a 20 percent likelihood of exceeding 4°C by 2100. If they are not met, a warming of 4°C could occur as early as the 2060s. Such a warming level and associated sea-level rise of 0.5 to 1 meter, or more, by 2100 would not be the end point: a further warming to levels over 6°C, with several meters of sea-level rise, would likely occur over the following centuries."[12]

[8] Kindly provided by Malte Meinshausen, private communication, 2011. For a most recent treatment of this see; Rogelj, J., David L. McCollum, Andy Reisinger, Malte Meinshausen and Keywan Riahi, "Probabilistic cost estimates for climate change mitigation", *Nature*, 493, 2013, pp. 79-83

[9] http://climateinteractive.org/scoreboard/scoreboard-science-and-data, viewed March 24, 2013

[10] Intergovernmental Panel on Climate Change (IPCC), *Fourth Assessment Report, Synthesis Report,* Table 3.1, p. 45. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf, viewed July 2, 2011

[11] Ibid, Figure 1.1, p. 31

[12] World Bank, *Turn Down the Heat: Why a 4 deg C Warmer World Must be Avoided*, November 2012. xiii

2. The Pacific Ocean and climate change

As the Asian Development Bank reports, globally, eight of the ten economies with the largest number of people living in low-elevation coastal zones are in the Asia-Pacific region." [13] Already, Asia is known to be the region most affected by weather-related disasters. It has experienced 90% of the world's weather-related deaths since 1990. Rapid urbanization has left more than 70% of the urban population in Asia and the Small Island Developing States in the Pacific (SIDS) located in areas prone to flooding. This has contributed to the region's vulnerability to natural and man-made disasters which will be further exacerbated by climate change. In particular it is the urban poor who live in hazardous areas, with the most vulnerable being women, children and the elderly.[14] The governments of Pacific Island countries already say that climate change is overwhelmingly the challenge for their future.[15]

Climate-related displacement of people in the Asia-Pacific region is already visible and as climate change intensifies, the associated countries and communities will need to address the prospect of not only the destruction of infrastructure but also the inevitability of massive population shifts. Indeed, more than 42 million people were displaced in 2010-2011 by environmental and weather-related disasters across Asia, far more than in any other part of the world.[16] In the future tens of millions more people are likely to be similarly displaced by the effects of climate change, including rising sea levels and floods. Governments must start to prepare for the problems this will create. Bangladesh, India, the Maldives and Pakistan face the greatest risk. Indonesia, the Philippines, Thailand, Vietnam, Japan, China and South Korea are also especially vulnerable. As the Asian Development Bank stresses: "Asia and the Pacific is the global area most prone to natural disasters, both in terms of the absolute number of disasters and of populations affected. It is highly exposed to climate impacts, and is home to highly vulnerable population groups, who are disproportionately poor and marginalized."[17] And "environmental events are already causing people to move in Asia and Pacific region. By taking actions today, governments can reduce the likelihood of future humanitarian crises…"[18]

3. Food and fish

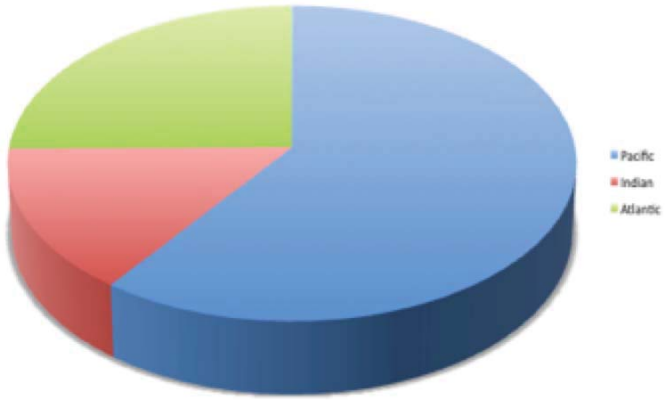
Access to food is a central determinant of the level of vulnerability of impoverished populations. In relation to this, the impacts of climate change in the Pacific need to be evaluated in the context of impacts on global markets. Rising temperatures and extreme weather events have already contributed to loss of crop yield in many economies and crop yields are currently projected to decline by a further 10% by 2020. [19]

Matching its share of world ocean area, the Pacific Ocean was, in 2010, the source of some 60% of

[13] Asian Development Bank, *Addressing Climate Change and Migration in Asia and the Pacific,* Asian Development Bank, Manila, 2012, p. 4
[14] UN Habitat, *Climate Change Risks in Asia and the Pacific*, Cities and Climate Change Initiative, UN-HABITAT Global Division, Urban Environmental Planning Branch, September 2010. http://www.fukuoka.unhabitat.org
[15] Cooney, C, "Climate Change to Dominate Pacific Islands Forum ", Australian Broadcasting Commission -Asia Pacific News, September 2011
[16] Asian Development Bank, *Addressing Climate Change and Migration*, p. 2
[17] Ibid, p. viii
[18] Ibid. p. ix
[19] United Nations Environment Program, "Climate Change - Helping Countries Tackle Climate Change in Asia Pacific", http://www.unep.org/roap/Home/tabid/roap/Activities/ClimateChange/tabid/6834/Default.aspx. Viewed 6 April 2013

the world's captured fish, representing some 20% of the world's consumed protein. According to the UN Food and Agricultural Organization (UN-FAO), over the last forty years that resource has come under pressure with human population and demand increasing rapidly. The tonnage of captured fish has peaked and is declining, and whilst aquaculture did grow rapidly since the 1970s, filling the gap, the growth rate of aquaculture is now declining.

Figure 2. *The Pacific Ocean is by far the largest fish producer, producing about 60% of the world's fish catch in 2010.*[20]



Source: Food and Agriculture Organization of the United Nations, FAO Fisheries and Aquaculture Department

Increases in atmospheric carbon dioxide are leading to an increase in the acidification of the Pacific Ocean surface (as measured by reduction of the ph level). Ocean surface ph has dropped by 0.1 ph units since the beginning of industrialization with this drop likely to increase to 0.3 to 0.4 ph units by the year 2100.[21] There are serious implications for the survival of many marine species which will have difficulties reproducing their skeletons in this environment,[22] with consequent repercussions up the food chain.

The World Bank reports that a warming of 4° C would correspond to a carbon dioxide concentration above 800ppm and a corresponding increase in ocean acidification of 150%.[23] The Bank continues with the warning: "Ecosystem damage would be expected to dramatically reduce the provision of ecosystem services on which society depends (for example, fisheries and protection of coast- line—afforded by coral reefs and mangroves)."[24] Further, it notes, "… there has not been a study published in the scientific literature on the full ecological, human, and economic consequences of a collapse of coral reef ecosystems, much less when combined with the likely concomitant loss of marine production due to rising ocean temperatures and increasing acidification, and the large-scale impacts on human settlements and infrastructure in low-lying fringe coastal zones that would result from sea-level rise of a meter or more this century and beyond."[25]

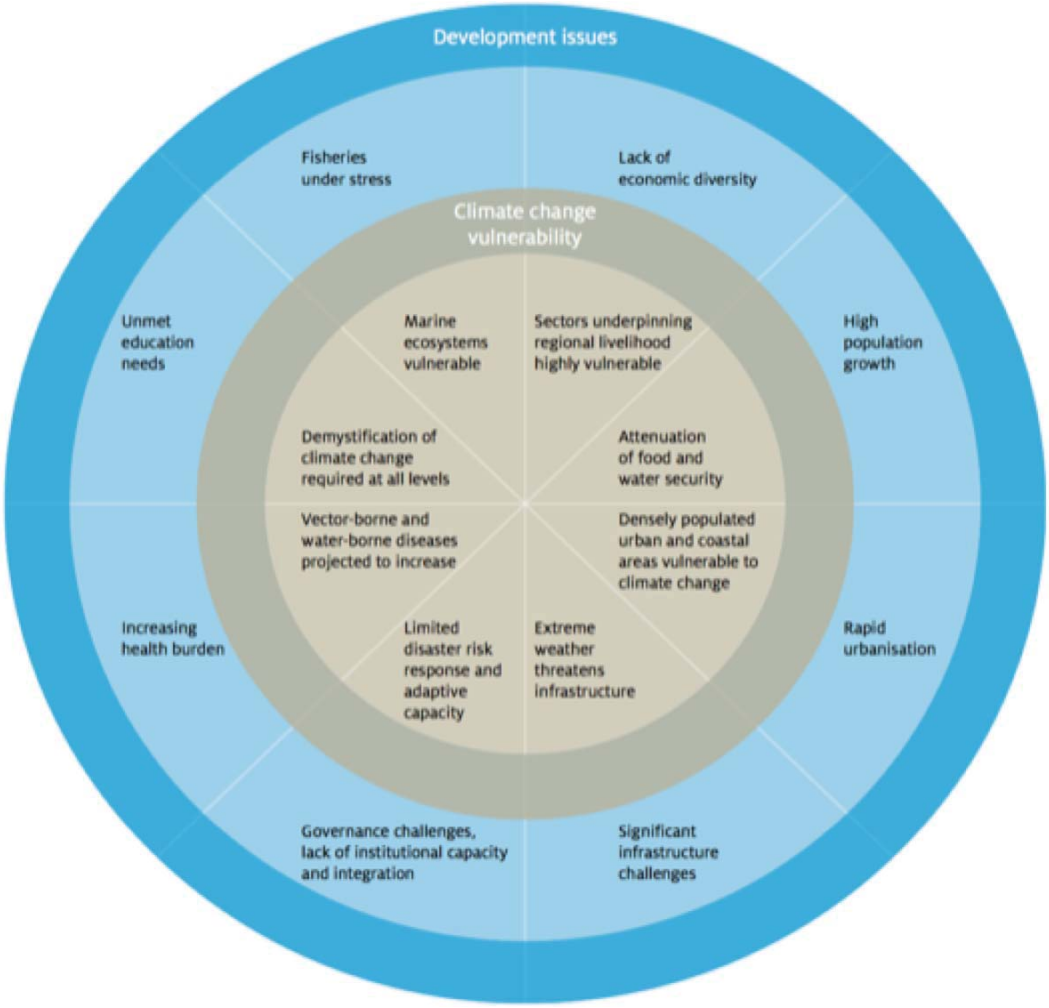
The above are just a few of the direct implications of marine-mediated impacts of climate change for the Asia-Pacific Region. There are of course many more and there is a complex interaction between

[20] Calculated from Food and Agriculture Organization of the United Nations, FAO Fisheries and Aquaculture Department, *The State of the World Fisheries and Aquaculture*, FAO, Rome, 2012, Fig 17, pp. 54-5
[21] Orr, J. C. et al. "Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms", *Nature,* vol. 437, 29 September 2005, p. 681
[22] Kufner, I.B. et al., "Decreased abundance of crustose coralline algae due to ocean acidification", *Nature Geoscience*, vol. 1, February 2008, p. 117
[23] World Bank, *Turn Down the Heat*, p. xv
[24] ibid
[25] ibid p. xvii

climate change and climate vulnerabilities, as indicated by Figure 3 below, using a schematic from the Australian Government.[26]

Binding together the challenge of climate change is a single vital proposition. Whilst we humans (as a global community) know, at least in broad, what threatens and what needs to be done to avoid it, we have not found the collective capacity to do that. In short, between knowledge and decisive effective action, we are experiencing a governance gap.

Figure 3. *Pacific vulnerabilities to climate change - all of a piece*[27]



Source: Australian Government, *Engaging our Pacific Neighbours on Climate Change, 2009*

Joseph Camilleri and I have written quite extensively about the nature of this gap.[28] It is not a static deficit but rather a dynamically evolving relationship between the intensifying needs for action and the collective preparedness (or lack thereof) to meet them. The experience in Australia has illustrated the complexities with what is virtually a political pendulum, swinging between: a) concern about climate change as it impacts on what is perhaps the most climate vulnerable continent on the planet, and b) political reaction to proposed measures to reduce emissions. Most notable is the unsuccessful proposal by the Rudd Government to introduce an emissions trading scheme, the

[26] Australian Government, Engaging our Pacific Neighours on Climate Change, 2009
[27] Ibid
[28] Camilleri J. and Jim Falk, *Worlds in Transition: Evolving Governance Across a Stressed Planet*, Edward Elgar, London, 2009

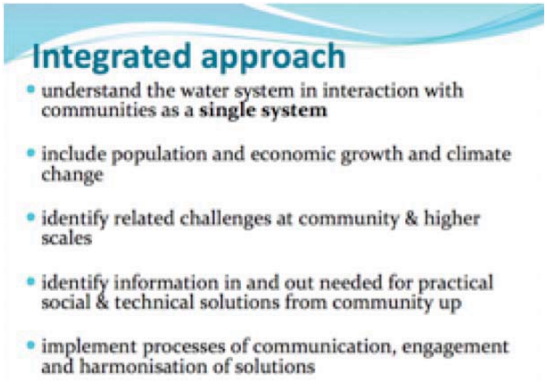
subsequent highly controversial introduction of a price on carbon by the Gillard Government in November 2011, and the quite likely removal of that price by the next government, depending on the outcome of the forthcoming national election. This unsteady progress (oscillating to regress) can be set against equally slow and difficult progress in international negotiations, as evidenced by the failure to agree globally the binding emissions targets which could constrain emissions to a trajectory compatible with holding the global temperature rise below the internationally agreed target of no more than two degrees.

4. Approaches to change: Harmonization across scales and domains

The challenge then is to find means to bridge the gap between what needs to happen and collective resolve to achieve it. No single approach seems likely to achieve that. This constitutes a challenge which stretches across scales – policy makers for larger scale organization (whether nation-states or regional organizations) need the consent of the governed to move forward. That consent will only be forthcoming if the multiple people and organizations at smaller scale believe the policy necessary and implementable. That in turn can only be achieved if the policy takes account of local concerns and builds on local knowledge. There is thus a dilemma which might be characterized as how to *harmonize* knowledge of the local and global challenges, in this case including local and best global knowledge of climate impacts and options.

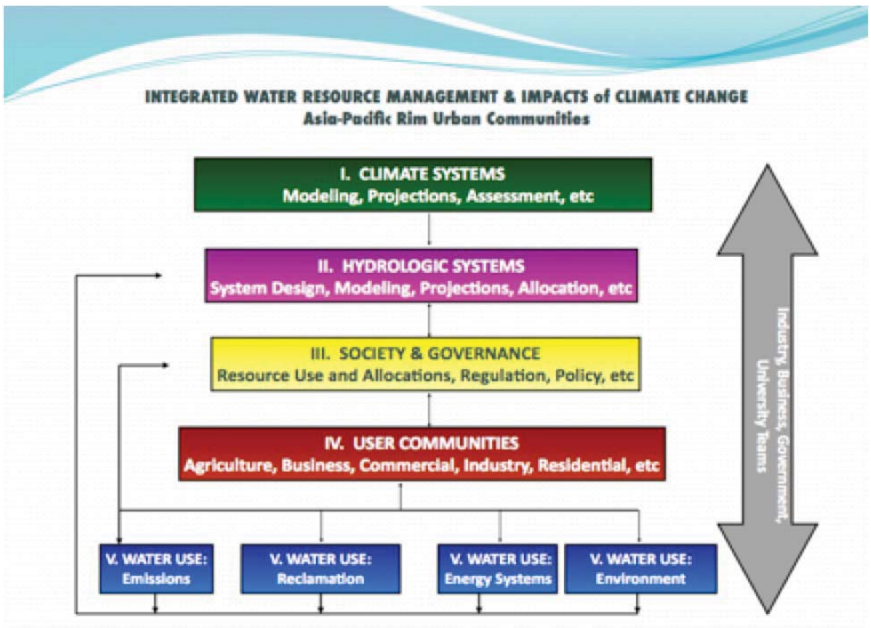
Finding ways of achieving that harmonization is a key challenge of our time, whether across the Pacific or elsewhere. One initiative which has sought to construct innovative solutions has been the work of the Association of Pacific Rim Universities (APRU). It launched a research and intervention program on climate mitigation and adaptation strategies (CMAS) in 2008, focusing on climate change and its interaction with human settlements and their water systems. The central approach of this research program (now called the APRU-SCC "Sustainability and Climate Change" research program) has been to emphasize that the human, hydrological and climate components of this should be treated as one integrated system. The key elements of this approach are summarized in Figure 4 below.

Figure 4. *The APRU-SCC integrated approach*



The way in which the integrated water system has been envisaged in the APRU approach is shown in Figure 5. The system is seen as dynamically evolving through two-way interactions between its environmental, hydrological, social and technological components. The approach taken in APRU-SCC was to establish research teams around these different "thrust areas". Whilst in practice progress was far from uniform across these areas, the team leaders then worked collectively to provide information and approaches which could then be harmonized in engagement with relevant policy communities.

***Figure 5**. The APRU-SCC (previously AWI-CMAS) approach to conceptually modeling the integrated water system*



The APRU-SCC approach seeks to bring best international research into engagement with the understanding and needs of local and regional communities, and their thought and policy leaders. APRU represents leading research universities across the economies of the Pacific Rim and has brought into the program research groups from as far afield as China, Australia, Japan, South East Asia and North America. It has joined up with other similarly inclined initiatives encompassing knowledge-action workshops and consultations ranging from Jakarta (Indonesia), Da Nang (Vietnam), Kuala Lumpur (Malaysia), Bangalore (India), Srinagar (Kashmir), Venice (Italy) and Cambridge (UK). The APRU-SCC (then AWI-CMAS) research teams that were operating as at 2010 are shown in Figure 6.

***Figure 6.** APRU-SCC (then AWI-CMAS) research teams as at 2010*

This sort of research which seeks to cut across the barriers that separate international expertise from local needs, and local understandings from higher-scale (national, regional and global) policy making is becoming known as "knowledge-action" methodology. Overall it aims to harmonize knowledge, understanding of locally meaningful options for action, and ultimately policy, resourcing and implementation, across scales from the local to the global arenas.

APRU-SCC's approach continues to be developed around aspects of water and climate change in particular, and knowledge-action approaches to sustainability and climate change in general. A major international workshop around this theme (with a particular focus on sea level rise and cities) was held at the University of California at Santa Cruz (UCSD) in September 2012 then acting as the secretariat for APRU-SCC,[29] and a forthcoming international symposium, on *Coastal Cities, Marine Resources and Climate Change in the Coral Triangle* will be held at the University of Indonesia on in Jakarta in June 2013.[30] In all of these there is a strong effort to combine international research with priority policy development needs in a particular location, in conjunction with local researchers, policy makers, and business leaders.

The knowledge action approach[31] is also being developed across a number of cognate initiatives spreading as widely as the Global Water Initiative (a collaboration of the University of Cambridge and UCSD),[32] and the Regional Climate Change forums which have regularly been held in conjunction with the Science, Technology and Society Forum held annually in Kyoto, Japan,[33] the next being in October 2013.[34] It is a not an easy task to harmonize knowledge across so many scales and sectors. But it is vital we learn how to do it well. This PECC workshop on "Sustainable Management of Marine Resources", strategically held in one of the more vulnerable locations of the Pacific Ocean, and bringing together policy makers and the international research community, has been well placed to contribute. It can be regarded as another extremely constructive contribution to the development of our understanding on how to carry out knowledge-action work and apply it effectively to meeting the challenges climate change poses for the multiple human communities which continue to grow in population and consumption across this very finite and increasingly stressed planet.

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[29] http://apru.org/news/item/359-the-apru-international-workshop-on-coastal-cities-and-sea-level-rise

[30] See: http://apru.org/partnering-on-solutions/sustainability-and-climate-change-program/item/412-international-symposium-on-coastal-cities-marine-resources-and-climate-change-in-the-coral-triangle

[31] See for example, Kennel, C.F. 'Think globally, assess regionally, act locally' (Issues in Science and Technology, Winter 2009 Issue, National Academies Press); and Kennel C.F. and S. Daultrey, "Knowledge Action Networks: Connecting regional climate change assessments to local action"
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[33] See for example: http://ssi.ucsd.edu/index.php?option=com_content&view=article&id=408&Itemid=18

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Implications of Climate Change for Contributions by Fisheries and Aquaculture to Economies and Communities in the Tropical Pacific

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1. Introduction

Pacific Island economies face considerable challenges in implementing their collective goals of economic, human and social development in the face of changes in population profiles, unstable financial markets, escalating food prices, changing terms of trade and the revolution in information technology. In particular, the rapidly growing population of the region – estimated to reach around 15 million by 2035 and 18 million by 2050 – means that new approaches will be needed. Sustainable management of the region's natural resources will play a major role in achieving the vision for a secure and prosperous future.

The vital contributions of fisheries and aquaculture to the development goals of the Pacific Islands region cannot be overstated. Nowhere else in the world do so many economies depend as heavily on the benefits derived from fisheries and aquaculture. License fees from distant water fishing nations (DWFNs) operating in the region contribute from 3% to 40% of government revenue for seven Pacific Island economies (Gillett 2009). Domestic fishing fleets and local fish processing operations provide further benefits and account for 3% to 25% of gross domestic product (GDP) in four economies.

Fish is a cornerstone of food security in the region. In more than half of all 22 Pacific Island economies, fish consumption is at least 2 to 4 times greater than the global average. In most rural areas of the region, 60–90% of this fish comes from subsistence fishing activities and fish often makes up 50–90% of dietary animal protein (Bell et al. 2009).

Fisheries and aquaculture are also an important source of jobs and opportunities to earn income. More than 12,000 people are employed in tuna canneries or processing facilities, or on tuna fishing vessels (Gillett 2009). Surveys in 17 Pacific Island economies show that an average of 47% of households in coastal fishing communities earn either their first or second income from fishing (SPC 2008a). In several remote atolls, pearl farming is an important source of employment and in inland Papua New Guinea there are now thousands of freshwater ponds producing fish (Ponia 2010, Pickering et al. 2011).

Developing and implementing practical plans to maximize the sustainable economic and social benefits from fisheries and aquaculture in the region is a major responsibility for all stakeholders. 'The Future of Pacific Island Fisheries' study (Gillett and Cartwright 2010) commissioned by the Forum Fisheries Agency and the Secretariat of the Pacific Community (SPC) maps out the management measures needed to retain the benefits of the sector. It also identifies plausible scenarios that could result in these benefits being reduced or lost. Achieving good outcomes will depend on our collective ability to respond to the various drivers likely to affect the sector.

One driver that is very likely to grow in significance in coming years is the increased emission of carbon dioxide (CO_2) and other greenhouse gases. There are serious concerns that global warming and ocean acidification could affect the plans being made to optimize the social and economic

benefits derived from fisheries and aquaculture. The region needs to know the vulnerability of these plans to climate change, and how best to adapt.

2. Vulnerability assessment

SPC has recently completed a vulnerability assessment to assist Pacific Island economies and communities to understand the effects of increased greenhouse gas emissions on the fisheries and aquaculture sector, and how to adapt appropriately (Bell et al. 2011a). The approach used to make the assessment involved six steps (Table 1).

Table 1. *The six steps involved in assessing the vulnerability of fisheries and aquaculture in Pacific Island economies to climate change*

Step	Description
1	Projecting changes to atmospheric (surface) climate
2	Projecting changes to the tropical Pacific Ocean
3	Assessing the way in which projected changes to surface climate and the ocean are likely to affect the ecosystems that support fishery resources (open ocean food webs, coral reefs, mangroves, sea grasses and intertidal sand flats, and freshwater and estuarine habitats)
4	Assessing the likely direct effects of projected changes to surface climate and the ocean, and the indirect effects of projected changes to ecosystems, on the abundance and distribution of species supporting oceanic fisheries, coastal fisheries, freshwater fisheries and aquaculture
5	Identifying the implications of projected changes to the productivity of oceanic, coastal and freshwater fisheries, and aquaculture, for regional plans to use fisheries resources for economic growth, government revenue, food security and livelihoods
6	Recommending adaptation responses, policies and investments (including research to fill gaps in knowledge) to help economies and communities maintain the benefits of fisheries in the face of climate change

To deal with the considerable uncertainty associated with steps 1 to 5, the vulnerability assessment was based on scenarios. The rationale for using scenarios was not only to encompass the range of possible outcomes stemming from existing uncertainties but also to alert decision-makers to potential future situations – ultimately, economies need to be prepared to adapt to all plausible scenarios.

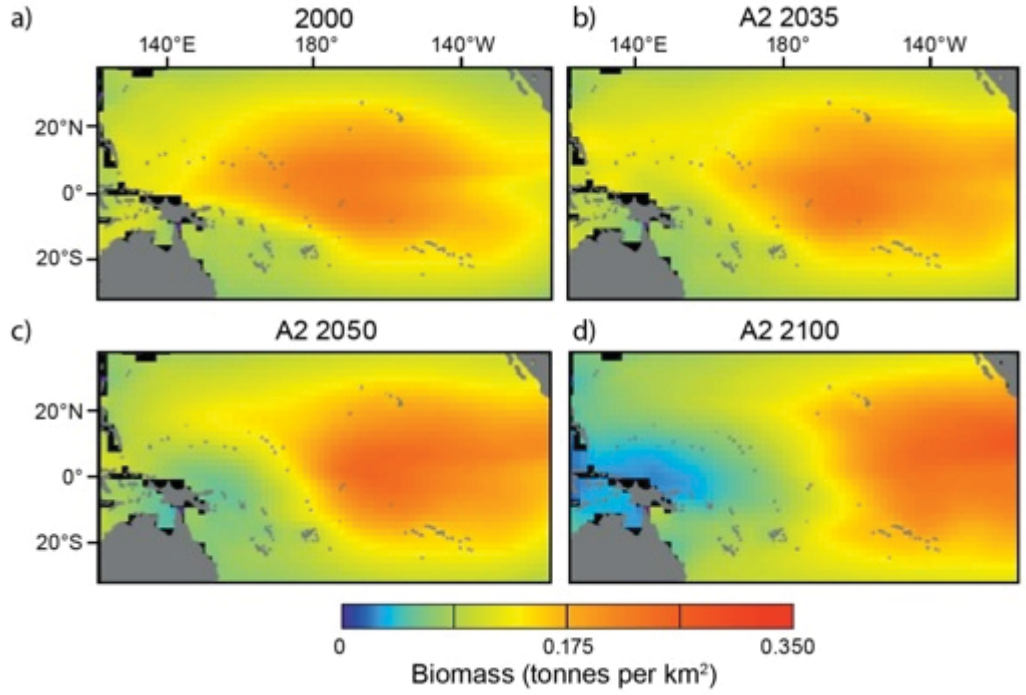
The scenarios were based on the IPCC *Special Report on Emissions Scenarios* storylines B1 (low emissions) and A2 (high emissions) (Nakicenovic et al. 2000) for 2035 and 2100. To provide mid-term projections, the B1 scenario in 2100 was used as a proxy for A2 in 2050 (Bell et al. 2011a).

3. Main findings

The results of the vulnerability assessment are mixed – there are likely to be winners and losers. Increases in sea surface temperature (Ganachaud et al. 2011) and changes in the location of nutrient-rich waters (Le Borgne et al. 2011) are projected to change the distribution and abundance

of tuna (Lehodey et al. 2011). In particular, tuna catches are eventually expected to decrease in the western Pacific and increase in the eastern Pacific (Figure 1).

Figure 1. *Preliminary projected estimates of total biomass (tonnes per km^2) of skipjack tuna from the SEAPODYM model based on average (1980–2000) fishing effort in (a) 2000, (b) 2035, (c) 2050 and (d) 2100. Projections are for a high (IPPC A2) emissions scenario (source: Lehodey et al. 2011)*



Increasing water temperatures and ocean acidification are expected to degrade coral reef habitats (Hoegh-Guldberg et al. 2011) and affect the replenishment potential of coastal fisheries across the region (Pratchett et al. 2011). The greatest negative effects are likely to occur for the component of coastal fisheries comprised of bottom-dwelling fish associated with coral reefs and other coastal habitats. Production of these reef-associated fish is expected to decrease by 20% in 2050 and by 20–50% in 2100 under the high emissions scenario (Pratchett et al. 2011). Such conditions are also expected to cause problems for the main forms of coastal aquaculture – pearl culture, shrimp farming and seaweed cultivation (Pickering et al. 2011).

On the other hand, warmer surface temperatures and higher rainfall (Lough et al. 2011) are likely to enhance production from freshwater fisheries (Gehrke et al. 2011) and freshwater pond aquaculture (Pickering et al. 2011).

4. Implications

4.1 Economic development

The projected changes to the catches of tuna across the region are expected to have implications for government revenue and GDP in those economies where these fish are caught and/or processed. For economies in the central and eastern Pacific, where access fees from DWFNs already provide a large proportion of government revenue (Kiribati, Tokelau and Tuvalu), there is expected to be potential to negotiate for increased revenue between 2035 and 2050, with opportunities diminishing somewhat in 2100 (Table 2). GDP in Marshall Islands could also increase until 2100 as a

result of the greater catches by national vessels (Table 2). Similarly, canning operations in American Samoa have the potential to benefit until 2050 from the more eastern distribution of tuna (Table 2).

Table 2. *Estimated changes in percentage contributions of skipjack tuna catches to government revenue and GDP in selected Pacific Island economies, relative to 1999–2008, in 2035, 2050 and 2100 under the A2 emissions scenario (source: Bell et al. 2011b)*

Economy	Change to government revenue (%)									Change to GDP (%)							
	1999–2008 (%)		2035		2050		2100			1999–2008 (%)		2035		2050		2100	
	L	U	L	U	L	U	L	U		L	U	L	U	L	U	L	U
Western region[a]																	
FSM	6	12	+1	+2	0	+1	-1	-2		1.5	5	0	+1	0	0	0	-1
Marshall Islands	2	5	0	+1	0	+1	0	0		10	25	+2	+6	+2	+6	+1	+2
Nauru	10	25	+2	+6	+2	+5	0	0									
Palau	2.5	3.2	+0.2	+0.3	0	+0.1	-0.7	-0.9									
PNG	0.2	0.8	0	0	0	-0.1	-0.1	-0.2		1.5	4	0	+0.1	-0.2	-0.4	-0.4	-1.2
Solomon Islands	0.2	5	0	+0.2	0	-0.3	0	-0.8		2	5	+0.1	+0.2	-0.1	-0.3	-0.3	-0.8
Eastern region[b]																	
American Samoa	5	20	+1	+4	+1	+2	0	-1		20	25	+3	+6	+2	+4	-1	-2
Kiribati	30	50	+11	+18	+13	+21	+7	+12									
Tokelau	2	15	+1	+9	+1	+10	+1	+9									
Tuvalu	10	25	+4	+9	+4	+10	+2	+6									

a = Located west of 170°E; b = located east of 170°E

* Estimates are based on projected alterations in the catch of skipjack tuna from preliminary modeling (Lehodey et al. 2011). Lower (L) and upper (U) limits are shown for the estimates, together with the average contributions of skipjack tuna catches to GDP and government revenue for the period 1998–2008. Only economies where industrial fishing or processing contributes > 1% of government revenue or GDP are included (source: Bell et al. 2011b).

The projected reduction in tuna catches from the exclusive economic zones (EEZs) of Papua New Guinea (PNG) and Solomon Islands in 2050 and 2100 (Lehodey et al. 2011) are expected to affect the canneries there unless arrangements can be made to maintain the supplies of fish needed for processing operations. In the event that such measures are not successful, the projected reductions in tuna catch from the EEZs of PNG and Solomon Islands could affect the profitability of canneries and the opportunities for employment. Overall, however, the impacts on economic development in PNG and Solomon Islands would be relatively limited because the fisheries sector makes a minor contribution to GDP in these relatively large economies (Table 2).

4.2. Food security

The projected changes to the supply of bottom-dwelling fish associated with coral reefs are expected to have effects on food security because so many people in the Pacific depend heavily on these coastal fisheries resources for dietary protein (SPC 2008b, Bell et al. 2009). Nevertheless, in many Pacific Island economies, population growth is expected to be the main reason that the availability of fish from coral reefs will fall short of the 35kg of fish per person per year recommended for good nutrition in the years ahead (Table 3).

For the nine economies in this category (American Samoa, Fiji, Guam, Nauru, Commonwealth of the Northern Mariana Islands, PNG, Samoa, Solomon Islands and Vanuatu), plans are needed to provide access to the fish required for food security in the face of growing populations and climate change. These plans involve (1) improving the management of coastal habitats and fish stocks to reduce the gap to be filled between the fish needed for food security and sustainable coastal fish harvests; (2) assessing how best to fill the gap with tuna; (3) promoting the 'vehicles' needed to deliver the fish

required; (4) increasing access to tuna to meet the needs for food security (Bell et al. 2009; 2011b, c).

Table 3. *Gap between recommended fish consumption and the estimated sustainable annual supply of fish per person from coastal bottom-dwelling (and freshwater) fish stocks, due to the effects of population growth in 2035, 2050 and 2100 for selected Pacific Island economies (source: Bell et al. 2011b)*

Economy	Total fish production (tonnes)[a]	Population (x 1000)[b]			Total fish available per person per year (kg)			Gap in fish needed per person per year (kg)		
		2035	2050	2100	2035	2050	2100	2035	2050	2100
American Samoa	1104	87	98	135	13	11	8	22	24	27
Fiji	34,146	978	1061	1332	35	32	26	0	3	9
Guam	717	250	268	296	3	3	2	32	32	33
PNG	83,500	10,822	13,271	21,125	8	6	4	27	29	31
Nauru	21	14	16	21	1	1	1	34	34	34
CNMI	750	76	80	87	10	9	9	25	26	26
Samoa	6100	202	210	240	30	29	25	5	6	10
Solomon Islands	27,605	970	1181	1969	28	23	14	7	12	21
Vanuatu	3812	400	483	695	10	8	6	25	27	29

a = estimates assume sustainable fisheries production of 3 tonnes per km^2 of coral reef per year (Newton et al. 2007) but also include freshwater fisheries production where relevant based on estimates by Gillett (2009); b = provided by SPC Statistics for Development Programme; c = based on the recommendation of SPC's Public Health Division that people in the Pacific should eat an average of 35 kg of fish per person per year for good nutrition (SPC 2008b); PNG = Papua New Guinea; CNMI = Commonwealth of the Northern Mariana Islands.

5. Adaptations and supporting policies

5.1. Economic development

The adaptations and supporting policies required to maximize the benefits from tuna fisheries for economies in the central and eastern Pacific, and to minimize the impacts for economies in the west, as the distribution of skipjack changes are outlined below. These adaptations involve development of flexible management measures to allow fishing effort to shift east, while ensuring that large quantities of tuna can still be channeled through the established and proposed canneries in the west; and optimizing the productivity of tuna resources across the region.

Full implementation of the Vessel Day Scheme (VDS): the 'cap and trade' provisions of the VDS enable all members of the Parties to the Nauru Agreement[35] to receive some level of benefits during El Nino Southern-Oscillation events, regardless of where tuna is concentrated (Aqorau 2009). As redistribution of tuna occurs, the periodic adjustment of allocated vessel days within the VDS should reduce the need for members in the east to purchase days from those in the west.

Develop and maintain an economic partnership agreement (EPA) with the European Union: the global sourcing provisions of an EPA assist economies processing tuna to obtain and export fish at

[35] Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands, Tuvalu

competitive prices. Developing and maintaining a long-term EPA will help ensure that these economies have continued supplies of fish as tuna are redistributed further east.

*Diversify sources of fish for canneries***:** other adaptations to help economies in the west secure fish for canneries include: reducing access for DWFNs to their EEZs to provide more fish for national vessels; requiring DWFNs to land some of their catch for use by local canneries; and enhancing arrangements for national fleets to fish in the EEZs of other PICTs.

Immediate conservation management measures for bigeye tuna: preventing the overfishing of bigeye tuna in the WCPO should help rebuild the stock and make this valuable species more resilient to climate change.

Energy efficiency programs for industrial fleets: energy audits to identify how to reduce fuel use during fishing operations should assist fleets to cope with rises in oil prices. Energy audits should also reduce the costs for fleets fishing further afield as the distribution of tuna shifts to the east.

Environmentally-friendly fishing operations: minimizing the effects of existing fishing operations, and those projected to occur as tuna moves east on non-target species will help meet the requirements of certification schemes. Emissions of CO_2 from vessels and canneries should also be minimized to reduce the carbon footprint of industrial fisheries.

Safety at sea: conducting safety audits to ensure that longline vessels and any purse-seine vessels operating within the cyclone belt should help achieve acceptable standards for safety at sea in the event of more severe cyclones.

Climate-proof infrastructure: constructing new wharfs for fishing fleets and fish processing facilities, designed to prevent inundation by rising sea levels and withstand the effects of more severe cyclones, should safeguard investments in necessary infrastructure.

The policies required to pave the way for the adaptations needed to reduce the risk of climate change to the benefits that Pacific Island economies receive from tuna, and capitalize on the opportunities, are provided by Bell et al. (2011c) and include:

1) Promoting transparent access agreements between Pacific Island economies and DWFNs so that allocations under the VDS (and other fishing effort schemes) are understood by all stakeholders; and strengthening national capacity to implement these schemes;
2) Adjusting national tuna management plans and marketing strategies to provide more flexible arrangements to sell tuna, or acquire tuna needed for local processing operations;
3) Including the implications of climate change in the future management objectives of the Western and Central Pacific Fisheries Commission (WCPFC);
4) Requiring all industrial tuna vessels to provide operational level catch and effort data to improve the models for estimating the redistribution of tuna stocks;
5) Finalizing the declaration of national ocean boundaries in compliance with the United Nations Convention on the Law of the Sea;
6) Applying national management measures to address the implications of climate change for sub-regional concentrations of tuna in national archipelagic waters beyond the mandate of WCPFC;
7) Developing further measures to mitigate the capture of bigeye tuna by purse-seine; and
8) Using regional trade and preferential access agreements to market environmentally friendly tuna products, and develop distribution channels that minimize CO_2 emissions.

5.2. Food security

The adaptations and suggested policies for maintaining the important role of fish for food security in Pacific Island economies are set out below. These adaptations and policies centre on (1) minimizing the size of the gap between the fish required for good nutrition and the fish available to coastal and urban communities through appropriate management of coastal (and freshwater) fish habitats and stocks; (2) filling the gap by increasing access to tuna and boosting freshwater pond aquaculture.

Many of these interventions are not new – they have been proposed for many years as an integral part of effective coastal zone management and a community-based ecosystem approach to fisheries management (CEAFM, SPC 2010), and to address the effects of population growth on the availability of fish for food security (Bell et al. 2009). The CEAFM co-management framework, which integrates customary marine tenure and other social capital, local governance, traditional knowledge, self-interest and self-enforcement capacity, provides the most effective way to implement many of these adaptations. This is particularly the case when the adaptations include the principles of 'primary fisheries management' (Cochrane et al. 2010) and are considered by cross-sectoral management advisory groups comprised of both government and non-government members.

Manage and restore vegetation in catchments: increasing the vegetation in catchments will help reduce the transfer of sediments and nutrients to rivers and coasts after heavy rain and help prevent damage to the coral reefs, mangroves, sea grasses and intertidal flats supporting coastal fisheries.

Foster the care of coastal fish habitats: preventing pollution and managing waste in coastal areas to maintain water quality, and eliminating damage to coral reefs, mangroves and sea grasses, caused for example, by destructive fishing methods, gathering building materials, and poorly-designed tourist activities, will help build resilience of coastal fish habitats to climate change.

Provide for landward migration of coastal fish habitats: prohibiting construction of buildings on low-lying land adjacent to mangroves, sea grasses and intertidal flats, and installing wide culverts beneath existing roads, will allow low-lying areas to become fish habitats as sea levels rise.

Sustain production of bottom-dwelling fish: maintaining the replenishment potential of stocks will help reduce the gap between coastal fisheries production and the fish needed by rapidly growing populations.

Diversify catches of bottom-dwelling fish: taking catches representative of the changes in abundance of the fish that result from climate change will help optimize the potential production from coastal fisheries.

Increase access to tuna for coastal communities: installing anchored fish aggregating devices (FADs) (Figure 2) to increase catch rates of tuna close to the coast will provide subsistence and small-scale commercial fishers with better access to fish as human populations increase and bottom-dwelling fish decline. Providing training in the methods needed to fish around FADs, and maintaining FADs, will optimize such investments.

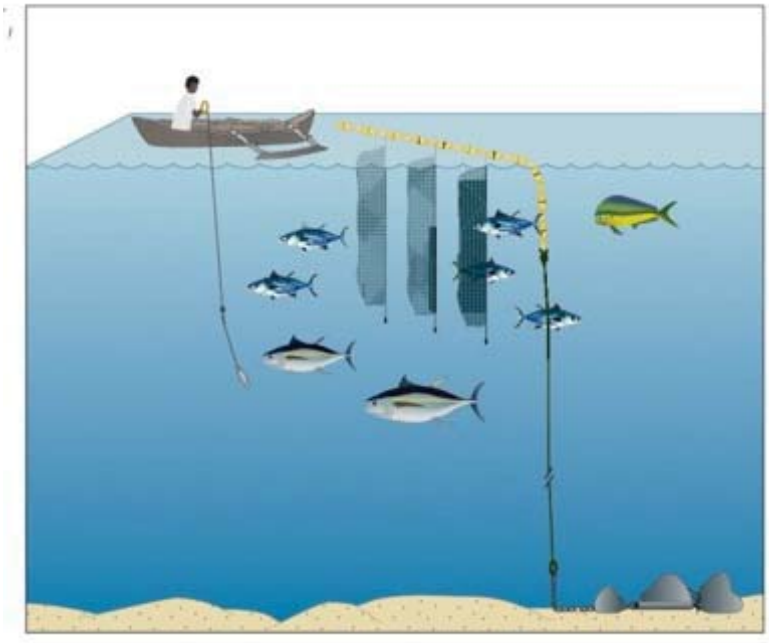
Increase access to tuna and bycatch for food security: promoting the distribution of low-value tuna and bycatch from industrial vessels transshipping their catch at major ports will provide inexpensive fish for rapidly-growing urban populations.

Develop coastal fisheries for small pelagic species: increasing the catch of mackerel, anchovies, pilchards, sardines, scads and fusiliers will improve access to fish for food security and livelihoods.

Develop appropriate models for expansion of freshwater pond aquaculture: identifying the hatchery systems and networks that allow high-quality juvenile fish to be distributed to both small- and large-scale farmers, and securing the supplies of cost-effective feeds required for semi-intensive and intensive farming systems, will help freshwater pond aquaculture fulfill its potential.

Improve post-harvest methods: training communities, particularly women, in appropriate ways to improve traditional smoking, salting and drying methods will extend the shelf life of fish when good catches are made.

Figure 2. *Anchored fish aggregating device (FAD) suitable for placing in coastal waters (usually 300–1,000 m deep) to increase access of small-scale fishers to tuna*



The policies required to support adaptations needed to reduce the risk of climate change to the contributions that fish makes to food security in Pacific Island economies, and make the most of the opportunities, are described by Bell et al. (2011c) and include:

1) Strengthening governance for sustainable use of all coastal fish habitats by: building the capacity of management agencies to understand the threats posed by climate change; empowering communities to manage fish habitats; and changing agriculture, forestry and mining practices to prevent sedimentation, addition of nutrients and pollution;
2) Protecting source and resilient coral reefs supplying recruits to fish populations on 'downstream' reefs to help these reefs recover after coral bleaching or cyclones;
3) Minimizing barriers to landward migration of coastal habitats during development of strategies to assist other sectors to respond to climate change;
4) Promoting mangrove replanting programs in suitable areas to meet the twin objectives of enhancing habitat for coastal fisheries and capturing carbon;
5) Applying CEAFM and 'primary fisheries management' to stocks of coastal fish and shellfish to maintain their potential for replenishment;
6) Restricting export of coastal bottom-dwelling fish to ensure that these resources are available for national food security where necessary;
7) Increasing access to tuna for the food security of coastal communities by reducing the catch of industrial fleets where required;
8) Including anchored inshore FADs as part of the national infrastructure for food security, and making provision for regular maintenance and replacement of FADs;

9) Dedicating a proportion of the revenue from fishing licenses to improve access to tuna for food security;
10) Providing training and technical support for coastal fishing communities to catch small pelagic fish;
11) Promoting the benefits of freshwater aquaculture based on Nile tilapia for supplying fish to growing inland communities and urban populations with poor access to other sources of animal protein, but limiting Nile tilapia farming to catchments where the Mozambique tilapia is already established to reduce any possible effects on freshwater biodiversity;
12) Facilitating the training needed to operate freshwater pond aquaculture enterprises successfully;
13) Developing partnerships with regional technical agencies to provide the necessary technical support for development of freshwater pond aquaculture; and
14) Revising primary school curricula to teach children about fish and food security, focusing on the importance of fish for their health; the basic management actions needed to maintain fish habitats and fish stocks; and the options for increasing future supplies of fish.

6. Conclusions

The results of the vulnerability assessment make it clear that the key challenges posed by climate change for plans to maintain and hopefully increase the contributions of fisheries and aquaculture to economies and communities in the tropical Pacific revolve around:

1) Creating flexible policy arrangements to ensure continued supplies of fish to established and proposed canneries and fish processing facilities in the region as the distribution of tuna shifts to the east;
2) Reducing the effects of local stressors on fish habitats by legislating to restore and protect catchment vegetation and prevent direct damage to coral reefs, mangroves, sea grasses and intertidal flats caused by excess sediments, nutrients, pollution and poor management of waste;
3) Launching adaptation initiatives favored by climate change that will improve the supply of fish available to the rapidly growing populations of the region, for example, by using FADs to increase access of coastal communities to tuna; and
4) Managing the development of freshwater pond aquaculture to optimize the benefits for food security and minimize any effects on freshwater biodiversity.

Despite the multi-disciplinary approach used in the vulnerability assessment, there is still considerable uncertainty about the magnitude of the projected effects of climate change on the fisheries and aquaculture sector. This uncertainty is due partly to the coarse resolution of the global climate models used to project changes to surface climate, the tropical Pacific Ocean and tuna stocks (Bell et al. 2011a). Some of this uncertainty has been reduced through the development of downscaled models by Australia's Pacific Climate Change Science Program (Australian Bureau of Meteorology 2011).

The remaining uncertainty needs to be addressed so that effective adaptations for Pacific Island economies and communities to climate change can be developed with greater confidence. In particular, this requires: (1) improved models of the responses of the ocean, and the natural living resources it supports, to global warming and increased CO_2 emissions; and (2) long-term monitoring to inform and validate these models.

To ensure that the billions of dollars committed to assist developing economies adapt to climate change are used effectively, adequate funds must also be allocated for the necessary modeling and

monitoring. Because developing economies do not usually have the capacity to do the research and monitoring needed to inform effective adaptations, this work will need to be done on their behalf by advance scientific institutions and international/regional organizations.

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Invisibility in Fisheries: The complex roles of women in fisheries and aquaculture

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Abstract

The role of women in fisheries is complex and yet almost completely invisible in policy and research. Fisheries and aquaculture are important sources of household income and are the leading sources of animal protein for many communities throughout the world. The participation of women, especially in small-scale artisanal fisheries, is critical for many coastal and fishery dependent communities. Yet there is little research on the impact of predicted changes in wild fisheries from harvest and climate change or the growth of aquaculture operations on local community structure. This article explores the professional literature and published research associated with women and their invisible roles in the fishing industry uses.

1. Introduction

The role of women in fisheries is complex and is often invisible because of that complexity. The invisibility is tied to a mixture of cultural norms (such as expectations of household roles in marketing and consumption of fish) or patriarchal norms within different cultures (Zayas & de la Peña 2013). Another aspect of invisibility is the almost total lack of information on the women in the fishing industry, and what studies exist are mostly anecdotal and fragmented or limited to specific case studies[36]. In the fisheries sector, women are engaged in visible roles (paid workers and job categories) but also as unpaid, "invisible" workers that often are not separated from household labor (Gerrard 2000; Zhao et al. 2013). In some countries, there are no official records on the active involvement of women in fisheries (e.g. Turkey - Göncüoğlu & Ünal 2011) or the participation is poorly defined as household chores (e.g. Mali- Tindall & Holvoet 2008). Women are active in post-harvest processing, market activities in coastal communities in both developing and developed countries; however data on the role of women in the fishery sector has been slow to mature To explore the role of women in fisheries, this article is divided into three sections. First, the question of scale between the two categories of fisheries (wild capture and aquaculture) and size of fisheries (artisanal or industrial) Second, a gender framework on the overlap of activities within these industries and where invisibility occurs. And third, a discussion on the impacts of climate change on fisheries-dependent communities and implications for socioeconomic wellbeing of women in the industry. A theme that is woven throughout the three sections is the question of culture, traditional roles and perceptions and stereotypes (Tuara & Passfield 2011). The overarching approach is the benefit that engaging women as an integral part of the fisheries workforce and the sustainability of fisheries-dependent communities is tied to understanding the vulnerabilities of these invisible fisherwomen. This article is based on existing literature on women in fisheries from a variety of disciplines including fisheries, marine policy and gender studies.

[36] Walker 2001; Tuara & Passfield 2011, Zhao, Tyzack, Anderson & Onoakpovike 2013, Göncüoğlu & Ünal 2011, Frangoudes & Keromnes 2008

2. A question of scale: gender in the fisheries sectors

During the UN Framework Convention on Climate Change Conference of the Parties in Doha, 2012, the negotiation language included discussions of adaptation strategies for small scale agriculture and aquaculture, but included little on differing roles of men and women in these industries and did not separate out capture fishing. This difference in scale between capture fisheries and artisan fisheries that are both part of food security (or fisheries dependence), complicates the ability to analyze roles of community members and the vulnerability to changes within the industry socioeconomic structure. Fisheries associated with coastal or mangrove communities may also be vulnerable to catastrophic climate events that can have devastating short-term effects on local fisheries or local (Brookfield, Gray & Hatchard 2005; Trimble & Johnson 2013). However, deciding the scale of community that is dependent on fisheries resources is variable: from a local village to a larger municipal region or an entire country.

2.1. Onshore/near shore/offshore elements

The fisheries industry has a pattern of scale and distance that are an important landscape for exploring the engagement of women in fisheries. International management of stocks through the high seas agreements (United Nation Convention on the Law of the Sea-UNCLOS) dominates the wild capture fisheries where industrialized fleets and multi-national crews control the industry (Wright 2011). Brookfield et al. (2005) discuss the constraints of globalization, mobile labor and capital penetration as three constraints on fisheries dependence within a community. For the first two, globalization and mobile labor, the impact on women involved in onshore and invisible roles, or those in informal roles may be greater than men (Frangoudes & Keromnes 2008). For example, the globalization of the fishing industry has led to capture fisheries being dominated by large corporations and industrial boats that are almost completely gender segregated (Zhao et al. 2013). In addition, the constant upgrade and modernization of fishing gear also trickles down to artisanal fishing and disrupts cultural norms within coastal communities and within subsistence livelihoods (Brookfield et al. 2005).

The issue of mobile labor in South America, as an example from the developing world, is concentrated around young men and migratory near-shore fisheries with growing immigrant males in the industry but not on women (Trimble & Johnson 2013). Small-scale fisheries dependent on migratory and seasonal fisheries are dominated by men who follow the fisheries up and down the coasts in countries such as Brazil and Uruguay (Trimble & Johnson 2013). Artisan fishing off the coasts of these countries tends to be dominated by men and even in discussions on the influx of new migrant workers, migrant women were not entering the capture fisheries aspects of this workforce (Trimble & Johnson 2013). This pattern is repeated in more northern countries such as England (Zhao et al. 2012), Norway (Gerrard 2000) and Turkey (Göncüoğlu & Ünal 2011). Aquaculture, interestingly has a larger proportion of women in the workforce and in the case of England, the earnings between men and women in the aquaculture sector is equal (Zhao et al. 2012). However, this trend is different in Oceania (Tuara & Passfield 2011).

2.2. Fisheries-dependent communities

Fisheries dependence, a term used to define fisheries-dependent communities in the United Kingdom (Brookfield et al. 2005), is one way to define the nature and complexity of both capture fisheries and aquaculture. First, fisheries dependence is a concept of economic sector or where the contribution of fisheries is measured in terms of the labor market (as quoted in Brookfield et al. 2005) where a broad area of socioeconomic activities are dependent on stability of the fisheries resource and where various sectors of an economic value chain are based around a fisheries resource, including onshore and offshore activities and other industries dependent on fishery resources (Bell et al. 2011). However, fisheries dependence can also include social and cultural

values where the act of fishing, whether economically viable or not, is part of the character of the community or is expressed by community members as an essential part of life (Phillipson & Crean 1997; Zhao et al. 2012; Satyanarayana, Mulder, Pulukkuttige Jayatissa & Dahdouh-Guebas 2013). In some countries, female fish traders can be both lead entrepreneurs and conservationists for fisheries (Walker 2001). In other cases, changing the value chain of a fisheries commodity can conflict with traditional fishing and lead to the displacement of local women by men or multi-nationals (Crow & Carney 2013).

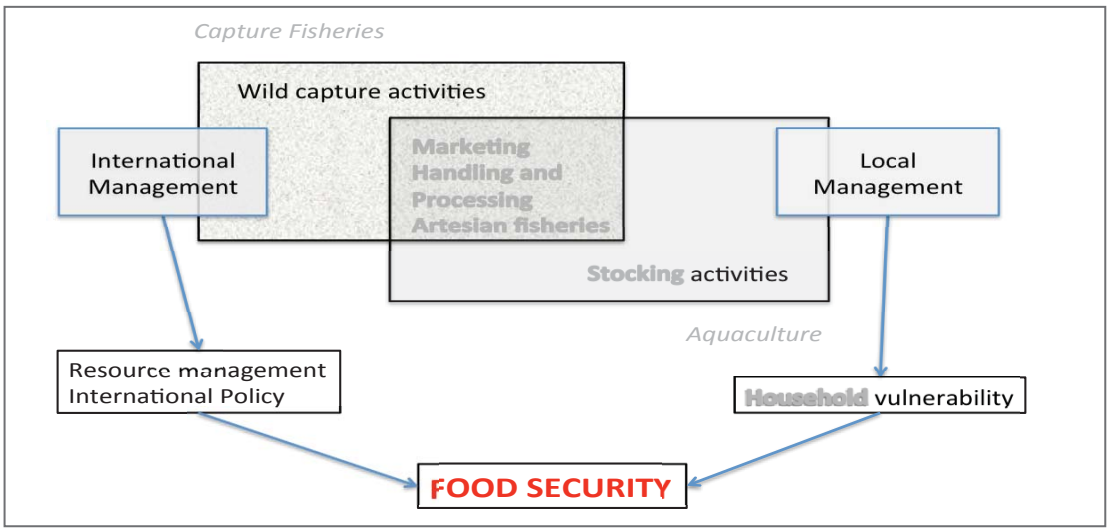
2.3. Artisan fisheries and small-scale fisheries

Coastal fisheries including artisan, mangrove, coral reef and sea grass habitats, are often small scale, subsistence fisheries with equipment owned by fishers or local communities (Bell et al. 2011). Artisan fisheries and small-scale aquaculture are important sources of economic well-being in many parts of the world (Francoudes & Keromnes 2008, Trimble & Johnson 2012). In the Pacific Islands, these fisheries represent a significant part of the local economic structure and with the addition of fish processing for wild capture industries, the employment footprint of fisheries can be as high as 20% (Bell et al. 2011). In Oceania of the Polynesian Island Nations, communities' dependence on fisheries can exceed 47% of the household's income (Bell et al 2011b). In other cultures, fisheries are part of the community identity and coping strategies with changes in fleet scale and economic stability are more for the preservation of the activity of fishing rather than for their economic necessity (Brookfield et al. 2005; Trimble & Johnson 2013). That cultural identity often includes gender roles (Frangoudes & Keromnes 2008; Crow & Carney 2013) even when socioeconomic shifts in fisheries-related activities (such as processing or marketing) introduces migrant workers, multi-nationals and others with different cultural norms (Walker 2001; Tindall & Holvoet 2008).

3. A gender framework on fishery activities and food security

The global context of women in fisheries crosses both the ongoing debates on climate adaptation and the impacts on ecosystem services. While issues of gender are common in the climate adaptation language, food security and disaster event planning as part of the climate change framework (UNFCCC 2013), in the fisheries sector, the invisibility of women is particularly problematic because of the dual roles they play in the economic value chain. In Figure 1, the two main fishery sectors (capture fisheries and aquaculture) are highlighted in a simplified schematic to demonstrate the invisibility of women.

***Figure 1**. Gender roles and relative invisibility in the fisheries sector*



Women predominate the marketing, handling and processes fields in both wild capture and aquaculture or stocking operations and yet the economic influx has two different paths (international management versus local or national management). While international management of wild caught fisheries has direct interactions with the international fisheries treaties and other UN agreements through UNCLOS), local management is limited to regional fisheries management organizations (RMFOs) or even smaller community management. While larger international treaties include specific language linked to food security issues and the protection of national economics, these treaties rarely address or affirm other international treaties on women including the UN Commission on the Status of Women (CSW) or human rights treaties. In contrast local community management, through the food security paradigms of the UN and other agencies, is more likely to address food security or household vulnerability through aquaculture and some artesian fishing.

3.1. Capture fisheries versus aquaculture

The wild capture industry (mostly high seas and far offshore) is believed to have few to no women on the larger deep sea boats with the "culture" on the vessels being a significant barrier to women participating. Interviews of women in fisheries industries by Zhao et al (2013) highlight that cultural norms not only deter resident women but even immigrant women. Despite the influx of migrant workers, there are no known immigrant women workers on the larger vessels. Similarly, on smaller artisanal fishing vessels in Latin America, women were extremely rare among locals and nonexistent among immigrant workers (Trimble & Johnson 2013). Interestingly for aquaculture, the smaller the scale the higher the representation of women and in shellfish harvesting (oysters, mangrove harvesting, etc.) women dominate in the wild capture collecting, processing and handling in areas from Gambia (Crow & Caraney 2013) to Sri Lanka (Satyanarayana et al. 2013). Socioeconomic roles are also more prominent in aquaculture, especially where small scale harvesting has been augmented into an aquaculture industry; however those roles have started to shift in areas where industrialized production methods have outpaced traditional collecting so women have been replaced by men in those formally female-dominated roles (Gerrard 2000; Walker 2001; Zayas & de la Peña 2012; Crow & Carney 2013).

3.2. Visible versus invisible

The role of women in fisheries falls at the intersections between capture fisheries and aquaculture, and because of that overlap, they are not clearly seen as a part of either industry. Figure 1 highlights this invisibility by focusing on the roles that are invisible (indicated in grey letters) versus those that are frequently highlighted in policy, management and international fora. Socioeconomic factors such as marketing or household decision-making tend to get folded under "traditional gender roles" (Walker 2001), or shifted to male dominance if economic influence of the woman's livelihood becomes too high (Gerrard 2000; Tindall & Holvoet 2008). Small-scale artisan fish stocks (Trimble & Johnson 2013) are highly susceptible to economic shocks as well as climate change shocks (Bell et al. 2011). Where women lead the intermediate roles of onshore processing and marketing, these shocks can have different impacts making women more vulnerable to sudden economic changes in fisheries-dependent communities (Brookfield et al 2005; Zayas & de la Peña 2012). Other vulnerabilities such as shifts in stocking activities (e.g. mangrove fisheries in The Gambia - Crow & Carney 2013), can expose gender vulnerabilities within the industry or create an economic vacuum in places like Ghana (Walker 2001).

3.3. Management paradigms

One unique aspect of the fisheries industry is the dual role of local and international governance at different steps in the value chain. Multilateral negotiations work at a government-scale through the RMFOs and larger treaties. However, the role of women in fisheries is at a lower level with household vulnerability and local management usually viewed through the lens of food security (see

Figure 1). International management and multi-national culture on fishing vessels in the high seas has a cultural boundary that very few women are willing to transcend and from interviews of those women who spent some time on the high seas, few were willing to recommend the experience to their peers (Brookfield et al. 2013). For smaller management paradigms, this cultural trend does not hold true, so in many countries and cultures, women have a significant presence in the local management of fisheries resources or the conservation of shellfisheries or artisan fisheries. Management paradigms have direct implications on policies (Wright 2011), so the disassociation of women from the larger scale resource management and from UNCLOS will have long-term implications for the industry and community adaptation strategies for fisheries. For example, international policies that address rural poor and food security as the core drivers for the engagement of women will miss the importance of women on policy and negotiations on the highly profitable tuna and other UNCLOS treaties.

4. Climate change, invisibility, and the wellbeing of women in fisheries

Chapter 24 of Agenda 21 on Global Action for Women towards Sustainable and Equitable Development underlines the role that women play in sustainable development and distinguished 11 commitments with specific recommendations to strengthen the role of women in sustainable and beneficial development. The chapter contains specific recommendations to strengthen the role of women in sustainable development and to eliminate all obstacles to their equal and beneficial participation, particularly in decision-making activities relating to promoting environmental sound management and sustainable development (UNFCCC Doha Declaration of 2012). Climate events, such as extreme weather events and shifts in food supplies, have differing impacts on women and children with these groups often being the most vulnerable. Industries where those groups are not represented in the policy or management structure are often more likely to overlook such issues (Resurreccion 2006; Tuara & Passfield 2011). In small island states in Oceania or coastal communities in developing and developed countries, the roles and rights of women in small-scale agriculture including aquaculture (shellfish, mollusks and fish) are critical, yet those same women may not have any active involvement in *de facto* fisheries management as integral to the value chain from the infrastructure to informal credit systems or management of households (Figure 2).

Figure 2. *Shrimp processing at aquaculture operations (photo credit: Gillian Bowser)*

Women having no representation in the management or policies affecting the industry as a whole will have lasting impacts on the nexus between fisheries and food security (FAO 2007). Indeed, the invisible positions women hold within fisheries are unique for the food security paradigm and yet, in many ways, are also a peculiar Achilles' heel. As long as these invisible roles remain out of the view of policy makers and resource management strategies, women as active parts of the fisheries paradigm will be overlooked and long-term food security is questionable. In larger scaled terrestrial systems, the separation of roles by gender is well documented (FAO 2006) and policy frameworks reflect change. Women are represented at the end of the economic chain and not part of capture fisheries.

The role of women in capture fisheries is complex and needs further research. The climate change debate includes questions on fisheries as a major source of protein for the world's poor and many countries have coastal communities dependent on fishery resources. Future governance of fisheries resources under the stress of a changing climate, ocean acidification and ocean temperature changes needs to focus on the complexity of the industry in terms of gender. While mobility of labor changes the dynamics for youth in traditional fishing communities, the role of women and girls as part of that industry is still often overlooked. Here we explored some of the gender issues within the fisheries and implications for livelihoods and community stability. To bring the invisible into the policy arena, the role of women in fisheries must be fully explored.

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The Role of Multilateral Regulators in the Management of Shared Fish Stocks

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1. Introduction

The purpose of this paper is to provide a summary of multilateral cooperation for the conservation and management of shared fisheries resources with a focus on those economies associated with the Pacific Economic Cooperation Council (PECC). Climate change is exerting an increasing influence on the work of these organizations as they incorporate considerations of the combined impacts of fishing and climate change on the dynamics and status of the fish stocks that they are responsible for conserving and managing.

2. Trends in global fisheries production

Every two years the United Nations Food and Agriculture Organisation (FAO) provides an overview of the status and trends in world fisheries and aquaculture production. The most recent report was published in 2010[37]. The following elements of relevance to PECC are adapted from the 2010 report[38].

- Capture fisheries and aquaculture supplied the world with about 142 million tonnes of fish in 2008. Of this, 115 million tonnes were used as human food, providing an estimated apparent per capita supply of about 17 kg (live weight equivalent), which was an all-time high. Aquaculture accounted for 46 percent of total food fish supply, a slightly lower proportion than reported previously owing to a major downward revision of aquaculture and capture fishery production statistics by China, but representing a continuing increase from 43 percent in 2006. China remains by far the largest fish-producing economy, with production of 47.5 million tonnes in 2008 (32.7 and 14.8 million tonnes from aquaculture and capture fisheries, respectively).

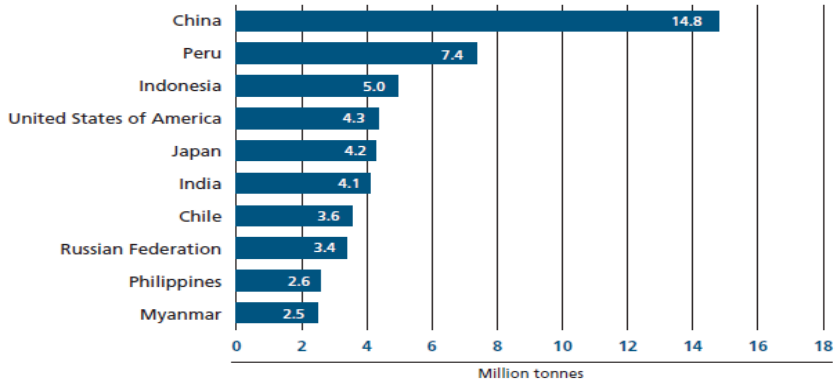
- In 2007, fish accounted for 15.7 percent of the global population's intake of animal protein and 6.1 percent of all protein consumed. Globally, fish provides more than 1.5 billion people with almost 20 percent of their average per capita intake of animal protein, and 3.0 billion people with at least 15 percent of such protein.

- Global capture fisheries production in 2008 comprised about 80 million tonnes from marine waters and a record 10 million tonnes from inland waters. World capture fisheries production has been relatively stable in the past decade, with the exception of marked fluctuations driven by catches of anchoveta – a species susceptible to oceanographic conditions determined by the El Niño Southern Oscillation – in the Southeast Pacific.

- In 2008, China, Peru and Indonesia were the top producing economies. China remained by far the global leader with production of about 15 million tonnes. Marine and capture fisheries production for 2008 for the top 10 producing economies is presented in the figure below (Figure 1). Members of the Pacific Economic Cooperation Council (PECC) account for more than 40% of this production.

[37] *The State of World Fisheries and Aquaculture (2010).* United Nations Food and Agriculture Organization. Rome, 2010.
[38] Reproduced with the permission of the FAO.

Figure 1. *Top ten marine and capture fisheries producing economies (2008)*



Source: United Nations Food and Agriculture Organisation, *The State of World Fisheries and Aquaculture (2010)*

- The Northwest Pacific leads the ranking of marine fishing areas, followed by the Southeast Pacific, the Western Central Pacific and the Northeast Atlantic. The Indo-Pacific region accounts for 45% of global fisheries production.

- The proportion of marine fish stocks estimated to be underexploited or moderately exploited declined from 40 percent in the mid-1970s to 15 percent in 2008, whereas the proportion of overexploited, depleted or recovering stocks increased from 10 percent in 1974 to 32 percent in 2008. The proportion of fully exploited stocks has remained relatively stable at about 50 percent since the 1970s. In 2008, 15 percent of the stock groups monitored by FAO were estimated to be underexploited (3 percent) or moderately exploited (12 percent) and able to produce more than their current catches. This is the lowest percentage recorded since the mid-1970s. Slightly more than half of the stocks (53 percent) were estimated to be fully exploited and, therefore, their current catches are at or close to their maximum sustainable productions, with no room for further expansion. The remaining 32 percent were estimated to be overexploited (28 percent), depleted (3 percent) or recovering from depletion (1 percent) and, thus, yielding less than their maximum potential production owing to excess fishing pressure, with a need for rebuilding plans. The increasing trend in the percentage of overexploited, depleted and recovering stocks, and the decreasing trend in underexploited and moderately exploited stocks give cause for concern. Most of the stocks of the top ten species, which account in total for about 30 percent of the world marine capture fisheries production in terms of quantity, are fully exploited.

3. Reasons for cooperation

Cooperation is required when the actions of one state cannot secure the sustainable use, conservation and management of a fisheries resource. There are three broad instances where the distribution of a fisheries resource, and its shared nature, require international cooperation and management.

Straddling fish stocks are those stocks inhabiting a water body which is shared by two states or more. This may include lakes and rivers, contiguous waters under national jurisdiction (territorial

waters and EEZs) involving two states or more, or EEZs and the high seas where a number of states may utilize the fisheries resource while it is on the high seas.

Highly migratory fish stocks move long distances through territorial seas, EEZs and the high seas. They are listed in Annex 1 of the United Nations Convention on the Law of the Sea (UNCLOS). Whales are not included in Annex 1.

High seas fish stocks are those stocks fished entirely on the high seas that are neither highly migratory in nature nor straddling. In such instances, it is necessary for those states utilizing those fish stocks to cooperate in their conservation and management.

4. International institutional basis for cooperation

A variety of hard and soft laws are available to guide the conservation and management of shared fisheries resources. Hard laws include:

- 1958 High Seas Convention
- 1982 United Nations Convention of the Law of the Sea (UNCLOS)
- 1995 Implementing Agreement of the UNCLOS for the conservation and management of straddling fish stocks and highly migratory fish stocks (UN Fish Stocks Agreement)
- 1979 Convention on Migratory Species (CMS)
- 1973 Convention for International Trade in Endangered Species (CITES)
- 1993 Convention on Biological Diversity (CBD)

The principle basis for international cooperation on the conservation and management of shared fish stocks is drawn from Articles 61, 63, 64, 66 and 67 of UNCLOS. The duty to cooperate on the conservation and management of straddling fish stocks and highly migratory fish stocks was further elaborated in the 1995 UN Fish Stocks Agreement (UN FSA). Articles 8 to 14 inclusive of the UN FSA describe the basis for cooperation, including through sub-regional or regional fisheries management organizations or arrangements. The functions of such arrangements are described at Article 10.

Soft laws include the 1995 FAO Code of Conduct for Responsible Fisheries, associated International Plans of Action and Technical Guidelines and the outcomes of significant global events such as the World Summit on Sustainable Development.

Global attention to the conservation and management of marine resources in areas beyond national jurisdiction has increased in the last 5 years particularly in relation to the protection of ecological and biologically significant areas (EBSAs) and the impacts of bottom fisheries on vulnerable marine ecosystems. Discussions in relation to these matters, and means to conserve and manage EBSAs in areas beyond national jurisdiction (ABNJs), are being progressed through several fora. These include United Nations processes to promote sustainable fisheries and in the Convention on Biological Diversity in relation to EBSAs and access- and benefit-sharing supported under the Nagoya Protocol. Vulnerable marine ecosystems, and the means to conserve them, such as through the establishment of systems of marine protected areas, was a key topic discussed at the Rio+20 Earth Summit in 2012.

5. Examples of multilateral fisheries cooperation in the Indian Ocean, Asian and Pacific regions

5.1. Inter-American Tropical Tuna Commission

Until August 2010, the Inter-American Tropical Tuna Commission (http://www.iattc.int)[39] operated under the authority of a convention originally entered into by Costa Rica and the United States in 1949. In August 2010, a new convention, the Antigua Convention, which was negotiated to strengthen and replace the 1949 Convention establishing the IATTC, entered into force. IATTC manages a tropical fishery for tunas in the Eastern Pacific Ocean (west from the Central and Latin American seaboard to 150W) that harvests around 700,000 tonnes annually.

5.2. Western and Central Pacific Fisheries Commission

The Western and Central Pacific Fisheries Commission (http://www.wcpfc.int)[40] was established by the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPF Convention) which entered into force on 19 June 2004. The Convention was concluded after six years of negotiation which commenced in 1994. The period between the conclusion of the Convention and its entry into force was taken up by a series of Preparatory Conferences that laid the foundations for the Commission to commence its work. WCPFC manages a fishery in the tropical western Pacific (west from 150W to the Asian seaboard) that harvests 2.4 million tonnes annually.

5.3. Asia Pacific Fisheries Commission

The Asia-Pacific Fishery Commission (http://www.apfic.org)[41] was established under the APFIC agreement as the Indo-Pacific Fisheries Council in 1948 by FAO as an Article XIV FAO Regional Fishery Body. The purpose of the Commission is to promote the responsible utilization of living aquatic resources by the development and management of fishing and culture operations and by the development of related processing and marketing activities. APFIC provides a forum for APFIC members to share information and resources on a broad range of inland and marine resources issues including climate change, illegal, unregulated and unreported (IUU) fishing, ecosystem considerations and social and economic issues. Unlike the other organizations profiled here (IATTC, WCPFC and IOTC), it does not have a management function with associated capacity to adopt and apply regulations and compliance obligations.

5.4. Indian Ocean Tuna Commission

The Indian Ocean Tuna Commission (IOTC) (http://www.iotc.org)[42] is an intergovernmental organization established in 1996 under Article XIV of the FAO Constitution with a mandate to manage tuna and tuna-like species in the Indian Ocean and adjacent seas. Its objective is to promote cooperation among its Members with a view to ensure, through appropriate management, the conservation and optimum utilization of stocks and encourage sustainable development of fisheries based on such stocks. The IOTC currently manages a tuna harvest of around 1 million tonnes annually.

There are other multilateral arrangements within this large geographic region that support multilateral cooperation on the sharing of fisheries data and information, and/or the conservation and management of shared fisheries resources. These include arrangements for fish stocks in the

[39] IATTC has 21 members, 11 of which are also members of PECC.
[40] Of its 25 members, 10 WCPFC members are also members of PECC. Chinese Taipei is a Member of WCPFC, IATTC and PECC.
[41] Eleven of APFIC's 22 Members are members of PECC.
[42] Nine of IOTC's 29 members are members of PECC.

Yellow Sea, the South China Sea, the Bay of Bengal, North Pacific catadromous fish stocks and North Pacific benthic fisheries resources, the riverine resources on the Mekong River and an arrangement for the conservation and management of non-tuna resources in the South Pacific that entered into force in mid-2012. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) manages a single global fish stock in temperate and southern latitudes, while the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) manages fishing activity in the Southern Ocean.

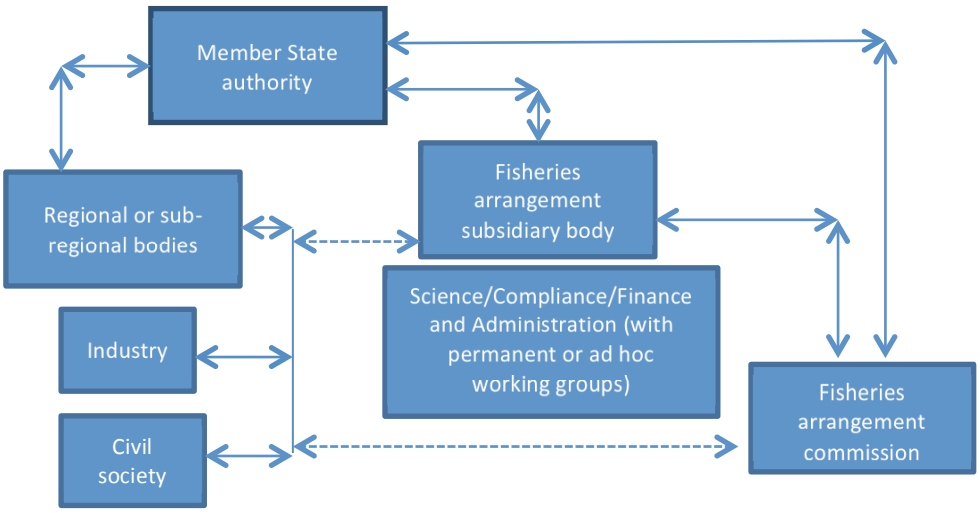
6. The structure of multilateral fisheries arrangements

The institutional structure for multilateral fisheries arrangements with a management function is similar. A commission is usually established as the principle decision-making body. A variety of subsidiary bodies usually function to provide commissions with advice and recommendations. Such subsidiary bodies generally include a scientific committee, a compliance committee and a finance and administration body. Most organizations provide for the establishment of short-term or permanent working groups that may advise the subsidiary bodies on specific technical or policy matters.

Some arrangements in some ocean regions may include additional sub-regional or regional arrangements which are comprised of some of the membership of the full commission. Such sub-regional or regional arrangements may provide a sub-set of the commission's full membership with specific technical and policy advice. This is the situation for the Western and Central Pacific Fisheries Commission where the interests of Small Island Developing States in the Commission are serviced by three sub-regional agencies – the Parties to the Nauru Agreement, the Forum Fisheries Agency and the Secretariat for the Pacific Community.

Almost all multilateral fisheries arrangements support roles for the participation of industry and representatives from non-government organizations in their work albeit not in a decision-making capacity.

Figure 2. *General institutional structure for multilateral fisheries arrangements. Not all multilateral arrangements accommodate a role for sub-regional or regional arrangements that cater for a sub-set of the broader membership of the multilateral fisheries arrangement.*



7. Tools and measures employed by multilateral cooperative arrangements

In most multilateral arrangements for fisheries conservation and management, decisions are formalized in a statement adopted by consensus by the governing body of the organization. The decisions are frequently referred to as "Conservation Measures", "Conservation and Management Measures" or "Resolutions". They may be binding or non-binding in nature and be fixed-term or subject to periodic review.

The means to encourage compliance with the regulatory environment put in place by multilateral fisheries arrangements is supported through a suite of integrated measures and tools including, but not limited to:

7.1. Catch reporting and data sharing obligations

Data collection and sharing procedures are mandatory in almost all multilateral arrangements in fisheries. Data, which includes data generated from commercial fishing operations and research initiatives, is the fundamental basis for supporting the science that underpins decision-making in these institutions. In recognition of commercial sensitivities some operational level data from individual fishing vessels is generally not available in the public domain. It may only be released subject to formal data sharing and security agreements established by each institution.

7.2. Positive and black vessel lists

Positive vessel lists are centrally administered by the secretariats of multilateral cooperative arrangements. Such lists contain details of the characteristics of individual vessels, ownership history and flag State details, including authorizations issued by the 'flag state' in relation to species, seasons and/or fisheries in which the vessel has been authorized to fish.

Black lists are administered by multilateral arrangements to dissuade illegal, unreported and/or unregulated fishing (IUU fishing). Black lists contain the known details of vessels that have been confirmed to have been involved in undermining the conservation and management measures established by multilateral conservation and management organizations. Black lists are often reciprocally recognized by different organizations. As a result, a vessel blacklisted by one organization will result in that vessel being denied fishing opportunities in the convention areas of other organizations. Although not infallible, this has proven to be an effective regulatory tool to deter non-compliant fishing operations.

Both positive and black lists are generally in the public domain.

7.3. Catch Documentation Schemes

Catch Documentation Schemes (CDS) are designed to apply to all fish, from the point of first capture by a 'flag state' through domestic and international trade pathways to the 'state of final presentation' of that fish for sale. CDS provide evidence that fish have been caught legally and in compliance with applicable regulations and management measures. CDS are designed to make it more difficult for fish originating from operations that undermine agreed conservation and management measures or regulations adopted by multilateral fisheries management arrangements to legitimately enter global fish trade.

7.4. Port State measures

'Port states' may elect to implement measures that govern the entry to, and activities in, its ports by foreign fishing vessels. Measures may include denial of access to port facilities, including unloading, for vessels that are understood to have been involved in activities that undermine fisheries

conservation and management arrangements. In 2009, FAO member states adopted the text for an international agreement concerned with port state measures. It will enter into force when 25 states have ratified it (http://www.fao.org/Legal/treaties/list1-e.htm).

7.5. Satellite-based vessel monitoring

Vessel Monitoring Systems (VMS) using satellites are common in domestic and high seas fisheries to assist national or multilateral fisheries monitoring of fishing vessels. National fisheries management and licensing authorities, and regional fisheries management organizations utilize VMS to, at a minimum, provide vessel information such as the position, time at a position, course and speed of fishing vessels. These systems are also increasingly supporting close to real-time catch reporting by vessels to appropriate fisheries authorities.

7.6. Ship-based observer programs

Trained observers are commonly deployed on fishing vessels, or vessels that receive transshipments of fisheries product from fishing vessels, to provide independent information on fishing operations. Observers may be deployed for the purposes of collecting catch data, scientific information or contributing to onboard research programs. Some observer programs also support a monitoring role where observers report on the compliance of fishing vessels with conservation measures and fisheries regulations.

7.7. Aerial surveillance

Some national fisheries authorities and members of multilateral fisheries arrangements support aerial surveillance operations to monitor the activities of fishing vessels. Such operations usually are undertaken in conjunction with other surveillance activities such as at-sea surveillance undertaken by navies or coast guards. It is common for such operations to utilize information generated by VMS to assist with targeting specific areas of interest for surveillance.

8. Challenges

The key challenges for multilateral fisheries arrangements include, but are not limited to:

- Increasing populations and pressures associated with providing sustainable livelihoods and food security for those populations;
- Environmental degradation and threats to ecosystem services associated with habitat loss including from destructive fishing practices and land-based sources of pollution;
- Supporting sustainable fisheries arrangements that take adequate account of environmental changes arising from climate change;
- Weak national or multilateral governance arrangements manifested in on-going support for un-economic fisheries operations through the provisions of subsidies, poor flag and port state compliance, illegal, unreported and unregulated (IUU) fishing, and decision-making processes that do not adequately take account of the best available scientific evidence; and
- Lack of data from fisheries operations which results in uncertainties associated with the analysis of the status and trends of fisheries stocks, including inadequate support for fishery-independent research programs.

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Coastal Conservation Practices (Satoumi) and Marine Protected Areas in Japan: Institutional approach

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1. Satoyama and Satoumi

The *Satoyama* Initiative was adopted at the tenth meeting of the Conference of Parties (COP10) of the Convention on Biological Diversity (CBD) held in October 2010 in Nagoya, Japan. The COP10 specifically recognizes "The *Satoyama* Initiative as a potentially useful tool to better understand and support human-influenced natural environments for the benefit of biodiversity and human well-being" (Page 260; UNEP/CBD/COP/10/27).

Satoyama is a Japanese word meaning "mountains in human residential areas", as the term *sato* means "residential area" and *yama* means "mountain" in Japanese. The marine and coastal version of *Satoyama* is called *Satoumi* ("the sea in human residential areas"), where the term *umi* means "sea".

Satoyama and *Satoumi* are Japanese concepts for long-standing traditions associated with land and coastal management practices. These traditions have allowed sustainable use of natural resources and provide historical models for environmental stewardship and resource management that contributes to human well-being[43].

The management practices usually take a form of a stakeholder initiative to conserve and sustainably use the ecosystem services. Collective efforts by stakeholders (local residents) for resource managements started before the Edo-era which ended in 1868, when feudal landlords granted a right for local fishers or foresters to manage and harvest the resources in return of levying a portion of the harvest as tributes.

At that time, marine resources were particularly important to fulfill the dietary needs of the residents. Japanese people did not eat cattle animals for religious reasons and so the main source of protein was seafood. Despite the widespread demands, marine and coastal resources have been sustained for centuries through the collective efforts by the people. There are records, for instance, which indicate the sustainable use of coastal abalone resources for more than 600 years in some coastal villages in Japan.

Satoumi activities are still ongoing at various coastal communities in Japan. The Meiji Government, established in 1868, rigorously surveyed traditional local fishery management rules and attempted to incorporate them in its legal system (Takahashi, 2007). The current Government issues licenses called "fishery rights", which allow exclusive harvest of fishery resources by local fishermen in specified areas. It does not levy a portion of the harvest as tributes anymore, but does collect taxes and licensing fees. This system is considered to provide continued incentives for local fishers to collectively manage their own resources in order to maximize the long-term economic benefits of the marine resources.

[43] United Nations University, *Satoyama-Satoumi Ecosystems and Human Well-being*, 2010 http://www.ias.unu.edu/sub_page.aspx?catID=111&ddlID=1418

2. Marine Protected Areas in Japan

Various Marine Protected Areas (MPAs) and various conservation activities in other areas have been created as bottom-up, self-imposed instruments for local communities. Many local rules, however, have been left unlisted in the government regulations until now, presumably because they are too parochial. Such local rules are implemented in the present days as self-imposed agreements among local fishing communities and a complete picture of these conservation activities has been largely unknown until now.

A survey was conducted by a team from the University of Tokyo during late 2009 to early 2010 in an effort to grasp a comprehensive picture of MPAs in coastal Japan. As a result, the survey identified 1,161 locations of MPAs in Japan (Yagi et al., 2010).

Table 1. *Number of MPAs in Japan*

MPA type	Management authorities	Legal framework	Number of sites
Marine park areas	Ministry of the environment	Natural parks law	82
Marine special areas	Ministry of the environment	Nature conservation law	1
Wildlife protection areas	Ministry of the environment	Wildlife protection and appropriate hunting law	23
Protected waters	Ministry of agriculture, forestry, and fisheries	Act on the protection of fisheries resources	52
Legally-binding no-take zones	Ministry of agriculture, forestry, and fisheries	Prefectural fishery coordinating regulations	616
Community-based self-imposed no-take zones	Local fisheries cooperative association (FCA)	Published and unpublished FCA rules	387

Source: Yagi et al., 2010

Table 1 shows the number of MPAs in Japan grouped by their management mechanisms. Protection is provided through various legal instruments. The six types of MPAs are:

- Marine park areas, established by the Natural Parks Law and managed by the Ministry of the Environment;
- Marine special areas, established by the Nature Conservation Law and managed by the Ministry of the Environment;
- Special protected zones inside the Wildlife Special Protection Areas, which are established by the Wildlife Protection and Appropriate Hunting Law and managed by the Ministry of the Environment;
- Protected waters, established by the Act on the Protection of Fishery Resources, managed by the Ministry of Agriculture, Forestry and Fisheries;
- Legally binding no-take zones of aquatic animals and plants established under the Fishery Act and prefectural fishery coordinating regulations and managed by the Ministry of Agriculture, Forestry and Fisheries); and
- No-take zones established through self-imposed agreements among the members of the Fishery Co-operative Associations (FCAs).

Of the 1,161 locations, 1,055 (52+616+387) are implemented in conjunction with fishery regulations. Specifically, they take the form of no-take zones of fishery species. The actual number of bottom-up self-imposed MPAs (387 locations in the study) had not been available for many years in Japan, and this study is the first publication to show that approximately 30% of all MPAs in Japan are community-based, self-imposed no-take zones.

MPAs managed by the Ministry of the Environment take a top-down approach where the central government is the major driver of conservation, while MPAs managed by the MAFF (Ministry of Agriculture, Forestry and Fisheries) take a bottom-up approach in which the informal functions of local FCAs are critically important.

The total size of MPAs in Japan was not provided by this study. Information on possible overlaps between different types of MPAs, as well as the exact size of some areas in community-based, self-imposed no-take zones is missing and thus an accurate calculation of the total coverage is difficult at this stage (Yagi et al, 2010).

3. Nature of area-based management in coastal fisheries

The relevance of the number of such no-take zones can be explained by the management system of fisheries in Japan.

As noted above, traditional Japanese fishery management systems are based on limited entry system and area allocations. At present, fishing areas are allocated to FCAs through the government licensing system. These area allocations are, in many cases, based on a traditional tenure system of managing coastal fishery resources which assume a right-based co-management of resources in the community.

The number of the FCAs in Japan was 1,092 as of March 31, 2009, according to the fisheries agency of the Government of Japan. Many FCAs each owned one no-take zone, while other FCAs had two or more while some others had none. The number of no-take zones roughly corresponds to the number of FCAs, which function as local co-management units of coastal fisheries in Japan (Yagi et al., 2010).

A question may arise on how to enforce regulations in self-imposed areas. Yagi et al (2010) explained a mechanism for compliances of the rules as follows:

First, self-imposed no-take zones carry certain economic relevance when implementing peer monitoring among the members of same FCAs. Because the limited entry system in coastal fisheries is strictly maintained by the fisheries' right regime imposed by the government, the people who belong to a same FCA assume long-standing rights to collectively use fishery resources in their waters. In other words, the same group of fishermen bears the cost of conservation and receives the benefits inside their local waters. Once they mutually agree to create a no-take zone as a mean to maximize their collective benefit, they have a strong incentive to adhere to it and peer-monitoring activities would be initiated to deter poachers. Several fishermen informed the authors that they, in fact, monitor positions of boats of their peers in the sea using vessel positioning devices, cell-phones or other communication tools. Sanctions among co-operative members and the local societies are often levied in the case of infringement.
Secondly, self-imposed no-take zones are perceived as being just as legally binding as other no-take zone agreements among FCA members. The majority of legally binding no-take zones and protected

waters listed in prefectural fishery coordinating regulations are considered to be originated from historical voluntary no-take zones in the past. Community-based coastal fisheries management started more than 250 years ago in Japan (Aotsuka, 2000). The records show that the fishery regulations of Tokushima prefecture, for instance, which were enacted in 1895, contained provisions of closed areas and seasons. Such provisions were not a new creation at the time of the legislation about 115 years ago, but merely a legalization of measures that already existed as self-imposed community rules (Aotsuka, 2000). This observation is reasonable judging from the fact that a new creation of no-take zones from scratch usually requires more transaction cost than just reauthorizing already existing customary rules. It can be argued that, because starting points of voluntary and legally binding no-take zones were similar, the members in FCAs tended to adhere to both rules in similar manners.

The question is then: why are so many self-imposed MPAs left unlisted in the government's legal framework? FCAs usually have both published and unpublished rules, but many MPAs are unpublished. Yagi et al. (2010) explains the reason why some of them are left unpublished in official documents as follows: first, the non-binding rules are relatively new and therefore missed the timing of major revisions of prefectural fishery coordinating regulations. Members of FCAs would prefer to avoid the rigorous documentation process required to register such areas as legally authorized protected areas, when good compliance for such local MPAs are maintained even without the formal legal status. Second, fishermen prefer flexibility in protecting migratory species. In the case of the sand eel fishery in Isebay, the area of autonomous MPAs changes weekly to allow timely escapement of moving fish stocks (Matsuda et al, 2010). If the regulation was legalized, it would not be fully adaptive to the rapidly changing biological distributions of target protected species of the protection (Yagi et al., 2010).

4. MPAs and *Satoumi*

Activities of *Satoumi* are not limited to the creation of self-imposed MPAs. They also include positive interaction with the environment such as habitat rehabilitations or tree planting in upstream rivers to help maintain water quality throughout the river. They include sea-grass planting, sediment removal from the ocean bottom, removal of alien species or tree planting adjacent to upland rivers to improve the water quality entering the ocean. However, such activities which contribute to the environmental conservation are not counted in the same manner as MPAs according to the study by the University of Tokyo. Nonetheless, such activity should also be accounted for as long as its marine or coastal biodiversity benefits from a higher level of protection as do MPAs.

Reports on many such activities are available through various publications and websites[44].

As for the discussion on the CBD, attention should be given not only to the total area coverage of MPAs but also to *Satoumi* activities, which include various bottom-up conservation activities of local stakeholders. This would render fair and holistic evaluation of marine conservation activities.

5. Future challenges of Japanese-style Satoumi and MPAs

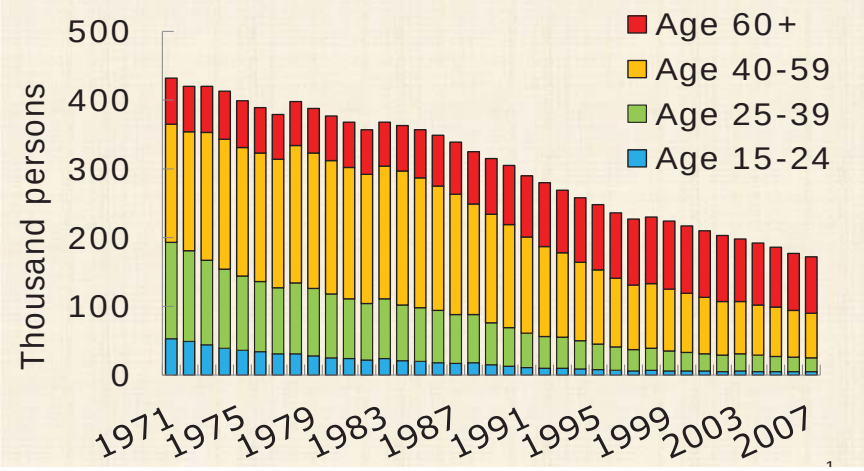
Japanese-style *Satoumi* and MPAs require labor-intensive activities, such as monitoring and controlling of the sea and coastlines. This could bring economic disadvantages to Japanese coastal fisheries. In fact, foreign products are dominant in the Japanese market and approximately 50%

[44] For instance, http://hitoumi.jp/hozen

value of fishery products sold in Japan is imported. Exports of Japanese fishery products are minimal. This suggests that Japanese fisheries are less competitive compared to their exporting rivals.

Additionally, as a result of weak economic performance and low income levels, the workforce in the Japanese fishing industries - mostly coastal small-scale fishermen - is on the decline. Finally, that same workforce is gradually ageing due to unsuccessful recruitment and overall decline in attraction to the fishing industry.

Figure 1. *Number of male fishermen in Japan*



Source: Ministry of Agriculture, Forestry and Fisheries, Japan

There are apparent trade-offs between economically efficient fisheries on the one hand and autonomous MPA systems on the other hand under *Satoumi*. Ostrom et al. (1999) pointed out that users of resources must be interested in the sustainability of that particular resource so that the expected benefits will outweigh current costs. To this end, the role of the government is important in keeping the non-stakeholders from gaining access to no-take zones. This is exactly the case in Japan. The fishery rights issued by the government allows exclusive access by the license-holder to Japanese coastal fishery resources, and is treated as a non-transferrable property right under the Fishery Act. In return, FCAs are expected to establish their collective management rules for resource exploitation in allocated area. Such stringent limited-entry system is a key foundation for the *Satoumi* and autonomous MPA systems but it also poses as a barrier to new recruitments in the fishing sector in Japan.

Viability of this system is at risk as long as fishermen are exposed to international competition on economic efficiency, without a proper compensation for the cost they voluntary pay for peer-monitoring and other transactions to maintain the *Satoumi* and autonomous MPA systems.

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Critical Indicators on Marine Spatial Planning and Community Renaissance around Turtle Island

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Abstract

In recent years, Marine Spatial Planning (MSP) and community renaissance have become the mainstream for coastal zone management. In 2006, a White Paper on Marine Policy was also planning to set Turtle Island on the map of Marine Protected Areas (MPA), but was unable to do so as Turtle Island was near an important economic fishing ground. Therefore, this study will focus on MSP and critical indicators on community renaissance. We started with interviews with experts and scholars of coastal management, as well as local representatives. We also referred to related literature, set environmental sustainability, industrial developments and social justice as a dimension for our analysis, and used the Delphi Method to design the questionnaire submitted to experts and stakeholders to gather their attention factors and satisfaction on MSP and community renaissance. Finally, we used Factor Analysis (FA) to identify important key factors. Empirical results show that the three dimensions of weighting order are (a) social justice, (b) environmental sustainability and (c) industrial development. Sustainable use, natural resources and landscape maintenance are factors of the environment dimension. The traditional industry sector puts more weight on the industrial dimension than leisure service and innovative industries. Policies and laws have more weighting than community development and cultural inheritance. On the other hand, the cross-analysis of attention and satisfaction factors showed that monitoring non-take zone in marine protected area and implementing coastal management and marine education are important key factors to improve. This study suggests four protected areas of marine spatial planning around Turtle Island, namely (a) fisheries resource, (b) submarine hydrothermal vent, (c) coral reef resource and (d) whale-watching. The paper is proposing possible management of development after the planning period, recommending an enhanced concept of conservation through communication and educational promotion, and increasing the support from stakeholders and law enforcement from the community.

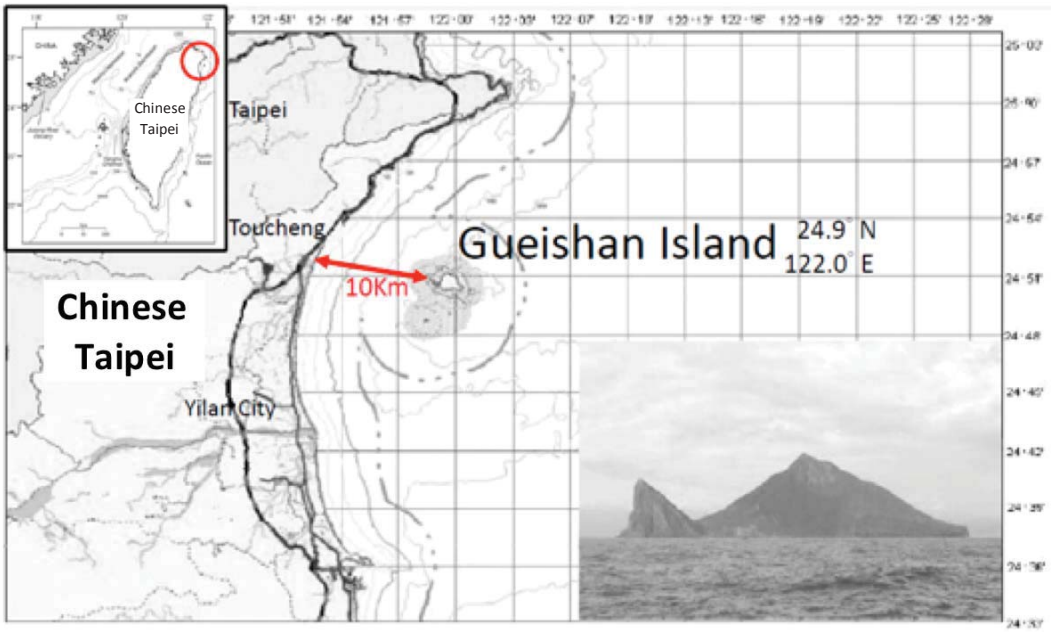
1. Introduction

In recent years, Marine Spatial Planning (MSP) has emerged as an international ocean governance trend. MSP is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process[45]. Characteristics of marine spatial planning include ecosystem-based, area-based, integrated, adaptive, strategic and participatory[46]. In 2006, the Chinese Taipei administration set up the "White Paper of Marine Policy", which was planning to set Turtle Island on the map of Marine Protected Areas[47]. But it was unable to achieve this as Turtle Island was near an important economic fishing ground[48].

[45] UNESCO, 2010
[46] Shao, 2004
[47] Council of Marine Affairs Advancement, Executive Yuan, 2006
[48] Chuang, 2009; Chuang et al., 2009

This study focuses on MSP and critical indicators on community renaissance around Turtle Island. The geographical position of Turtle Island is 122.0° E and 24.9° N. The island is located northeast offshore of Chinese Taipei and is within the jurisdiction of Toucheng Township, Yilan County (see Figure 1). Being on the path of the Kuroshio Current, the waters around Turtle Island are environmentally complicated and have biologically diverse fisheries with abundant commercial fish stocks[49]. With the advancement of the tourism industry and after the maritime prohibition was lifted, people in Chinese Taipei have been increasingly keen on marine recreational activities. This has not only made Turtle Island a favorable fishery spot but also a popular tourist attraction.

Figure 1. *Location of Turtle Island*



Turtle Island possesses one of the few remaining primary forests, home to 300 varieties of vascular plants and nearly 150 species of animals. The island records a total of 21 families and 33 species of birds, most of which are not resident but migratory birds[50]. The insects, amphibians and reptiles on the island take up 15% of the total population found in Chinese Taipei. The waters around the island are rich in marine biological resources and unique in water flow structures. There are 45 families and 298 kinds of marine mammals, commercial fishes and shrimps, and corals fish which gather around 87 different kinds of corals[51]. Shallow-water hydrothermal vents off Turtle Island create very rare ecological environments because most of the hydrothermal vents are normally located in deep seas. The *Xenograpsus testudinatus*, which was found in these shallow-water hydrothermal vents in 1999, is a new specie of crab[52].

As for the fishery economy, fishing activities surrounding Turtle Island are mostly inshore fishing, with a total volume of 84,055 tons valued at US$3,024,988. This production accounts for 84.62% of the volume and 70.91% the value of Yilan County's total fisheries[53]. Although the tourism activities around Turtle Island were helpful to the local economy, they also created some problems like pollution, habitat degradation, biological interference, noises and landscape imbalances which can

[49] Chiang, 2006
[50] Gueishan Island Community Development Association, 2007
[51] Hwang, 2007
[52] Kuo, 2001
[53] Yilan County Government, 2009

easily impact the ecosystem of the surrounding marine environment[54]. In fact, the marine resources around Turtle Island are gradually being overexploited. Problems arising from inshore fisheries activities include: weak policy-making mechanism; poor implementation and inefficient solutions in addressing conflicts; lack of awareness of precautionary measures in the industry; and shortage of local manpower and funds[55]. Hence, these are important topics of discussion. This study identifies Turtle Island MSP's important key factors for fishermen, fisheries, economic and community development. The final conclusions lie with the Government's planning reference developed for Turtle Island MSP policies.

2. Research method

This study focuses on MSP and critical indicators on community renaissance. First, we have interviewed experts and scholars of coastal management and local representatives. We have also referred to related literature, environmental sustainability, industrial development and social justice which are cited as analysis dimensions. We have used the Delphi Method is used to design the questionnaire to gather expert and stakeholders' attention factors and their satisfaction on MSP and community renaissance. Finally, we use Factor Analysis (FA) to identify Turtle Island MSP's important key factors for fishermen, fisheries, economic and community development. The questionnaire addressed three areas: environmental and ecological sustainability, industrial economic development and social justice. Each area has three directions and 15 factors (see Table 1).

***Table 1**. Perspective target construction*

Surfaces	Direction	Factors
A. Environmental and ecological sustainability		
	a. Natural resource	
		1. The uniqueness of endemic species (Aa1)
		2. Diversity of marine life (Aa2)
		3. Marine fishery resource abundance (Aa3)
		4. Particularity of submarine volcanic geology (Aa4)
		5. Coral reef habitats of the original species (Aa5)
	b. Landscape maintenance	
		1. Marine pollution monitoring (Ab1)
		2. Artificial reduction in coastal landscape (Ab2)
		3. Ruins and fishing village beautification (Ab3)
		4. Turtle Island history, animal and plant maintenance (Ab4)
		5. Unique intertidal ecology of original species (Ab5)
	c. Use continuing forever	
		1. Artificial reefs (Ac1)
		2. Marine protected area designation (Ac2)
		3. A forbidden fishing zone (phase) monitoring (Ac3)
		4. Purpose of fishing vessel operations and network restriction (Ac4)
		5. Fish fry releasing and ecological assessment (Ac5)
B. Industrial economic development		
	a. Traditional industry	
		1. Stability of traditional fishery income (Ba1)
		2. Set-fisheries exploitation and utilization (Ba2)
		3. Coast capturing business planning management (Ba3)

[54] Chuang et al., 2008
[55] Fan, 2006

4. Total amount of coral reef fishery capture control (Ba4)
5. Fishing port and tourist fish market transformation (Ba5)

b. Innovation industry

1. Blue highway construction (Bb1)
2. Marine Aquarium and museum management (Bb2)
3. Diversification of fishing village and fishing port (Bb3)
4. Fishermen's brand product development (Bb4)
5. Marine research and development of green energy industry (Bb5)

c. Leisure service

1. Island tour guide professionals (Bc1)
2. Self-guided bike path (Bc2)
3. Local hand-made arts advocacy and succession (Bc3)
4. Diversification of Riviera Beach leisure activities (Bc4)
5. Marine and recreational industry (yacht) (Bc5)

C. Social justice

a. Community development

1. Community establishment and training (Ca1)
2. Promotion of Community transit and infrastructure (Ca2)
3. Capacity of the community from the bottom up construction (Ca3)
4. Community care and health conditions (Ca4)
5. Residents cleaning beaches and fishing port of initiative (Ca5)

b. Policy and law

1. Sea recreation area tourist volume control (Cb1)
2. Sea area of open space activities Act (Cb2)
3. Management of whale- and dolphin-watching (Cb3)
4. Marine environmental education policy (Cb4)
5. Top-down government policy support (Cb5)

C. Cultural inheritance

1. Preservations to fishing village life and customs (Cc1)
2. Education of cultural and creative industries (Cc2)
3. Poseidon Temple and celebration of cultural continuity (Cc3)
4. Fishermen's knowledge network (Cc4)
5. Cooperation with local activities (Cc5)

This study included both a survey questionnaire and an in-depth face-to-face survey. The questionnaire focused on two townships (Toucheng and Suoa) and the respondents were comprised of fishermen, staff of fishermen's associations and fisheries experts and scholars. The in-depth face-to-face survey used semi-structured interviews of stakeholders and was carried out to survey relevant MSP issues and concerns. There were seven interviewees: five local fishermen or representatives and two government personnel. The initial survey addressed specific issues in particular ocean areas. As a result targeted sampling was applied to collect representative samples. The design of the questionnaire was based on Delphi sampling and its content included basic information and current status of fishing operations, the understanding of marine resources on Turtle Island, fishermen's opinions and ideas about the establishment of a MSP in Turtle Island, and fishermen's cooperation and expectations of an MSP in Turtle Island. The questionnaire was designed with the Likert five point scales, where number 1 signifies strong disagreement and number 5 represents strong agreement. A total of 60 questionnaires were distributed, 57 questionnaires were collected and 45 were accepted for purpose of this study. The response rate was 75%.

3. Empirical results and analysis

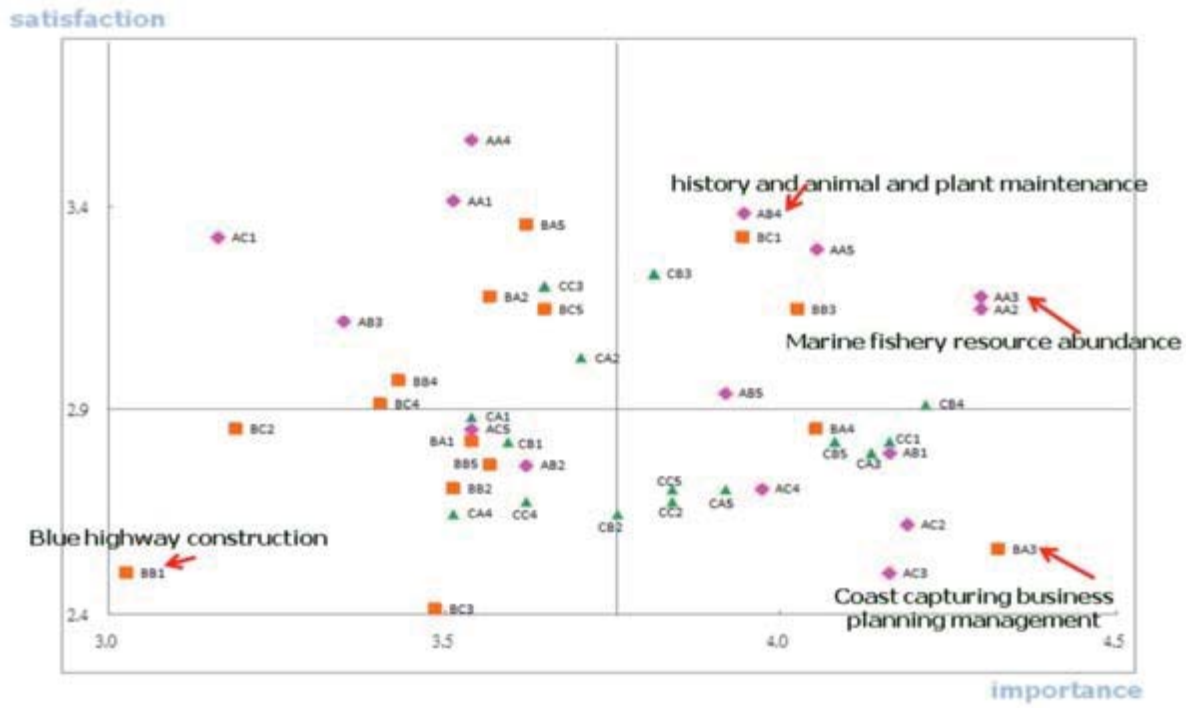
The survey results and findings are as follows. All 91% of the interviewees were in favor of MPA, 9% of the interviewees objected; 96% of the experts were in favor, 4% of the experts objected; 83% of the stakeholders were in favor, 13% objected, and 4% had no opinion. The reasons behind experts objecting to MPA were: MPA set-up should be based on specific and accurate scientific data and materials, and any decision-making process should fully take into consideration stakeholders' and fishermen's concerns.

Out of 45 factors, interviewees' principal concerns were: coast capturing business planning management (Ba3), diversity of marine life (Aa2), marine fishery resource abundance (Aa3), marine environmental education policy (Cb4) and marine protected area designation (Ac2).

In terms of principal satisfaction, the preference was placed on submarine volcanic geology (Aa4), the uniqueness of endemic species (Aa1), Turtle Island history and animal and plant maintenance (Ab4), fishing port and tourist fish market transformation (Ba5), installation of artificial reefs (Ac1). Interviewees remained confident on the geological environment and ecological species of the volcanic sea floor around the island, and the development of history and. The least satisfaction came from art and craft development.

In the cross analysis of importance and satisfaction (see Figure 2), factors of high importance and low satisfaction were: coast capturing business planning management (Ba3), a forbidden fishing zone (phase) monitoring (Ac3), and marine protected area designation (Ac2). This implies that the interviewees placed importance on management and control aspect.

Figure 2. *Cross analysis of importance and satisfaction*



In analyzing factors of environmental and ecological sustainability, there were two principal components: (1) biodiversity conservation, and (2) marine environmental resource control (Table 2).

In terms of industrial economic development, there are three principal components: (1) sightseeing and recreation building, (2) ecology and tourism management, and (3) industrial heritage and innovation (see Table 3). Sightseeing and recreation building have highest proportion (21.177%) of principal components, this imply interviewees importance sightseeing and recreation building on Industrial economic development.

Table 2. *Factor analysis for environmental and ecological sustainability*

project	factor loading	eigenvalue	proportion	cumulative proportions
principal components 1: Biodiversity conservation				
Ac1	0.828	4.704	39.197	39.197
Aa1	0.797			
Ab3	0.788			
Aa4	0.771			
Ab4	0.743			
Ac5	0.717			
Ab2	0.714			
Aa2	0.620			
principal components 2: Marine environmental resource control				
Ac3	0.818	2.497	16.646	48.189
Ab5	0.755			
Ac4	0.734			
Ab1	0.588			

Table 3. *Factor analysis for industrial economic development*

project	factor loading	eigenvalue	proportion	cumulative proportions
principal components 1: Sightseeing and recreation building				
Bb1	0.838	2.541	21.177	21.177
Bb4	0.748			
Bc5	0.675			
Bc2	0.568			
principal components 2: Ecology and tourism management				
Ba4	0.804	2.496	20.798	41.975
Bc1	0.709			
Ba3	0.664			
Ba2	0.626			
principal components 3: Industrial heritage and innovation				
Bb2	0.803	2.443	20.359	62.334
Ba5	0.737			
Ba1	0.714			
Bc3	0.691			

In terms of social justice, there are three principal components: (1) autonomous community development, (2) sustainable tourism and network platform construction, and (3) Policy Act to support and enforce rights (see Table 4). Autonomous community development has the highest proportion (26.452%) of interviewees' preference in terms of social justice.

Table 4. *Factor analysis for social justice*

project	factor loading	eigenvalue	proportion	cumulative proportions
principal components 1: Autonomous community development				
Cb1	0.787	3.174	26.452	26.452
Cc3	0.776			
Ca1	0.739			
Cc2	0.717			
principal components 2: Sustainable tourism and network platform construction				
Cb3	0.797	2.750	22.914	49.367
Cc5	0.793			
Ca2	0.636			
Cb4	0.546			
Cc4	0.441			
principal components 3: Policy Act to support and enforce rights				
Cb5	0.805	2.011	16.762	66.129
Cb2	0.680			
Ca3	0.652			

4. Discussion

Empirical results show that three major dimensions in terms of weighting are social justice, environmental sustainability and industrial development. Sustainable use, natural resources and landscape maintenance are factors in environment dimensions. Traditional industry has more weighting than the leisure services and innovative industry in the industrial dimension. Policies and laws have more weighting than community development and cultural inheritance. On the other hand, a cross-analysis of attention factors and satisfaction showed that monitoring non-take zone in marine protect area and implementing coastal management and marine education are important key factors to improve. The above expert interviews and analysis of the questionnaire results, indicate the following:

1) The MSP and the development of community management will contribute to the ecology of the marine environment and sustainable economic development, industry and the multiple goals of social equity and justice.

2) The stakeholders held a positive attitude towards MSP, and most of them supported the conservation and restoration of marine biological resources. Nevertheless, the establishment of MSP should give considerations to fishermen's economy, compensation mechanism, the exertion of government power, and strict implementation of the program.

3) Turtle Island MSP's implementation of key elements on environmental and ecological sustainable factors are marine protected area designation and a forbidden fishing zone (phase) monitoring. Industrial economic development's factors are coast capturing business planning management and local hand-made arts advocacy and succession. Social justice's factors are top-down government policy support, preservation of to fishing village life and customs, and capacity of the community for bottom up construction.

4) Turtle Island MSPs planning of key factors on environmental and ecological sustainability are biodiversity conservation and marine environmental resource control. Industrial

economic development factors are sightseeing and recreational building, ecology and tourism management and industrial heritage and innovation. Social justice's factors are autonomous community development, sustainable tourism and network platform construction, and policy act to protect rights.

5) MSP around Turtle Island includes fisheries resource, submarine hydrothermal vent, coral reef resource and whale-watching activities. The research proposes the possible management of development after the planning phase, recommending an enhanced concept of conservation by communication and educational promotion, and increasing supports from stakeholders and law enforcement assistance from the community.

5. Conclusion

This study targets the marine spatial planning and community renaissance around Turtle Island, and applies Factor Analysis to identify important critical indicators. Empirical results show that the three dimensions most important are, in order, social justice, environmental sustainability and industrial development. Sustainable use, natural resources and landscape maintenance are factors in the environment dimension. Traditional industry has more weighting than leisure service and innovative industry in the industrial dimension. Policies and laws have more weighting than community development and cultural inheritance. On the other hand, a cross-analysis of attention factors and satisfaction showed that monitoring non-take zone in marine protect area and implementing coastal management and marine education are important key factors to improve. This study suggests four protected areas of marine spatial planning around Turtle Island, namely fisheries resources, submarine hydrothermal vent, coral reef resources and whale-watching. The study proposes possible management of development after the planning phase, recommending a enhanced concept of conservation through communication and educational promotion, and increasing supports from stakeholders and law enforcement assistance from the community.

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New Economic Models to Preserve Natural Resources and to Limit Pollutants Discharged into the Oceans

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1. Introduction

We need to invent new economic models that have a less consumption-driven relationship with nature. Material wealth creation and destruction of natural resources have been the two-stroke engine powering our economic system. This combination cannot last. Sooner or later, a polluted environment puts a brake on growth. In the long run, no country, no city, no company can keep on growing in an environment that has been laid waste. Thus we need to devise new economic models capable of preserving nature even as we use it. Can the economy protect the environment? And can it reduce these scarcities it helped create? Yes, but not as currently practiced.

If we want to regain our lost friendship with continental and marine environments, we have to change the existing natural resource and space-hungry growth into a thriftier form of growth. This implies a three-pronged approach to our economy, decarbonating it, dematerializing it, and dehydrating it:

- Decarbonating the economy, to break free from the world of oil, gas and coal;
- Dematerializing the economy, to consume fewer natural resources; and
- Dehydrating the economy, in order to reduce the amount of water we draw from rivers and underground sources.

Veolia is world leader for environmental services. It is working for many major coastal cities of the world such as Shanghai, Shenzhen, Hong-Kong, Sydney, Hiroshima, and Manila to help them protect their environment, by collecting and treating wastewater and solid waste.

2. Instituting new methods of remuneration and making economic models "*independent*" of nature

2.1. Sober growth cannot be achieved by mechanisms that encourage consumption

Two broad families of solutions are emerging for reforming the model for water, energy and waste services:

- The first one goes to the very heart of economic models, namely the method of remuneration that generates and underpins productivism. The recent need to limit our demands on nature is undermining the prevailing commercial logic: far from seeking to sell more, providers of water and energy services are requested to sell less, although they are paid by the amount they sell. They are asked to promote best practices that will diminish their revenues. They need to design an economic architecture that does not clash with the general interests of the community, since no activity will last long if it conflicts with the long term interests of the territory in which it operates.
- The second family of solutions sets out to change the value chain's starting point, by switching from an initial and limited store of fossil energies and raw materials to renewable and hence inexhaustible resources.

Option 1: Instituting performance-based remuneration, partially disconnected from volumes sold
In this economic system, there is no point in selling more cubic meters of water or kWh if an operator wants to boost its revenues. The aim rather is to meet the objectives set by the client. Operators commit to results in terms of service quality, reliability, cost controls, etc., with a system of bonuses and penalties to sanction outcomes.

This economic mechanism, which is more qualitative, exists already in some water or wastewater services in the United States. The operator's remuneration comprises a fixed and a variable portion (usually up to 25% of the fixed part), with the latter dependent on meeting a number of performance targets. A set of indicators evaluates performance, covering key criteria such as water quality, environmental protection, managing assets, customer satisfaction, and so forth.

Option 2: Shifting from a volume-based economy to one based on "non-volumes" that remunerates natural resources saved
The overriding aim here is to make savings for one's clients, and that is what gets remunerated under the contract. This is a performance-based remuneration, except that here, the main performance expected is a saving in energy, water or materials.

For instance, energy performance contracts remunerate "*negawatts*", as opposed to megawatts. Their underlying economic logic is simple: they consist in financing initial investments via the energy savings they will achieve later. The contract splits the gains between the owner and the service operator, to encourage both parts to cooperate well.

Potential gains are huge. "*In 2005, it was reckoned that if all of China's urban buildings were built to energy conservation standards, the load on the grid could be cut by 80 GW, equal to the capacity of 4 Three Gorges dams*." [56]

Option 3: Changing raw materials and energy sources, rather than the method of remuneration
Renewable energy is inexhaustible, so when we use it to produce electricity we leave problems of scarcity and its constraints behind. Using recycled waste or recycled wastewater separates volumes sold from volumes drawn from earth and sea. In this model, the raw materials used are no longer "*raw*", having been used once already. Consequently the commercial imperative to "*sell more*" no longer conflicts with the ecological imperative to "*conserve natural resources*".

Recycling gives wastewater and "*used*" materials umpteen additional lives. In so doing, it multiplies the productivity of the resources borrowed from nature. But much remains to be done to exploit the potential of these models. Out of the 4 billion tons of waste the world produces annually, only 1 billion are recycled: a further 3 billion await their turn. On a planetary scale, barely 2% of wastewater is recycled.

The waste sector is gradually becoming a raw materials industry: stocks of household waste are turning into mines, and wastewater is coming to be a well filled with new resources. These economic models are leading us in the direction of a society where we continually reutilize the same raw materials in an unending cycle. Indeed, the recourse to "*renewable*" raw materials and to renewable energies is a powerful driver of economic change.

But there is a key difference between a "*used*" product economy and a "*new*" product one: in general, no one is actually asking for the former. Therefore we need incentives, either financial or standards, to encourage recycling and reuse. But steadily rising prices for virgin raw materials are helping this move, making secondary raw materials more attractive.

[56] Message from the Director General of the French Development Agency, March 11, 2011

2.2. These new business models reflect many of the demands ecology places on modern humans:

- Maximizing the usage of each molecule of fossil fuel, each cubic meter of water and each kilogram of material drawn from sea and earth as efficiently as possible;
- Turning useless items into something useful, or in other words bringing more waste into economic circuits;
- Making dirty things clean. For instance, the Fresh Kills landfill, near Manhattan, was long the largest open-air landfill in the world. It was closed in 2001. In 2030, it will become a public park; and
- Being local.

3. Towards local economic models

3.1. Local economic models rely first on local sources of energy, materials and water

The 20th century saw the triumph of large infrastructures. The 21st century will see a proliferation of decentralized equipment at the local level (solar panels, waste recycling centers, wastewater reclamation plants, etc.). It is these "*local energies*", "*local materials*" and "*local water sources*" that will allow to de-carbonate, dematerialize and dehydrate the economy. Tomorrow's economic models will largely be local models, blending local resources with local uses. They will promote a local economy and minimize long-distance exchanges.

3.2. Recycling wastewater vs. recycling solid waste

Recycling wastewater is always a local economic model: water is heavy yet low in value, which makes transporting it over long distances uneconomical.

This is not the case with waste recycling, where products can be used either locally or on the other side of the planet, depending on their nature, because the recycling markets have gone global. While sources of secondary raw materials are located in economies with high living standards, demand stems mainly from the emerging economies. In the last century, the United States built its prosperity with the natural resources of the developing countries, the Asian countries among them. Now it is the Asian countries, China especially, which are industrializing and buying secondary raw materials from the developed countries - so much so that secondary raw materials are one of the United States' largest export items.

3.3. The city has a central role to play in shaping new local economic models

Most wealth originates in cities and most cities are located close to the sea, since 40% of the world's people live less than 70 km from a coast. Therefore, cities have a crucial role to play in defining new models to break the link between GDP growth and the consumption of natural resources. In the new urban economy, all materials and water cycles will form a loop wherever possible. It will be an economy where one person's waste becomes another's raw material.

New economic models will favor function over ownership. Car sharing is an idea whose time has come, showing how a service can replace a good. This has spread widest in the United States, though, even there, it is still marginal compared to other transportation means. The economy of function has yet to become firmly established. Indeed, the rule of "*renting rather than buying*" can only take root in a climate of solid confidence between user and provider, and between successive users. This last condition is not always easy to meet: some cities' cycle hire schemes suffer from rampant vandalism.

4. Will more recycling be enough?

The economic models of scarcity described above offer solutions for dealing with the widening gap between supply and demand for natural resources. Yet will these solutions be enough?

If global use of raw materials continues to grow exponentially, and given the length of time during which each material remains in the economy, then unfortunately recycling will have only a marginal impact on the volumes we extract from the sea and the earth. When we recycle 80% of a material, we draw 5 times less from nature[57]. Consequently, the degree of scarcity we would otherwise have reached in a century will in fact be reached only after 5 centuries. An insignificant difference on a geological time scale, but an extraordinary one on the scale of the life of humans.

Unfortunately, this is misleading. Or, rather, it is correct only if consumption remains unchanged or grows in a linear fashion.

The conclusions diverge when consumption grows exponentially: even with high recycling rates, humanity is depleting its resources quickly. For example, if the consumption of a material grows by 3% annually, if its residence time in the economy is 7 years and if the degree of scarcity is reached after 100 years without recycling, then even with an 80% recycling rate (which is a huge percentage.), its scarcity will be reached not in 500 years as seen previously but after only 135 years.

It is therefore vital to decouple growth and raw materials consumption to break the link between economic development and total consumption of raw materials, whatever virgin or recycled. Making the leap from a high-consuming economy to a sober economy demands greater efficiency in all areas: energy efficiency, "*materials*" efficiency, hydric efficiency. For the economy to become economical once more, we need to "*do more with less*".

5. Why are economic models so far from internalizing the issues of scarcity and pollution? Why has so little changed, when so much needs to change?

This is due to several factors:

- The illusion of immensity of the sea. The sea, which is the final garbage of the world, is still suffering from this illusion;
- The very long lifetime of some equipment (10 years for a car, 100 years for a building), which delays their renewal and the deployment of clean technologies;
- Manufacturers' reluctance to use secondary raw materials. We need to offer them the same guarantees of quality and reliability of supplies as for virgin raw materials;
- Penalization of virtuous behaviors in fixed-cost activities that bill by volume. 80% of drinking water service's costs are fixed, whereas 80% of its revenues are variable. Consequently, when total consumption falls, the average price per cubic meter rises. The more consumers act virtuously, the more they pay for their water (However, their total bill remains unchanged);
- New markets' lack of solvency;
- The unwillingness or difficulty to change inappropriate habits. How can we dematerialize production if customers are persistently materialist, wasting marine or continental resources?

[57] Le découplage croissance/ matières premières (Decoupling growth and raw materials), François Grosse, *Futuribles* no. 365, July-August 2010.

- Pricing policies pursuing conflicting goals: on the one hand, holding prices down in order to promote economic growth and make public services available to all; and on the other hand, using price signals to express the scarcity of natural resources, which implies raising prices;
- Regulations propping up outdated economic systems. In China, heating operators bill according to floorspace (m^2), as is the custom. Thus there is no incentive to conserve energy, as opposed to billing per kWh consumed; and
- The "*rebound effect*", i.e. an increase in traffic or output that cancels out the benefits of policies to improve environmental efficiency. More fuel-thrifty cars, and hence lower energy costs per km, have encouraged many motorists to use their car more.

6. Conclusion: Economy and ecology

Economy without ecology is no longer an option, but opposing ecology and economy will be self-defeating.

The economy is not the enemy of the environment, but its ally, provided that:

- It discards formulas that subsidize pollution and waste. For example, abolishing the US$300 billion per year in global fossil fuel subsidies[58] would save enough energy to meet the needs of Japan, South Korea and New Zealand[59];
- It takes negative externalities into account and sets a price on pollution. This is the principle behind carbon taxes, which charge people who use the atmosphere as a "*greenhouse gas landfill*";
- It allows price to reflect scarcity. The aim is to use prices as a mean to regulate demand, making bad behavior costlier than good behavior; and
- It keeps economic incentives in place for long enough to develop clean technologies on a large scale. In many countries, renewable energies (in particular marine ones) have yet to find their place in a viable economic model without relying on subsidies.

Ecology need not be expensive. On the contrary, it can be profitable thanks to the savings it achieves or additional revenues it generates. Just look at the way the recycling of waste and wastewater can restore value to things that no longer had it.

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[58] US$300 billion is based on year 2009. International Energy Agency (IEA) estimated US$523 billion for year 2011. http://www.worldenergyoutlook.org/resources/energysubsidies
[59] *Les Echos*, July 1, 2011

Fish Waste Valorization in New Caledonia: A sustainable development approach towards the management of industrial waste

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The fish waste valorization project is driven by the New Caledonia Agency of Economic Development (ADECAL), at the request of regional provinces, and aims to identify the best ways to generate or increase the value of fish waste produced by the New Caledonia fisheries.

We distinguish two major active fisheries in New Caledonia:

- Long-line fisheries: they operate in the exclusive economic zone (EEZ) on 24-meter ships and target pelagic fishes, essentially albacore tuna. All year round, 27 boats are in activity for a total catch of 2,859 tons.
- Coastal fisheries: they operate in the lagoon and inside the 12-mile coastal area and target essentially bottom and reef fishes with 5 to 12-meter boats. A small part of the professional coastal fleet is targeting pelagic fish around the anchored FAD. All in all, there are 305 boats, which exercise their activity in three provinces, for a total catch of 1,000 tons.

A significant part of the fisheries product is locally processed and generates some waste. The total amount of fish waste produced each year is estimated at 1,400 tons:

- For the long-line fisheries, 72% of the total production is processed by 3 major companies (2 located in Nouméa and one located in Koumac in the Northern Province). A majority of the captures (60%) are sold on the local market. The total weight of waste produced every year reaches 1,042 tons.
- For the coastal fisheries, the majority of waste is concentrated in the Nouméa market and the total weight of fish waste reaches over 300 tons per year.

A very large volume (1,000 tons or 70% of the total) of the waste is concentrated in Nouméa, far from the other sites of production (400km from Koumac in Northern Province, where a long-line company is based, and 180km from Lifou). At present, the majority of the waste is buried in controlled landfills. This is why the Provinces have mandated ADECAL to explore different ways to increase the value of this waste. Currently, a local private operator based in the South processes about 25 tons of waste annually into foliar spray liquid fertilizer, and some trials are underway for composting in the Northern Province.

Waste treatment is addressed by numerous publications and the complete works of IFREMER proposes a graph which illustrates the relation between the size of the market and the added value for every type of possible production. With regards to agriculture, the production of soil amendment or liquid fertilizer offers a very large market but profitability is low. For the energy sector, the possible production is biogas. For animal nutrition, we can imagine aquaculture or pig nutrition with fish meal, protein hydrolysate or fish silage. For human food, different possibilities exist: e.g. fish pulp, gelatin, and oil. Other sectors, such as dietetic, cosmetic and biotechnology, offer very high added value products such as Omega-3, collagen, and minerals.

We tried to identify the best way to explore the valorization of fish waste produced in New Caledonia, on the basis of adequacy between possible production and local specifications, including the size of the waste field:

- In regards to biotechnology, cosmetic, dietetic and human food segments, there could be some very interesting options in terms of profitability and innovation. Although certain negative aspects, such as the small size of the local market, high investment, and the technology-intensive process requirements need to be highlighted, the biggest obstacle is the near incompatibility between these types of products and the local needs. At this stage, the potential is very limited.
- Animal nutrition is a very interesting market because it represents a high-quality protein source usable in pig feed or aquaculture feed. The size of the market is sufficient to absorb all of the processed waste. However, the fish meal production requires a large quantity of waste. The hydrolysate protein or the dry silage (and equally the fish meal process) require high quantities of energy for the drying process. At this stage, the most negative factor in animal nutrition is the presence of mercury in the pelagic fish waste. A study conducted by the veterinary administration on representative samples of pelagic fishes has shown high mercury contents in tuna, swordfish, marlin and mako shark. One sample of fish silage realized during a test in Lifou (Loyalty Islands) has confirmed a rate of 1.2mg/kg. Supplementary analyses have to be performed, but at this stage precautionary principles are recommended and more studies need to be undertaken to specify the chemical characteristics of mercury and its future implications in the final products.
- Biogas can also be a good source of renewable energy. It offers a very interesting usage of the waste in terms of sustainable development because it would allow one to envisage treatment of other organic waste such as meat or breeding effluents. However, if this requires a very large volume of organic matter in order to yield profitability, the technology process would require high levels of competence and in terms of distribution, the outlets would be difficult to specify.
- If we prioritize simplicity over other factors to implement a fish-waste treatment in New Caledonia with aims to produce value-added goods in large quantities, agriculture sector seems the best option to be explored at this stage. Indeed, the production of soil amendment or fertilizer from organic fish-waste requires low investment and low technology processes. The needs from agriculture and mining operators are important and this type of product is much in accordance with the integrated management urged by businesses, policy-makers, communities as well as the general public. As previously mentioned, however, we would need to carry out further research concerning the profitability and the efficiency of this type of output.

Two major types of products are identified as most feasible:

1) Foliar fertilizer, better known as 'liquid fish fertilizer,' has many advantages: it is cheap to produce with a well-identified process. The final product is rich in oligo elements, stimulates plant growing, has an efficient insect repellant effect and is a good wetting additive for phytosanitary treatment.

However, a local private production already exists currently producing approximately 20 tons per year. The size of the market is relatively small for this product, estimated at 30 tons per year. Hence, it is not advisable to select this type of production for the total volume of produced waste.

2) The other possibility is to produce soil enrichment. Made up of organic matters, rich in oligo elements, it favors the nutrition of soil micro-organism, contributes to the health of the soil and presents a slow speed of organic matter mineralization. In terms of needs, these types of products are used in very large quantities by mining operators and can also be used by the agriculture sector as substitutes to imported chemical fertilizers (3,200 tons are imported every year).

If we decide to go with the above two options of plant fertilizer and soil enrichment, we need to identify the technology processes to produce these goods.

First, in cooperation with the fish processing companies, we need to collect the waste. If we consider the characteristics of this type of waste (bloody, wet, smelly), and the geographical distribution of this waste product, stabilization is required before it can be transported. One easy and cheap process is called fish silage technology. The principle of this technology is to grind the waste and to acidify the mixture. The low ph of the mixture has a bactericide and fungicide effect, and it activates the enzymatic digestion of the flesh. After some maturation time (depending on the freshness of the waste and the presence of guts, naturally rich in proteolytic enzymes), one can obtain a raw silage that is in liquid form, pumpable and stable at ambient temperature. This raw silage can be processed differently to obtain two different final products.

One can dry it and apply a granulation process to obtain dry, granulated soil enrichment. With the aim of achieving economical optimization, various drying technology processes should be explored and tested. This end-product, only efficient for soil, is nitrogen-rich with a low speed of mineralization, easy to transport and use, notably for the mining operators.

When plant waste is mixed into fish waste, organic compost is obtained. This option is the most complete solution in terms of integrated management and the cheapest to produce due to its low energy cost. In terms of agronomic value, it should be a complete fertilizing product, carbon- and nitrogen-rich, efficient for soil and plants.

In conclusion, in regards to the needs expressed by different provinces in terms of identification of fish waste treatment, corresponding waste production characteristics and local market possibilities, and short timeframe, the option of soil enrichment and/or organic compost production seem to be the best solutions.

We propose to initiate a pilot study to produce and characterize fish silage. The pilot production will be used for:

- Producing dry silage and co-compost;
- Featuring the agronomic value of each product;
- Measuring the absorption of the elements by soil and plants; and
- Operating agricultural tests to control the efficiency of each product.

However, a complementary study, led by IFREMER and funded by the French Pacific Funds, will begin soon, to clarify the mercury problem notably for the animal nutrition option. Another study concerning the content of mercury in the different part of the pelagic fishes is currently in progress in Fiji and Samoa, and is led by the Secretariat of the Pacific Community (SPC). The results will determine the best ways to roll out industrial valorization of fish waste produced in New Caledonia.