Usable Science 9:
El Niño Early Warning for Sustainable Development in Pacific Rim Countries and Islands

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El Niño Early Warning for Sustainable Development in Pacific Rim Countries and Islands

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During the preparation of this report, including the feedback from participants from various countries, cultural and disciplinary backgrounds, it became clear that "words matter." They matter because we communicate by way of the written or spoken word. Some of the key words, including notions and concepts, used during the workshop were either not easily translated into other languages or cultures, or had different meanings and nuances, depending on the context in which they were used. The notion of "hotspots," serves as one example. The Latin American participants noted that it does not translate well into Spanish. This raised a concern about other notions that might also not be well expressed in other languages. The word "creeping" as part of the phrase "creeping environmental change" was difficult to express in Russian. Some participants took issue with phrases and words such as the following: "weak" El Niño (which could mean either weak physical aspects or weak societal impacts); "reliable forecast"; and even "adaptation." This suggested that many words and concepts we use are geography-bound or academic-discipline-bound.

Please keep this in mind when reading this report. Each word, even within a given language, can have several meanings in a dictionary. It is important to note the context in which the phrase or the concept is embedded and to realize that such cultural, technical, and geographic meanings can vary in interpretation from their intended use in this report. This is an ever-present problem for which there is no easy solution.

Introduction

The convening of a workshop on "El Niño Early Warning for Sustainable Development in Pacific Rim Countries and Islands" was inspired by the deliberations of an earlier workshop held in Shanghai, China in October 2003 on *Early Warning Systems: Do's and Don'ts*. The Galapagos workshop was the ninth "Usable Science" workshop organized by the Environmental and Societal Impacts Group at NCAR in the past ten years. This workshop was co-organized by Jose Luis Santos of CIIFEN (Centro Internacional para la Investigación del Fenómeno de El Niño). Several of the Usable Science workshops were linked to various aspects related to El Niño: forecasting, impacts, responses to forecasts and responses to impacts of El Niño, and the extreme meteorological events that an El Niño often spawns. The goal of the Galapagos meeting was to regionalize early warning systems geographically and to focus on a specific climate-related phenomenon – El Niño. El Niño is known with varying degrees of reliability to spawn climate- and weather-

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related hazards in many parts of the globe. ***Knowledge*** of El Niño, coupled with El Niño forecasts, provides one of the earliest warnings of possible climate-related impacts problems that a government decision maker or the manager of a climate-sensitive industry might receive in time to take action.

Thirty-four participants from 12 countries (Australia, Canada, Chile, China, Colombia, Costa Rica, Ecuador, Germany, Mexico, United Kingdom, United States, and Uruguay) gathered together for four days, representing many disciplines, including marine biology, fisheries, oceanography, agriculture, communications, political science, economics, engineering, meteorology, anthropology, forestry, philosophy, and history. The initial grant that began the process leading to this multidisciplinary workshop was provided by the US National Science Foundation's Atmospheric Science Division. The workshop was co-sponsored by NCAR (National Center for Atmospheric Research/National Science Foundation) and CIIFEN (Centro Internacional para la Investigación del Fenómeno de El Niño), with support from NOAA (National Oceanic and Atmospheric Administration), CIIFEN, WMO (World Meteorological Organization), ISDR (International Strategy for Disaster Reduction), UNESCO (UN Educational, Scientific and Cultural Organization) and the IOC (Intergovernmental Oceanographic Commission), the UN Development Programme, and the Inter-American Institute.

Coincidentally, our Galapagos workshop was convened thirty years after the first "International Workshop on the Phenomenon Known as El Niño" was held in Guayaquil, Ecuador. The report from that 1974 workshop served as an important catalyst to increasing interest among scientific researchers in El Niño at that time. The workshop was sparked by the devastating impacts of the 1972-73 El Niño on Peru's lucrative fishmeal industry, which was and still is primarily dependent on anchovy catches. One could argue that the 1972-73 El Niño was the "El Niño of the scientists." Research on air-sea interactions in the tropical Pacific began to accelerate. The participants had prepared an international research plan for the physical and biological sciences. Its stated goals were as follows: to analyze the state of El Niño knowledge; to identify questions to allow understanding and prediction of El Niño; to devise a regional cooperative research program; and to develop a plan to study El Niño-fisheries interactions (Guayaquil, 1975). The 1982-83 El Niño, the first "El Niño of the Century," was the episode that generated interest among governments around the globe in El Niño and its devastating impacts.

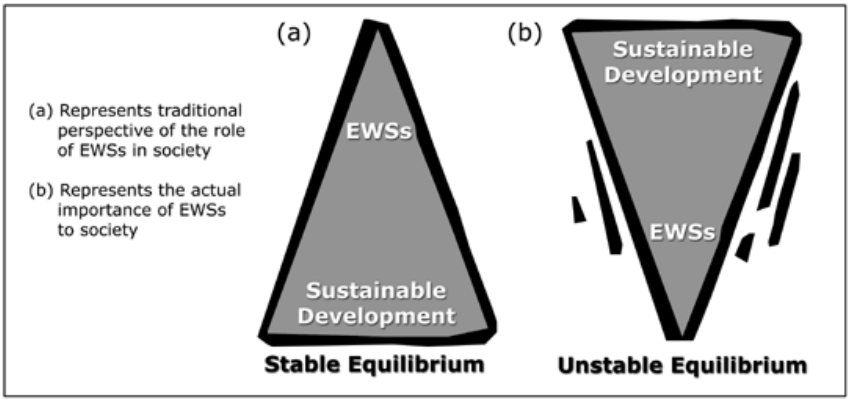
While preparing the materials for this workshop, the organizers came to realize that El Niño information encompasses much more than just an El Niño forecast as an early warning of potential harm. That realization led to the use of a shadow title for the meeting: "**El Niño Knowledge for Sustainable Development**." This seemingly subtle shift in words was, in fact, more than that. It was a realization about the need to broaden concern from one primarily about a forecast of a specific event (e.g., El Niño) at a given point in time to one that includes all available information about El Niño including forecasts but also including historical and traditional (including indigenous) accounts of El Niño-related socioeconomic impacts that resulted from droughts, floods, fires, and infectious disease outbreaks. For example, people and governments in Mexico, Peru, the Philippines, and Australia have been coping for a long time with droughts and floods,

only some of which may have been related to El Niño. Thus, there is considerable knowledge, much of it unrecorded or unpublished, about El Niño's impacts and responses at the local level.

There were at least two key objectives of this meeting in the Galapagos, in addition to networking among participants: (1) exploring the notion of El Niño knowledge for sustainable development, and (2) discussing the notion of "linking or sinking," that is, the linking of issues so that holistic (as opposed to piecemeal) solutions can be developed. As an example, it is not only sufficient to link sustainable development issues and El Niño-related early warning issues in a meaningful way, it is obligatory in regions known to be affected by El Niño if there is any hope of achieving sustainable development at some point in the future. A goal of disaster assistance is to get the life of victims of disasters back to a semblance of "normal." This, however, raises a question about what a "return to normal" means. In many parts of the world, "normal" does not necessarily equate with a good life, or with human or ecosystem well-being. Rather, a return to normal is often unwittingly setting up the same society for similar disasters at some time in the future. Linking a longer-term perspective with the short-term considerations to get back to normal can hopefully reduce the likelihood of the same level of vulnerability to similar hazards in the future. In other words, an issues-linked policy would likely be more beneficial that the sum of two separate policies that focus on either sustainable development considerations or on getting thing back to normal. Perhaps there are ways to do better than normal, if normal was not a favorable condition.

From the perspective of the workshop organizers, most if not all societies are in some level of unstable equilibrium. Early warnings can help to maintain, if not improve on, a country's level of equilibrium. In the absence of linking early warning and El Niño forecasts or linking disaster response with sustainable development, for example, the stability of many governments can be at risk.

The Shanghai workshop on "Early Warning Systems: Do's and Don'ts" (www.esig.ucar.edu/warning) produced a range of ideas about the need for, use of, and importance of early warning systems to governments and agencies worldwide. A diagram that was developed as a result of the Shanghai workshop deliberations succinctly suggests the way societies and governments and their relationship to early warning systems are, as opposed to the way we would like them to be.



The main point of view depicted in this illustration is that societies are in an unstable equilibrium. Early warning systems are needed to alert governments and societies about factors that might change that condition by increasing or decreasing their levels of stability. Whether a destabilizing factor results from economics, politics, terror, or from weather anomalies or climate extremes, governments must pay greater as well as constant attention to the early warning systems that are allegedly set up to warn them of processes or events they want to avoid.

Every government has several such systems. However, they are often poorly funded to carry out the tasks that have been so perfectly spelled out in documents and work so well in print, on paper, and in PowerPoint presentations. El Niño knowledge about the phenomenon and its teleconnections, if appropriately used, can help more than a few governments and societies around the globe to mitigate if not avoid the worst impacts of El Niño-related hazards. The better applied the science is to societal needs, the more secure will be the knowledge base upon which decisions are made. Highlights from this workshop are as follows:

Galapagos Highlights

- The notion of "El Niño knowledge" broadens concern from forecasts of a specific El Niño at a given point in time to one that includes all available knowledge about El Niño, including forecasts, as well as historical and indigenous accounts of El Niño-related socioeconomic impacts that had resulted from previous droughts, floods, fires, and infectious disease outbreaks.
- The phrase "climate knowledge" encompasses knowledge about climate variability, climate change, and extremes, as well as climate forecasting, and is used to enhance resilience, increase profits, and reduces economic and environmental risks.
- Being clever depends on how one interprets and uses El Niño knowledge to improve responses to climate-related natural hazards.
- It is not only useful to link sustainable development issues with climate-related early warning in a meaningful way, it is essential. The ultimate objective is to find a better way to use El Niño knowledge in a peoples' search for an improved sustainable future.
- It is necessary to pay attention to the context in which a phrase or concept is embedded, because cultural, technical, and geographic interpretations can easily vary from its intended use.
- The use of the term "weak," often used to describe the intensity of an El Niño event, when referring to relatively small increases in sea surface temperature, is very misleading in terms of early warning. It sends a message that potential users might not have to worry about impacts.
- All societies are in a state of unstable equilibrium. Effective early warnings can help them to maintain, if not improve upon, their level of equilibrium.

Destabilizing factors relate to economics, politics, terror, and weather extremes and climate anomalies.

- Governments must pay greater attention to the early warning systems that have been set up to warn them about processes and events they want to avoid.
- A government or a group must have efficient early warning systems in place to reduce the likelihood of unwanted surprises.
- For infrequent climate-related hazards, such as El Niño (or La Niña), it is difficult to develop a high level of confidence and trust in forecasts over the short term. Forecasters need time to develop a track record.
- Scientific output is not by itself automatically helpful to societies that are seeking solutions to many of their existing climate-environment-society issues. To move from potential to actual value in the near term, scientific findings must be applied to meet societal needs.
- The lack of effective communication to, from, and with the local level by those at higher political levels increases risk to climate-related impacts of local communities.
- There is often a need for a translator of the science so that non-scientists (the public, policy makers, media) can understand the potential benefits they can get from scientific findings.
- It is important for users of El Niño information to be aware of the qualifications of scientists, researchers, forecasters, and website that offer projections about El Niño.
- The ability to forecast various aspects of El Niño is still limited because air-sea interactions in the Pacific are nonlinear. No two El Niño episodes are exactly alike, nor is the set of impacts associated with them.
- The use of the term "hotspots" requires an accompanying adjective to clarify its meaning (e.g., flood or drought hotspots, biodiversity hotspots, disease hotspots, agricultural hotspots, and so forth). Within these categories are other hotspots. For example, agricultural hotspots could focus on a type of crop or on a type of farming system or on the degradation of the land quality on which agricultural activities are dependent.
- Potential benefits for sustainable development to the fishing sector are strategies for coping with impacts in designated El Niño-related fisheries hotspots.
- The scientific community owes it to the public to update its El Niño-related impacts maps. The data on which the Ropelewski and Halpert maps were based are now more than twenty years old. The maps are in need of updating, if not for the sake of the scientific community, then for the potential users of El Niño knowledge, including forecasts.

- Improved El Niño-related hotspots maps can provide an early warning, a "heads up," to decision makers about the likelihood of El Niño-related hazards that an El Niño could spawn in their jurisdiction.
- People expect their governments to take action when they hear that an El Niño is coming – preventive (i.e., evasive), mitigative, or adaptive.
- Responses to El Niño-related emergencies must mesh with development schemes and may even benefit from them, and vice versa.
- A SWOC assessment (Strengths, Weaknesses, Opportunities, Constraints) is useful in many ways. For example, once weaknesses and constraints have been identified, strategies can be developed to surmount them. Existing strengths and opportunities can be enhanced.
- Those concerned about early warning systems (producers, intermediaries, and users) must make explicit what they expect to achieve from them.
- An El Niño forecast sparks a cascade of forecasts of potential impacts downstream from El Niño's onset.
- The timing of responses of decision makers in various socioeconomic and political/administrative sectors of society to El Niño forecasts will depend on their concerns about specific possible impacts.
- Considerable experience with hazards already exists to draw on in both space (e.g., on both sides of the Pacific basin) and time (e.g., from the impacts of earlier El Niño episodes).
- El Niño and other climatic extremes, as well as climate change, pose great challenges to the health sector, which is already an overly stressed sector in many developing countries.
- To reduce the adverse health impacts of El Niño, the underlying factors that increase public health vulnerability ***must*** be addressed.
- We need to understand the epidemiological profile of El Niño-affected regions (i.e., hotspots), including the population's health status (preexisting conditions, nutritional status) the environmental situation (housing, water, sanitation, vectors, etc.), existing social conditions, and the effect of climate variability in each of these sectors.
- A key lesson of the 1997–98 El Niño was that the health sector must be an integral part of a multi-sectoral process of planning, management, and evaluation of risks. Action plans need to be in place for prevention, for action during the event, and for post-event actions.
- Decision makers cope with climate-related variability other than ENSO extremes. It is time to view El Niño as part of climate variability; in other words, "put El Niño back in the climate variability box."
- There are downsides to a forecast. For example, when drought in a given region is expected to accompany an El Niño, local banking institutions have been known to

withhold loans to farmers and ranchers because of their reduced likelihood to pay off their loans.

- Sustainable development programs depend on responses to El Niño episodes as well as ad hoc. However, ad hoc (tactical) responses must not impede the drive toward sustainable development objectives.
- Forecasts need to be tailored to the needs of the specific users, such as those in agriculture, fishing, health, rangelands, and livestock.
- Strategic thinking within a specific sector, such as fisheries, should involve using El Niño knowledge and lessons identified from the ENSO experiences of the industry both locally and in other regions.
- There are winners and losers related to responses to El Niño forecasts and to the impact of El Niño.
- In terms of sustainable development, those who can use El Niño knowledge to their advantage are likely to benefit over those who ignore such information.
- Governments should divert 10% of what their experts estimate could be the cost of possible impacts and use the funds to prevent at least half of those impacts.
- Trust between local stakeholders and their governments is very important when it comes to encouraging the use of and confidence in forecasts.
- Lessons taught to those with whom rapport has not been developed are not taken as seriously as those provided by trusted local people.
- Those directly affected by El Niño impacts are usually not involved in policy decisions about how to deal with forecasts, impacts, or reconstruction following adverse impacts. However, those who have been involved in the process have some ownership in the outcome and are more likely to apply lessons they had helped to identify.
- Lessons (i.e., knowledge) acquired over time by trial and error at the local level can be used to inform higher-level decision makers in a given society.
- There is a need to "scale up" local knowledge to national decision makers, because the locals have their own insights into coping with climate-related risks.
- It is not enough for decision makers to call for better interaction with "stakeholders." They must treat them as equal partners in an ongoing dialogue.
- Though we often refer to ***an*** El Niño forecast, we are really talking about a ***process*** where several El Niño forecasts are issued in series.
- Learning about El Niño and its consequences is best undertaken ***between*** El Niño events and not while an event is in progress.
- Referring to the "role of the media" is misleading, because each medium may have its own set of roles and rules by which it operates.
- Most El Niño stories are focused on negative impacts, because it is very difficult to get media coverage of its positive aspects, wherever or whatever they may be.

- While the catalysts to disaster from Hurricane Mitch (Central America 1998) were for the most part related to atmospheric processes, the extent of death and destruction depended in large measure on socioeconomic factors.
- Creeping environment problems (CEPs) are especially important to island nations and to Pacific Rim countries, because such problems develop at levels of change that are imperceptible on a daily basis. After a few years, however, the extent of their adverse impacts becomes obvious.
- Getting the appropriate level of detail to the correct level of decision making is a real challenge to those who produce the science about El Niño and to those who translate it for use by the public.
- El Niño events must be de-dramatized, a process that has to begin within the scientific community. Although El Niño knowledge does add skill to climate-related forecasts, it is only one aspect of variability in the global climate system.
- Pacific Rim countries and islands represent considerable diversity in terms of information needs and in terms of capabilities with regard to responding to El Niño events and to forecasts of those events.
- Concern about El Niño provides a legitimate reason to gather climate-related knowledge at the local levels around the Pacific region, because there is considerable local and traditional knowledge that must be shared. Such cooperation encourages collaboration about El Niño and its socioeconomic aspects across the basin.
- Governments often refer to local-level stakeholders. However, everyone is a stakeholder, including national policy makers, because they too have a stake in the outcomes in the effectiveness of their decisions.
- Regionalizing an El Niño forecast system around the Pacific would encourage the sharing of experience. For example, it is an effective way to share the ups and downs in the exploitation of migrating living marine resources.
- A "triple bottom line" notion of economic, social, and environmental impacts suggests that sustainable development is a negotiated tradeoff among these three elements.
- Society needs to understand how the climate system works. This would help to better identify climate-related vulnerable populations.
- The real challenge is how to reduce risk through applied science and a variety of already known effective approaches to climate-related risk reduction.

Some key findings of the Shanghai report appear in the following list. The list of highlights is meant to be illustrative of the observations of a preceding Usable Science workshop (#8) on early warning systems. (The entire list appears in Appendix A.)

Shanghai Early Warning Systems (EWS) Highlights

- One officially designated early warning system cannot meet all societal needs.
- Hazards and threats can change over time not only in intensity, frequency, and in location and duration, but also in importance and interest.
- Scenarios can help to uncover potential impacts of hazards that might otherwise have caught decision makers by surprise.
- Many early warnings knowingly and unknowingly activate other early warnings, as the time gap between a warning and the onset of a hazardous event shortens. This process can be referred to as a cascade of early warnings.
- Creeping environmental changes are in need of early warning systems because the impacts of incremental but cumulative changes on society in the long run may be more costly and disruptive than the quick onset hazardous events.
- EWSs should also report on advances in hazards research, advances in the development of early warning systems, and in new technologies and techniques that can improve the effectiveness of existing EWSs.
- Because of limited resources (human and financial) in many countries, it is important to distinguish between what is desirable for an effective EWS and what is essential.
- EWSs need to be treated as subsystems embedded and integrated into larger socioeconomic and political systems. Stakeholders need to be involved in the development of new EWSs or redesigning existing ones.
- Stakeholders can provide important insights into how warnings might best be prepared and delivered to the public, the media, and even to the governments at different levels.
- Early warning system operators face a dilemma: they are often criticized for a missed or erroneous warning, but are infrequently praised for having been correct.
- Early warning of hazards combined with the early warnings of underlying societal problems and processes can lead to a strengthening of resilience and a reduction in vulnerability.
- It would be useful to collect lessons of the past for evaluation by present and future EWSs.
- An early warning system is an important tool in a government's program to achieve sustainable development. In fact sustainable development prospects are very dependent on the effectiveness of the many early warning systems.

At the beginning of the Galapagos workshop, it was noted that the theme of the meeting was truly multifaceted. By this, we meant that each word in the title of the workshop — El Niño, early warning, knowledge, sustainable development, Pacific Rim countries, Pacific islands — could have been ***the*** single focal point of this four-day workshop.

Indeed, there have been numerous meetings (conferences, workshops, roundtables) on each of them. Our goal was to discuss them as a cluster of inter-related issues.

These topics do not have simple or uncontested resolutions because of scientific, political, and economic uncertainties that are embedded within them. We hoped to generate a modicum of new thinking about some of these issues and about their connectedness, the ultimate objective being "how better to use El Niño knowledge in a peoples' search for an improved sustainable future."

There is much more to El Niño than just a better forecast of its onset, which seems to be the primary focus of attention today. Participants were asked to focus on solutions as a contribution toward improved understanding. They were also reminded not to expect resolution during our four-day meeting of many of the issues raised for consideration.

In addition to a paper copy of the Galapagos report and its appearance on the NCAR website (www.isse.ucar.edu/galapagos), it also appears on the website of the Exploratorium in California (www.exploratorium.edu/el_nino). The Exploratorium has made audio recordings of the discussions of each session and has placed them on its website.

El Niño and Knowledge: A Few Definitions

Knowledge is Power.
(Sir Francis Drake)
Sharing knowledge is Empowerment.
(www.BearingPoint.com)

El Niño (also referred to as a "warm event") is used by many people as shorthand for ENSO (El Niño-Southern Oscillation) cycle, of which the warm event is just one part of a cycle. La Niña, or a cold event, is another part. Some years ago, researchers noted that, taken together, the sea surface temperature extremes are in an El Niño (warm) and a La Niña (cold) phase about 54 percent of the time. The other 46 percent of the time, the equatorial Pacific Ocean is in a neutral (or average) condition.

The Southern Oscillation Index (SOI) is the difference in sea level pressure between Darwin, Australia and Tahiti. Many Australian forecasters use the Southern Oscillation Index as a primary indicator for the likelihood of El Niño-related drought. In fact, this approach is used in applications research around the world (e.g., many applications in Africa and Asia). This is by no means restricted to Australia; the global applicability of this forecasting approach has been demonstrated in many publications (e.g., Stone et al., 1996).

There are many ways to define "knowledge." The following list of definitions from the Internet was presented to the participants for their consideration.

- the psychological result of perception, learning, and reasoning;

- the remembering of previously learned material, possibly involving the recall of a wide range of material, from specific facts to complete theories;
- information evaluated and organized in the human mind so that it can be used purposefully;
- the sum or range of what has been perceived, discovered, or learned;
- knowledge is information with guidance for action based upon insight and experience;
- understanding the significance of information;
- the final goal of the understanding in combining intuitions and concepts; and
- it is internalized by the knower over a long period of time, and incorporates accrued and embedded learning.

Clearly, the numerous definitions of knowledge were constructed to meet the needs of those creating them. However, there are recurrent themes among these definitions: perceptions, the mind, intuition, interpretation, and experience (by way of reading, observing, learning, living, etc.). A concern was expressed at the meeting that this particular list of definitions taken at random from the web is static and not dynamic, suggesting that in order to be useful, knowledge had to be linked to action. Beliefs, though formed by knowledge, are not necessarily action oriented. This generated a question about whether it is useful to distinguish between basic knowledge and applied knowledge. The former might refer to knowledge that is used to produce other knowledge. While the latter can be viewed as knowledge that leads to action, e.g., applied knowledge. Both aspects of knowledge exist side by side because not all aspects of one's knowledge is at play for each problem that arises.

> I will keep on protesting about the term "weak" until someone takes notice: do you mean "weak" in terms of the phenomenon's manifestation (i.e., SST anomalies) or "weak" in terms of its impacts (i.e., climate anomalies)? This is a rhetorical question, because I know that impacts vary and are regional and hence "weak" means "weak SST anomalies." Not explicitly stating this is very misleading and sends a wrong message to potential users. For instance, the "weak" event of 2002–03 wiped out most of the Australian wheat crop. This is a very important point. We need to change our language to something more appropriate for risk management.
>
> **--Holger Meinke, participant**

It was proposed to the participants that the notion of "El Niño knowledge" merited consideration. Usually, El Niño forecasts are considered to be the knowledge about El Niño that decision makers need to know. The forecasts are based on research about it as a geophysical phenomenon, using models and statistical correlations. It recurs every 4 ½ years on average, but can recur anywhere from 2 to 10 years apart. Not every El Niño is a strong memorable one. Temporal and spatial impacts can differ dramatically from one event to the next. Therefore, as a societal concern, it does not receive a high priority, because it is not constantly on the minds of decision makers in all countries or in all climate-sensitive segments of society.

Of those aware of it as a recurring phenomenon, many think there is little that they can do to get ready for it in advance of its occurrence. The reality, however, is that El Niño knowledge is much more than just the forecasts of its likely occurrence. In fact, this is where the term "climate knowledge" is preferred: the intelligent use of climate information, including knowledge about climate variability, climate change, and climate forecasting used so that it enhances resilience, increases profits, and reduces economic/environmental risks.

El Niño has a history; previous events have been observed in real time or in retrospect, through direct observations and the use of proxy indicators. Using a variety of research methods, El Niño events of the past have been identified with a degree of reliability, as have many of their teleconnected impacts. While El Niño was not named, as far as we know, till the early 1890s, its effects were felt in the form of recurrent droughts, floods, shifts in fish population location and species, outbreaks of vector-borne diseases, and the occasional greening of desert areas, referred to by the Inca as the septennial rains (Sears, 1895).

People in many places around the tropical and extra-tropical Pacific had been affected by and dealing with such anomalies for centuries or longer. Only in the past several decades have some of those anomalies in some locations been directly linked to the appearance of El Niño (or La Niña). The knowledge of such anomalies and coping mechanisms are now part of our expanding information base that can collectively be called El Niño knowledge. That knowledge is not just in the form of written reports and formal learning but is also in the form of traditional and indigenous knowledge. As cited in the workshop's viewbook, the following quote from the World Bank (www.worldbank.org/afri/ik/basic.htm) provides one comment on the importance of indigenous knowledge.

> Conventional approaches imply that development processes always require technology transfers from locations that are perceived as more advanced. This has led often to overlooking the potential in local experiences and practices.
>
> - A careful amalgamation of indigenous and foreign knowledge would be most promising.
> - Foreign knowledge does not necessarily mean modern technology. It includes also indigenous practices developed and applied under similar conditions elsewhere.
> - To foster such a transfer a sound understanding of indigenous knowledge is needed.
> - Indigenous knowledge forms part of the global knowledge.

Indigenous knowledge encompasses knowledge which local people (or people on the street or "in the fields") might have about climate-weather-environment-society interactions that relates indirectly as well as directly to the ENSO-cycle in general and El Niño specifically. There is also a considerable amount of folk wisdom associated with recurrent drought, flood, fire or disease outbreak that unknowingly may have been related to the occurrence of an El Niño or a La Niña event. For example, Euclides da Cunha

(1902) writing about drought in Brazil observed that "the drought cycles … follow a rhythm in the opening and closing of their periods that is so obvious as to lead one to think that there must be some natural law behind it all, of which we are as yet in ignorance." Recent scientific findings and improved understanding can help researchers and the public to put that folk wisdom and indigenous knowledge into a broader climate-related context.

In sum, El Niño knowledge (more broadly, ENSO knowledge) includes forecasts (previous as well as current ones); climate modeling output (ensemble forecasts, climate change scenarios); various time series (sea surface temperature, upper-level wind anomalies, thermocline depth, southern oscillation of sea level pressure, ecological, hydrological, meteorological, and demographic); satellite-derived information (imagery over time); case studies of suspected ENSO impacts on the physical environment and society (local, national, regional, global); folk wisdom (anthropological, sociological, anecdotal); the context in which an El Niño event takes place (political, social, economic, cultural). ***It is necessary to identify all facets that might be encompassed under the rubric of El Niño knowledge. This would help El Niño researchers from all disciplines to broaden their perspectives of the ENSO cycle and inform them about what societies need to know to better deal with it and its impacts.***

A few quotations were placed in the viewbook for participants to consider during the meeting – and afterwards as well. The following quote, taken from a work of fiction, is particularly relevant here (Haddon, 2003). It is a response of an autistic teenager to his father who had praised him for something he had witnessed.

> I said that I wasn't clever. I was just noticing how things were, and that wasn't clever. That was just being observant. Being clever was when you looked at how things are and used the evidence to work out something new.

In a way, the quotation relates to indigenous knowledge, to qualitative information about climate-society-environment interactions, to climate and weather-related extremes and to anecdotal information. Having more data in the form of quantified time series will not necessarily provide the insights needed to better anticipate and, therefore, cope with the forecasts of extreme events, as well as to cope with them and their impacts. Being clever depends on how we interpret and use that and other related information to improve our understanding and responses to climate-related natural hazards and their impacts on environment and society.

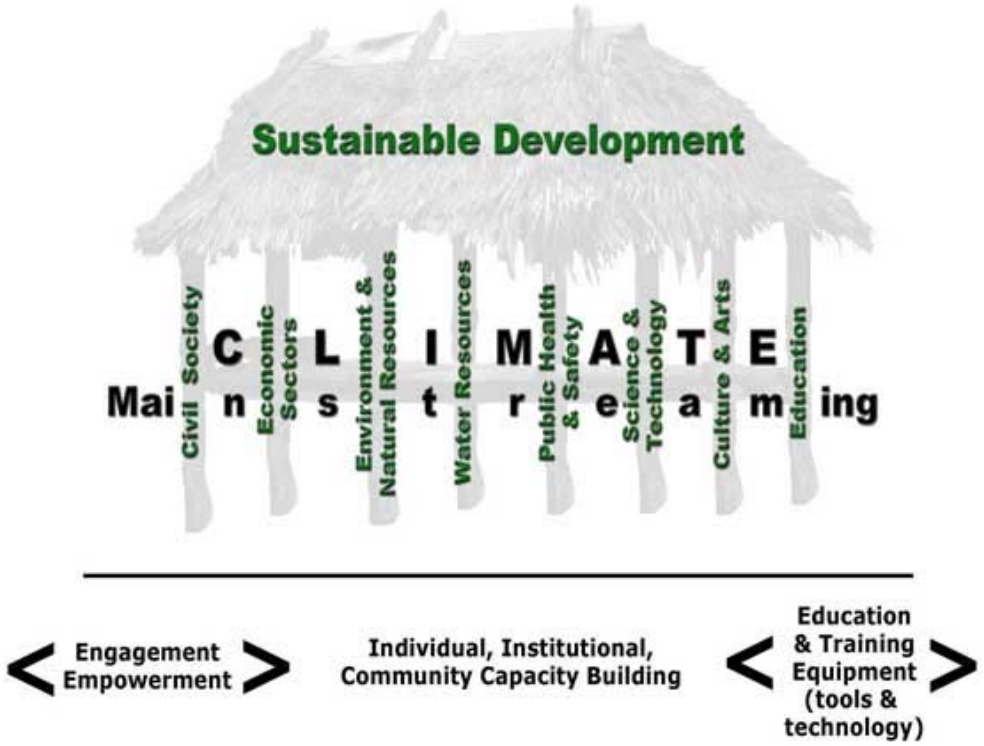
Linking Application to Science and Science to Application

The purpose of this session was to highlight the need for and application of scientific excellence and understanding to existing and emerging problems of concern to society. The necessity of this linkage was referred to in terms of "linking or sinking"; that is, societies need to link scientific output to societal needs in the area of early warning or face an elevated risk of development policy failure, e.g., sinking.

The more that reliable information can be made available in advance of the time needed to make a reasoned, objective decision, the better it is for society and for decision makers. They do not want to be surprised because surprise forces them to make decisions surrounded by considerable uncertainty on short notice. To avoid surprises a government or a group needs to have in place efficient and effective early warning systems (e.g., Streets and Glantz, 2000). Surprise can result from the time of an event's occurrence, a change in its frequency, an unexpected rare event, or a quick onset of a likely event that leaves very little time to react to a warning of its surprises.

Defining Sustainable Development

Sustainable development has been defined in the following way in the report of the World Commission on Environment and Development (WCED, 1987): *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* Today, there are many definitions of sustainable development, and they appear to be tailored to the needs of the researcher or group producing its definition, often tailored to its needs. A search on the web shows just how widespread the use of the notion of sustainable development has been. Definitions of sustainability that may meet the needs and interests of one group may impinge directly on those of another group.



A Pacific Islands perspective on the use of climate adaptation mainstreaming to support sustainable development. Created by Eileen Shea.

Indicators for monitoring progress towards sustainable development are needed in order to assist decision makers and policy makers at all levels and to increase focus on sustainable development. Beyond the commonly used economic indicators of well-being, however, social, environmental and institutional indicators have to be taken into account as well in order to arrive at a broader, more complete picture of societal development.

Based on the voluntary national testing and expert group consultation, a core set of 58 indicators and methodology sheets are now available for all countries to use. This core set was based on a working list of 134 indicators and related methodology sheets were developed, improved and tested as part of the implementation of the Work Programme on Indicators of Sustainable Development (ISDs) adopted by the Commission on Sustainable Development (CSD) at its Third Session in April 1995 (www.un.org/esa/sustdev). The following illustrative list of randomly selected weblines focuses on countries and organizations that have identified their own sets of indicators of sustainability (e.g., SDIs).

- Finnish set of sustainable development indicators (SDIs)
- Environmental and SDIs for Canada
- SDIs for the USA
- UK Government's core set of indicators of sustainable development
- SDIs for Wales
- SDIs for China
- SDIs for Sweden
- Scottish SDIs
- SDIs for Southeast Asia
- SDIs for urban water systems
- Gender and SDIs
- SDIs in the Mineral Industries
- Indicators of Sustainable Development for Estonia
- Jamaica Sustainable Development Network Programme
- The APEC Development Network

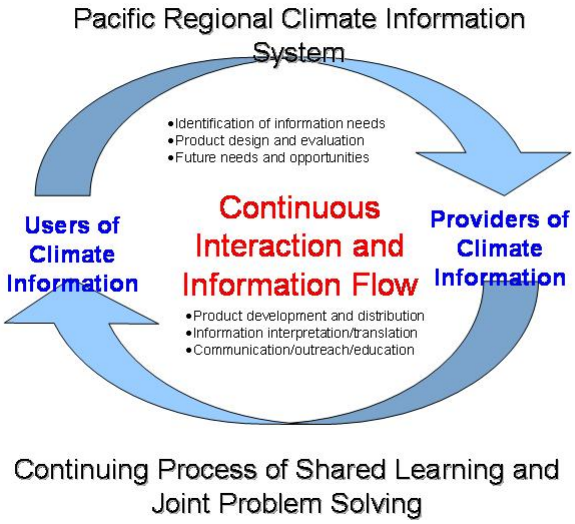
Trust in Forecasts

When it comes to El Niño-related climate and weather forecasts, it is difficult to maintain a high level of confidence and trust in them. Aside from the fact that forecasts (as early warnings) are usually in the form of probabilistic statements, for quasi-periodic events such as an El Niño or a La Niña, it is not easy to keep up that trust over the "in-between" years when neither of those extremes is occurring. "Out of sight, out of mind" is an adage that seems to apply to El Niño as an extreme event that does not occur frequently enough for people to have developed confidence in the forecast of it or of its associated cascade of impacts. In addition, not all forecasts have been "correct," and many people judge correctness of a forecast on a case-by-case basis, as opposed to thinking about them collectively and probabilistically. As long as we keep referring to outcomes of EWSs as

being "correct" or "false" (or even worse, "false alarm"), we are to blame for a misunderstanding of the use and value of forecasts.

Scientific output by itself is not automatically of help to societies that are seeking solutions to many of their existing climate-environment-society issues, not just problems. To move from potential to actual value in the near term, scientific findings must be applied. Often there is a need for a translator of the science so that non-scientists (the public, policy makers, and the media) can understand the benefits of those findings.

Top Down or Bottom Up?



Different views exist about whether scientific findings should be applied from the top down or from the bottom up. The former suggests that the research community has identified an approach to sustainability that a government will impose on its citizens. The latter suggests that local inhabitants have tested ideas about what is needed to achieve sustainable development and societal well being. Governments and their agents often refer to stakeholders, with those stakeholders being found at sub-national levels. In fact, everyone is a stakeholder, even those making decisions at the national level who have a stake in the outcomes related to the decisions that they make. It is obvious, though not often done, that the application of knowledge must be applied from both directions and integrated. The participant from Hawaii's East-West Center provided the above schematic to show the flow of information required for a robust and effective climate information system.

Sustainability Science

Sustainability Science is a new concept, which suggests an holistic (interdisciplinary) approach to sustainable development (Kates et al., 2001). At a conference on Sustainability Science held in Friberg, Sweden in mid-October 2000, it was recorded that "the goal of sustainability requires the emergence and conduct of the new field of sustainability science." It noted that

> Sustainability Science seeks to improve on the substantial but still limited understanding of nature-society interactions gained in recent decades…. [It] will therefore need to employ new methodologies that generate the semi-quantitative models of qualitative data, build upon lessons from case studies, and extract inverse approaches that work backwards from undesirable consequences to identify pathways that can avoid such outcomes. Scientists and practitioners will

need to work together with the public at large to produce trustworthy knowledge and judgment that is scientifically sound and rooted in social understanding".

Some reasons for developing a sub-field called Sustainability Science were provided by a university professor (Lowe, 2001):

Science needs "a fundamentally different approach" if the goal of sustainability is to be achieved.

- Modern science could be described as "islands of understanding in oceans of ignorance." Many environmental problems are the "direct result of applying narrow specialized knowledge to complex systems."
- Instead we need to work backwards from undesirable outcomes to identify pathways to avoid these problems.
- "Scientists and practitioners have to work together to produce trustworthy knowledge that combines scientific excellence with social relevance."

The reason for raising this concept briefly at the workshop was to make the participants aware of the interest in this sub-field of research and application. The contributions of such a new sub-field to an improved understanding of the concept of sustainability is yet to be shown, given the numerous activities that are explicitly related to sustainable development that have been under way for more than a decade.

The idea of Sustainability Science is user-oriented; i.e., the user defines the means. Sustainability Science is also about linking across fields of knowledge, breaking down the idea that science is about "islands of knowledge." If science is to be sustainable as an institution, it needs to be useful and connect to users. A new web-based journal has been created — *Sustainability: Science, Practice and Policy* — as part of this movement toward developing this sub-field: see http://ejournal.nbii.org/about/about.html

Some criticisms have been leveled at Sustainability Science for making it appear to be a new discipline that discounts traditional disciplines. Calling it a "science" makes it appear to be something new to be investigated, rather than a new way of doing science – a new way of approaching the traditional disciplines, i.e., science for sustainability.

ENSO Science: El Niño, La Niña, and In-between

Tony Barnston (International Research Institute for Climate Prediction (IRI), Columbia University, New York) presented an overview of the ENSO cycle with a special emphasis on the science and the forecasts of El Niño. The session provided the participants with a broad overview of the ENSO cycle and an indication of the state of the art of El Niño forecasting. He provided responses to such questions as: What is El Niño? What are the indicators on the onset of an El Niño? How reliable are the forecasts? How credible are the models that produce the forecast? Also addressed were questions relating to how good scientists were becoming at determining in advance the strength as well as duration of an El Niño.

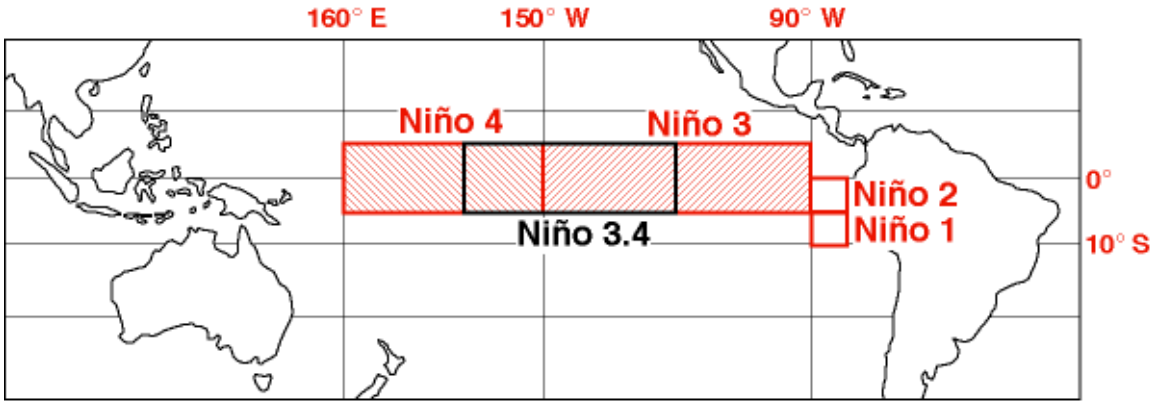
It was generally acknowledged that there is still considerable research needed to improve the reliability of El Niño forecasts. There are many groups and individuals with websites on the Internet that focus on forecasting El Niño and its impacts. Their level of reliability (e.g., accuracy and credibility) varies from one group to another and from one forecast to another. Many users of such forecasts around the globe are not yet good at distinguishing the forecast groups that are truly useful from those that are not. The problem is that all websites on the Internet can be made to look official and knowledgeable, when in fact they are not.

It is also important to note that different people are reacting in different ways to these forecasts. Even erroneous forecasts will have followers who believe them and act in response to them. There is no one group that has been authorized to provide a "seal of approval" to the various forecasts that are released to the public once an El Niño process is believed to begin setting up or to have begun. Although it is much easier said than done, forecasts should carry a "buyer beware" label. And, for those who are interested in El Niño and forecasts of it, it is best to familiarize oneself with the qualification of the scientists, researchers and forecasters as well as of the websites offering their projections about the current or future state of air-sea interactions in the tropical Pacific and elsewhere.

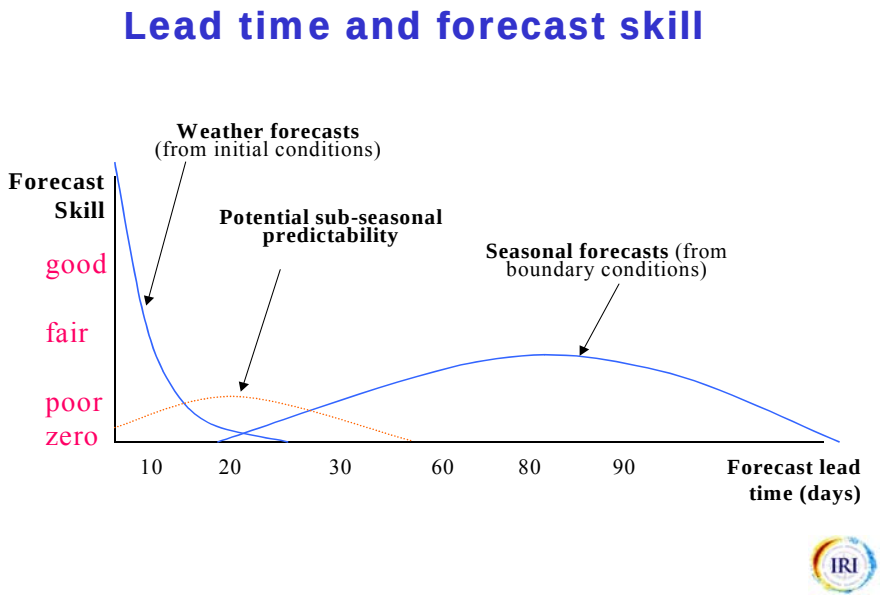
It was noted that once indicators of an El Niño have been identified and generally accepted by some keystone forecast groups, it is relatively easier to forecast its evolution (although not necessarily its strength or duration). Once the process has set in, it runs for 12 to 18 months on average. It was recognized that there is a need to improve El Niño forecasts. The good news is that global circulation models (GCMs) that forecast El Niño are improving. The bad news is that no two El Niño episodes are exactly alike, nor is the set of impacts associated with each of them. There are limits to the ability to forecast various aspects of El Niño as a result of the fact that the air-sea interactions are highly nonlinear. In other words, it is not simply a matter of forecasting sea surface temperatures in the equatorial Pacific or of projecting trends in the Southern Oscillation (the difference between sea level pressure at Darwin (Australia) and sea level pressure at Tahiti). El Niño *knowledge* then serves as an early warning for those responsible for societal and environmental well-being.

There is controversy over whether the general circulation models (i.e., the GCMs), as opposed to the statistical models, are better at aiding forecasters (i.e., have more skill) in forecasting the onset, duration, and impact of an El Niño event. Ensemble forecasts (a set of model runs) are a useful tool and are essential in estimating underlying uncertainties about the various characteristics, including onset, of the event. Data too is still a problem for those areas that are most at risk to El Niño's impacts, since the data (i.e., time series) are often incomplete, of poor quality, or are of short duration. The reporting of meteorological information from many stations to some of the groups that forecast El Niño globally (as opposed to regionally and locally) is irregular or nonexistent, a situation that needs to be addressed and improved.

Researchers use different regions of the central Pacific to identify the fingerprint of the onset of an El Niño: some use the region known as Niño3 and others use Niño3.4; still others use Niño4 or the Southern Oscillation Index. It appears that there is slightly better skill associated with changes in sea surface temperatures in the Niño3.4 region for the United States. However, this will depend on which region you are forecasting for. The following illustration (Glantz, 2001) shows the regions.



Barnston spoke about the spring barrier (in the northern hemisphere) to forecasting El Niño and the difficulty of forecasting across the barrier. He referred to the atmospheric phenomenon that can occur within a season known as the MJO (Madden-Julian Oscillation). An improved understanding and capability to forecast the MJO can supplement other forecasts of shorter duration (e.g., weather) and the longer term quasi-periodic El Niño or La Niña extreme, as suggested in the following graph.



From Barnston's PowerPoint presentation (September 13, 2004)

ENSO-Related Hotspots in the Pacific Region

This session's topic – hotspots – lived up to its name. It sparked lively exchanges about the notion of hotspots, the linkage of the hotspots notion to the ENSO cycle, and to its impacts on societies and environments worldwide. Hotspots can result from a single event or from the intersection of any combination of the following factors: political, economic, environmental, health, demographic, meteorological, and cultural.

The notion of hotspots is used in geology to reflect volcanic activity. On the societal side, it has been used in reference to zones of conflict (armed or otherwise) that are perceived to be dangerous. It has also been used to draw attention to desired vacation or amusement places. With regard to the environment, there are biodiversity hotspots, locations on the earth in which the diversity of biological species is on the decline (see the website at www.biodiversityhotspots.org/sp/Hotspots). Adverse changes in biodiversity are often the result of a combination of human activities as well as climate variability, fluctuations, change and extreme "events" such as the anomalous sea surface temperature increases associated with El Niño episodes. It soon becomes clear that the use of the word hotspots requires the use of an accompanying adjective to clarify its intended meaning. So, there can be flood or drought hotspots, biodiversity hotspots, disease hotspots, agricultural hotspots, and so forth. Within these broad categories there are also embedded other hotspots: agricultural hotspots could focus on a type of crop or on a type of farming system or on the degradation of the land quality on which agricultural activities are dependent. An another example, the Caspian Sea itself is a hotspot and within it are embedded other hotspots. See also the FAO hotspots website on HIV/AIDS hotspots at www.hiv-development.org/publications/climate_HIV.htm

In general terms a hotspot is any place, activity or event of keen interest to a subset of people in society. A hotspot can be geophysical, biological, or socioeconomic. More specifically, an El Niño hotspot is a location in which there is an elevated likelihood that El Niño's occurrence would generate anomalous climate and weather and their impacts about which the affected society must be forewarned. Societal responses to the forecast of an El Niño, combined with general El Niño knowledge, e.g., historical information about previous El Niño episodes (quantitative, qualitative and anecdotal), provide lead time for society to choose to react or to pro-act.

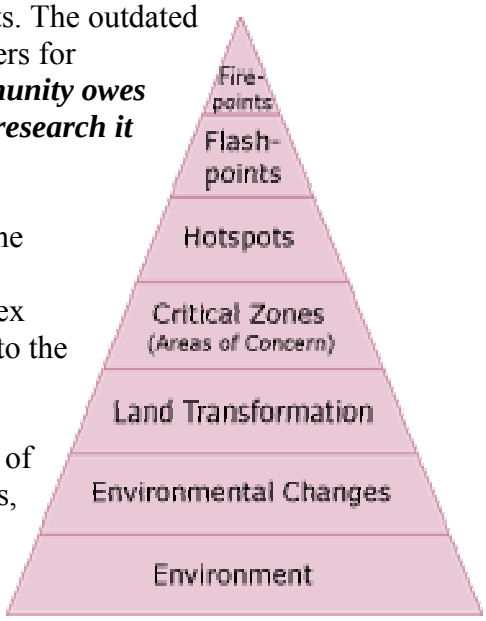
It was, however, pointed out during the workshop that the term "hotspot" does not translate directly into other languages; in Spanish, for example, the term "hazard" also carries a different meaning, and the word "hotspot" does not have an equivalent term. Nevertheless, the usage of the term "hotspots" is widespread in a wide range of contexts. It might prove to be a foreign term that eventually makes its way into other languages; e.g., in French there is now the English word "le weekend."

In the mid-1980s, researchers Ropelewski and Halpert (1987; revised 1991) prepared maps depicting locations, types, and timing of likely changes in rainfall and temperature that might be expected to accompany an El Niño (but should not be expected to accompany every El Niño). The maps, though based on data available up to that time,

were clearly meant to be suggestive and illustrative. Today, scientists refer to this type of map as a "cartoon graphic." Although it may provide a low level of scientific information, it seems to have a relatively high degree of policy credibility and acceptability. In any event, the reality is that such maps provide the public with an overview of the potential widespread influence and impacts of an El Niño event. They clearly have a role to play in educating the general public on this particular scientific process.

The maps also provide a general view of hotspots locations. However, any given El Niño can appear as a weak, moderate, strong or extraordinary physical event with highly variable impacts anywhere, even in places that had not been considered to be chronic El Niño-related hotspots. Thus, each of the evolving forecasts of a specific warm episode can identify new, temporary (to that episode) hotspots. An example provided in the workshop was the following: with the forecast of a strong El Niño, vacation areas in vulnerable locations may be avoided, thereby creating an economic hotspot. This year, a group outside the State of Florida suggested that this year 2004 is not a good one to visit Disneyland (in Florida) because of possible landfall there of hurricanes. This comment created a political backlash, as tourism is a primary source of revenue for Florida.

While the notion of hotspots seems to capture the attention of onlookers (the public, media and policy makers), it often lacks specific definition. The data on which the Ropelewski and Halpert maps were based are now more than twenty years old. The maps are in dire need of updating, if not for the sake of the scientific community then for the sake of potential users of El Niño knowledge, including forecasts. The outdated maps are still heavily used by the public, media and policy makers for educational and decision-making purposes. ***The scientific community owes the public updated maps based on the additional 20+ years of research it has funded.***



The pyramid diagram shows the dynamic nature of changes in the environment. The broad base of the pyramid represents the environment. The successive levels as one moves toward the apex (crises) are: transformation of the environment (not all changes to the environment are adverse); areas of concern (changes to the environment are beginning to show signs of negative impacts); hotspots (environmental changes have become serious with loss of productivity and livelihood. There can also be grades of hotspots, i.e.., hot, hotter, hottest); flashpoints (this represents the proverbial eleventh hour when the degradation is nearing irreversibility); and firepoints (too late to save the desired environment). As one can see from the pyramid, hotspots analyses tend to focus on negative impacts and their avoidance.

The function of this graphic is at least twofold. It highlights the location of hotspots along the continuum of changes to a specific type of environment. It also draws attention to the importance of dealing with environmental changes ***before*** they work their way to

become hotspots. This would involve an effective and efficient monitoring and early warning system for those environmental changes that are labeled as critical (i.e., areas of concern or AOCs). One could create another pyramid, an inverted one, adjacent to this one. At each corresponding level of the pyramid that depicts physical changes to the environment, there could be corresponding levels in the societal (inverted) pyramid that identify the human activities and natural factors that are causing or contributing to changes to the environment at that stage of change. An example from the Philippines was cited: vulnerability to El Niño's impacts had increased for the 1997–98 event, but not necessarily because the event was extraordinarily intense but because the region's irrigation infrastructure had not been maintained, the damage to crop production was higher than it might otherwise have been (e.g., a 30% reduction in the rice crop).

It was suggested that GIS (geographic information systems) approaches could be used in hotspots analyses by overlaying El Niño hotspots with other known hotspots such a biodiversity, at-risk coral reefs, floods, droughts, water resources (water quantity or quality), demographic trends, and so forth.

Several participants noted the importance of having to serve a range of decision makers with differing information needs about the geographic scale of hotspots maps. The broader the scale (e.g., national or global), the less likely is there to be usable detailed information. However, many decision makers would like to have detailed information about an El Niño's likely impacts in order to reduce impacts in their administrative, socioeconomic or political jurisdictions.

An issue was raised concerning locating the boundaries of a hotspot. One could ask why one side of a line is considered an El Niño hotspot while the other side of the line is not? Let's use the hurricane as another analogy. Forecasters of hurricanes identify zones of foreseeable impacts. These are envelopes surrounding the initially projected track of the eye of the hurricane that is expected to be affected by the tropical storm's winds, rains and tidal surges. The potential zone of impact changes as the hurricane changes it trajectory as it moves toward landfall. There are locations immediately outside of the envelope at a given point in time and they too are at risk of being affected by the hurricane. Further away from the boundary, the people and land are usually not affected by the storm. One must remember that areas are most likely on a gradient of risk. Although a simple graphic might be used to designate high risk (hotspot) regions, one must not take total comfort because their location is immediately outside the boundary line. Common sense should prevail when it comes to how one interprets such simple graphics. They serve as the lowest, and perhaps earliest, level of early warning of possible El Niño related impacts and problems.

As preliminary or as qualitative as El Niño-related hotspots identification might be, it can provide an early warning, a "heads up," to decision makers about the likelihood of El Niño-related hazards that an event could spawn in their jurisdiction. For some countries, decision makers will have considerable lead time to develop strategic responses to an El Niño forecast. For other countries decision makers will not have much time to respond and will have to resort to tactical and possibly reactive responses.

El Niño Knowledge as Early Warning for Sustainable Development: Using the SWOC Method

The SWOC method is designed to identify Strengths, Weaknesses, Opportunities and Constraints of activities or processes of concern. In this instance, it is about the value to society of using El Niño knowledge as early warning for sustainable development purposes. The results of a SWOC exercise carried out in a session or two in a workshop setting is meant to generate ideas and discussion and is in no way meant to provide definitive results. The SWOC approach itself can be the target of a SWOC review.

El Niño is a real phenomenon with which people must deal. An El Niño "industry" is also real; that is, a community of people has developed, including scientists and forecasters, that benefits from the El Niño phenomenon in one way or another, directly or indirectly. When people on the street hear the shout that "El Niño is coming" (usually a media article about a forecast), they expect their governments or leaders of their socioeconomic sectors to take some sort of action, preventive (e.g., evasive), mitigative or adaptive. There is likely, in any event, to be a response to the forecast of an El Niño occurrence, regardless of the correctness of that forecast. When a forecast is issued, someone is listening to it. Yet, the science of El Niño is not complete, nor have all the potential responses by governments or socio-economic sectors been identified, let alone worked out. The question is as follows: Can responses to El Niño knowledge (again, including but not limited to forecasts) be used in ways that do not hamper long-term development prospects and may even enhance them?

Workshop participants were separated into two groups in order to undertake a SWOC assessment. One group was asked to identify the ***strengths and weaknesses*** of using El Niño knowledge as early warning for sustainable development purposes in Pacific Rim countries and islands. The second group was asked to identify the ***opportunities and constraints*** in the use of El Niño knowledge as early warning for sustainable development purposes.

Strengths

There are at least two ways to look at the strength of using El Niño knowledge for sustainable development: conceptual and practical.

- Conceptual: Provides a new way of thinking related to learning to live with variability and thus can enhance the existing risk management framework. In particular, we are forced to think about a longer time scale than normal (e.g. the decision makers' terms of office). Thus, it helps to build up institutional memory, capacity, and capability particularly for improving the existing risk management framework.

- Practical: Building capacities and capabilities is also practical, especially in that uncertainties can be reduced while sectors can separately take El Niño early warning and apply it for their specific needs; for example, meteorological

services use the El Niño phenomenon and related early warning knowledge as a development opportunity. But because this theme is of interest to many socioeconomic sectors, it could also be a stimulus towards increased cooperation and collaboration among them.

The notion of El Niño knowledge provides a new way of thinking about El Niño. It can provide decision makers (or, more broadly, stakeholders) with longer lead times needed for strategic thinking about how to cope with El Niño and its impacts, not just a single threatening event but all such events.

Practically, El Niño knowledge can help to reduce uncertainties by drawing attention to the history of El Niño events and their past impacts, thereby putting the quasi-periodic event in an understandable context for the public. El Niño knowledge can be used to enhance institutional capacity with regard to responding to forecasts and projected impacts of a range of climate-related extreme events, and not just to ENSO's extremes. In this regard, El Niño knowledge can be used to make structural changes to public and private institutions.

El Niño knowledge can broaden one's view of El Niño from a focus primarily on El Niño forecasts of a specific event to the broader El Niño climate information system. It can also help to bring the players together in a given region that are affected by the same natural phenomenon – in this case El Niño – to work on the development of coordinated regional responses to El Niño events in general.

El Niño knowledge also provides a bridge between environmental change and economic well being. Linking environmental impacts in general and, more specifically, those related to El Niño with economic growth prospects can help to identify options for decision makers in their pursuit of sustainable development policies and practices.

Weaknesses

Weaknesses were divided into three categories: conceptual, informational, and communications. The group came up with the following points.

- Conceptual: The main conceptual weakness is that the term "El Niño" has a lack of specificity regarding what is being conveyed. Is it a coastal El Niño or a basin-wide El Niño? What space and time scales are being considered? Which stakeholders should be concerned and how? Are we really talking about El Niño *manifestations* (the event itself), *effects* (its impacts on regional climate), or *impacts* (on human activities)? An overall framework of climate risk management and ecosystem response may be more appropriate.

  On the point about making the El Niño focus broader to climate risk, a participant questioned why going to a more general and broader concept would be more useful and specific to those coping with El Niño's impacts in specific locations under different socioeconomic and geophysical settings. To be sure they are

dealing with other hazards as well; if one thinks El Niño science is difficult to make useful in an application to societal needs, how could broadening the overarching concepts make it any better or easier for decision makers to use? El Niño issues make up a subset of climate and climate-related risk issues and need not be replaced by it. To do so would turn away those whose focus is on El Niño per se.

- Information: The conceptual weakness associated with using El Niño knowledge to address sustainable development issues relates directly to the weaknesses in the information that is conveyed. Weaknesses include inconsistent data, incomplete data, inconsistent interpretation, lack of communication of uncertainties, timing with which the data are available and poor pathways of communication for information and data.

- Communication: Communication weaknesses include, in particular, translating the data into practical and operational outcomes. Politicians, of course, usually do not gain points for using climate- and risk-related information related to long-term processes, particularly when plenty of uncertainty exists and when consequences fall outside their particular tenure in office. Thus, communication problems arise as stumbling blocks regarding the direct link from science to policy.

El Niño science is not yet reliable at forecasting the onset of an episode or the severity and location of its teleconnected impacts. It is relatively more reliable, however, once an El Niño has started, because it tends to lock in (i.e., persist) for 12 months or so. El Niño science is young. The time series for observed El Niño episodes in short, although researchers have used proxy information to identify El Niño events back to the 1500s.

For some countries, the onset of El Niño is followed so quickly by the impacts that decision makers have little to no lead time to get people ready for its impacts ***(NB: the positive side of this, though, is that El Niño knowledge (as opposed to just one forecast) can provide decision makers (national to local) with planning potential for the long-term (strategic planning as opposed to tactical reactions).***

Opportunities

El Niño knowledge as an organizing theme helps to broaden the focus of attention away from a specific event and a specific forecast. It fosters longer term thinking and planning, even if the science of the ENSO cycle is still incomplete. El Niño episodes and their impacts, collectively speaking, can be put in a broader development (as well as risk) context. Such knowledge can find its way into development planning exercises.

There are known El Niño impacts that have been positive for development. Making these examples explicit alongside their other disaster-reduction activities and sharing that information with other El Niño-affected communities can benefit societies.

El Niño knowledge would add to existing climate forecast and information systems. Although an El Niño forecast might provide relatively short lead times to decision makers at all levels of society, El Niño knowledge would provide them with strategic information for increasing the range of their development options, while at the same time identifying activities or locations for development to avoid.

It was suggested that the ENSO cycle be addressed from a macroeconomics perspective by linking environmental impacts with economic growth and with sustainable development. How do El Niño impacts influence the national economy, e.g., economic growth? One can make El Niño knowledge relevant to the various policy-making (institutional) levels from local to global. In other words, an improved use of *ENSO knowledge* can help a society to generate as well as to save funds.

In sum, by focusing on the broader notion of El Niño knowledge, a basic toolkit for decision makers can be created, one that would contain a range of "no regrets" El Niño-related strategies.

Constraints

There has been a tendency to view El Niño episodes primarily and overwhelmingly in a negative light. It has been "sold" to the public only as a hazard, rather than just the "warm" end of the normal cycle of variability in Pacific air-sea interaction. After a few decades of having done so, it will be difficult for the scientific community and the media to change societal (and therefore decision makers') perceptions about the phenomenon. There have been a few attempts to put El Niño in a positive light (Philander, 2004).

The primary focus on El Niño forecasts is constrained by the public's relatively short attention span. El Niño episodes are quasi-periodic: they can recur anywhere from 2 to 10 years apart and do so every 4½ years on average. It is difficult to get society to stay focused on a natural phenomenon that occurs infrequently and irregularly. With regard to El Niño, this could be addressed by elevating the importance of La Niña events and more broadly La Niña knowledge. Doing so would provide the public with information about one of the two extremes of the ENSO cycle on a more frequent basis. Either anomalous event can cause problems or bring benefits to different locations or some socioeconomic sectors. Taken together, the 4½-year average waiting period for just an El Niño to occur can be cut in half, with an anomaly of opposite sign every couple of years.

There is a change taking place right now. The global warming debate has raised the prospect of a future climate system having a "semi-permanent El Niño-like condition" because of the warming trends in the global oceans. This has captured, rightly or wrongly, the imagination of the public and has led to a broader public knowledge of the ENSO cycle. See website www.exploratorium.edu/la_nina.

It is considered quite difficult for the media and the scientific community to interact with the public about the ENSO cycle. Like many other science-based issues of interest, it is difficult to explain ENSO in a few paragraphs, keeping the article or media message short

and interesting to the public. Nevertheless, a few paragraphs here and there can to be a way to go in the future in order to maintain societal interest in the state of air-sea interactions in the tropical Pacific Ocean, as well as their potential impacts.

A SWOC review is useful in many ways, but one important way relates to a view that weaknesses and constraints can also provide an opportunity. Once they have been made explicit, tactics and strategies can be developed to surmount them. Once they have been identified, existing strengths and opportunities are to be protected and, if possible, enhanced.

Expectations about Early Warning Systems

When it comes to early warning systems, it is important for those concerned about them – forecast producers, intermediaries, and users – to determine what it is that they expect to achieve from them. Often, expectations are high for the success of a warning system in that people expect to receive timely warnings that have a high degree of reliability. In reality, though, early warning systems, however efficient they might be, are not perfect. There are missed warnings, there are warnings for threats that never develop, and there are events for which there were no timely warnings.

Early warnings about El Niño's onset, intensity and possible impacts must be calibrated against and combined with other relevant information. There is a tendency to expect too much from an early warning system. Nevertheless, one could argue that El Niño forecasts represent the earliest warning that a user (government, business, or individual) might get about the possibility of climate-related anomalies. Decision makers operating within climate-sensitive sectors now have the option to pay attention to the warnings issued by one of the key El Niño warning systems that are considered relatively reliable. These El Niño EWSs need to be seamlessly coupled and frequently updated with advice based on monitored changes in sea surface temperature and sea level pressure across the Pacific basin as warning are updated.

El Niño's Cascade of Forecasts

The Use of El Niño Knowledge

An El Niño forecast from a reliable source sparks interest in various socioeconomic sectors throughout society. It tends to spark a cascade of forecasts of potential impacts in regions or sectors designated as, or perceived to be, El Niño hotspots. For example, decision makers responsible for water supply might begin to put into place strategies to assure water availability throughout the El Niño period, especially in those regions where water shortages are expected to occur, such as in the Pacific Islands. They may choose to lower reservoir levels in areas that receive above-average rainfall during an El Niño episode. Once water restrictions are implemented, families and local communities will make projections about their water needs under such stressed conditions and will react

accordingly. As another example, in regions where El Niño sparks malaria outbreaks due to excessive rainfall, local governments can order the spraying of swampy areas; people can take preventive measures depending on their perceived level of threat; and so forth.

Three separate cascade sessions were held, with each one focusing on a cascade of forecasts that can be sparked by an El Niño forecast: hazard forecasts, agriculture forecasts and forecasts for the fishing sector. The first of this set of discussion sessions focused on climate-related hazards such as droughts, floods, fires, and infectious disease outbreaks.

Hazards

Each country has its own unique set of climate-related hazards with which it is concerned. Neighboring countries often end up "sharing" a hazard and its impacts, such as a hurricane (or cyclone), a drought, or a transboundary flood. When an El Niño episode has been forecast, its onset observed, its development monitored, and its potential impacts identified, decision makers in various socioeconomic and political/administrative sectors of society become catalyzed to action. They do not all respond at the same time to the forecast of an El Niño but, depending on their specific concerns about impacts, may choose when to take the forecast seriously. In those regions where the visible impacts of an El Niño follow the forecast by several months, those decision makers have time to prepare. Those in other locations where the gap in time between impact and forecast is short have fewer options for their response.

Today there are many examples of how governments, administrative units, sectors of society and individuals have reacted to each of the forecasts for the stages in the evolution of an El Niño from its onset to its decay. There is considerable experience with hazards to draw on (e.g., droughts, floods, fires, disease) in both space (e.g., on both sides of the Pacific Basin) and time (e.g., from the impacts of earlier El Niño events) available to those decision makers wise enough to actively look for and use it.

The original intention for this session was to look at the El Niño forecast cascade as it has been described: that is, a forecast is issued from a recognized reliable source and then perhaps the water resource managers might begin to issue projections about water availability during the El Niño period. This would then stimulate municipal and agriculture decision makers to issue forecasts of impacts on locally available water supply. The public in turn decides how it will deal with, say, water shortages. Again, not all of these decisions are made at the same time as each has its own time lag of response to the previous forecast.

An alternative way to describe the forecast cascade was suggested by the participants: Manifestations, Hazards and Impacts. ***Manifestations*** refer to the impacts of a warming of sea surface temperatures in the tropical Pacific on physical attributes of the atmosphere and the ocean, e.g., anomalous changes in temperature, pressure, wind speed and direction, sea level and thermocline depth. ***Hazards*** refer to geophysical hazards such as meteorological droughts, floods, fires, mudslides. ***Impacts*** refer to social and ecological

responses to the changes in the regional atmospheric or marine environment's "average" condition. This alternative perspective is neither incompatible with or diametrically opposed to other ways to view an El Niño forecast cascade. Both will help to supply a decision maker with the El Niño related information that he or she may need in order to make effective and timely decisions.

Health

Carlos Corvalan of the World Health Organization (Geneva) made a brief presentation about climate and health, noting that climate variability poses a big threat to health conditions. El Niño and other climatic extremes, and also climate change, are a great challenge to the health sector. Health is a sector that is already under great stress in many developing countries: they are faced with great health challenges such as HIV/AIDS, TB, dengue, and malaria, and, increasingly, non-communicable diseases. But the adverse health conditions associated with the El Niño phenomenon are an important concern. The 1997–98 El Niño caused 24,000 deaths, with 6 million people displaced or homeless, and a total of 110 million affected: a large, yet hard-to-measure overall health impact.

Obviously, El Nino's health impacts pose a huge epidemiological challenge for several reasons: it covers a very large geographical area and is of very long duration. It has multiple risk factors and multiple health impacts. It is hard to correlate the event with an epidemiological process (i.e., hard-to-establish causality) which has implications for resource allocation and action. In addition, in many countries affected by El Niño, there is an increase in vulnerability brought about by heightened urban concentration as a result of rural-urban migration, chronic poverty, and high unemployment. It is therefore necessary to understand well the epidemiological profile of the affected regions, in the form of population health status (pre-existing conditions, nutritional status), the environmental situation (housing, water, sanitation, vectors, etc.), and the socioeconomic and political conditions.

Health impacts are manifested visibly and directly (and rather quickly) in the form of injuries and accidental deaths. But health effects are often delayed, such as certain communicable diseases and vector-borne diseases. Many indirect effects also occur as a result of population displacement and malnutrition, but these are harder to detect in the absence of a constant mechanism. Certainly a given population many suffer all such impacts simultaneously combined.

Preparations in the region of the Americas by the Pan-American Health Organization (PAHO) led to a reduced impact on human health. Although the region suffered 54% of the total economic loss, it had 4% of the overall death toll. The main lessons from the 1997–98 El Niño were: (1) that the health sector needs to be part of a multisectoral process of planning, management and evaluation of risks; (2) that plans of action need to be in place for prevention, for intense activity during the event, and ongoing post-event actions to reduce ongoing impacts and address immediate, as well as long-term, impacts. It is also clear that capacity building exercises are required on an ongoing basis and should include health as part of multidisciplinary teams. Communication is essential; the

media can be a good ally to assist in providing information and education to the public. Finally, responses to adverse impacts must contribute to long-term solutions.

It was suggested that there is an implicit connection between early warning and pro-active adaptation. In many parts of the globe where El Niño's impacts are felt, health services are so severely stressed that their ability to respond effectively and in a timely way to a warning is severely limited. The at-risk population (whether in situ or migratory) requires water, food, medicines, sanitation, and protection from disease-bearing vectors (mosquitoes, flies, rats, etc.). In some countries the existing services are so weak to begin with that additional stresses on them cannot effectively be responded to. In Haiti, for example, there is little that can be done in-country to mitigate the impacts of an adverse event and, as a result, the inhabitants are forced to *muddle through* the disaster and recovery periods. They live in at-risk areas out of necessity, not choice. In other places, such as in the richer countries (e.g., the State of Florida), people can choose to live in harm's way; that is, they are taking on elevated risk by choice to extreme meteorological events.

The 1997–98 El Niño made it quite clear that the health sector in El Niño hotspot locations needed to be an integral part of the planning activities for coping with El Niño forecasts and impacts. That means involvement in the pre-, during, and post-event activities. Also, capacity building in the health sector requires a multidisciplinary effort, because its activities must contribute to long-term solutions to the health problems at the same time that it copes with the current event's health impacts. The media have proven to be useful allies to the health sector, as with other sectors, in that they can be used (with encouragement) to educate the public and various levels of decision makers about sanitation, nutrition, and so forth, making the population relatively healthier in the face of future El Niño related impacts. Addressing the well-being of populations at risk to El Niño as a development goal builds more resilience within a community while at the same time tending to reduce its vulnerability. Increasing resilience enables a society to withstand more severe climate-related (and other) shocks.

El Niño has over the years received growing attention from the media, as well as from the scientific community. Users of information are lulled into a false sense of security because they only have to focus, every several years or so, on the impacts of an El Niño event. However, not every drought or flood is associated with a specific El Niño event. They also appear in non-El Niño years. Thus, decision makers need to be prepared for the eventuality of droughts and floods all the time. Thirty years ago, few people outside the west coast of South America knew or cared about El Niño. El Niño research, carried out with increasing intensity since the 1960s, is now quite mature and perhaps has had its moment in the spotlight of science. There are other forms of variability surprise that decision makers must contend with, beyond the ENSO extremes. Putting all these points together, it became clear that it is time to view El Niño as an expectable, therefore normal, aspect of climate variability. The participants expressed, almost unanimously, the idea to consider El Niño as one of several types of climate variability. The phrase used was as follows: *"**It is time to put El Niño back in the climate variability box.**"*

It became evident early in the workshop that, from the perspective of sustainable development and long-range planning purposes, the climate variability linked specifically to El Niño is a special case in the sense that it reappears irregularly but with a frequency that forces societies to take it as a serious potential disrupter of human activities. On the other hand, there is growing skill in forecasting its development, though forecasting the onset is still apparently problematic for researchers and forecasters. Nevertheless, there is still much to learn about how to most correctly forecast its onset and development, as well as its impacts on ecosystems and societies.

With regard to El Niño's health-related impacts, a participant noted that it was time to get beyond event-based, and therefore forecast-based, thinking, if planners are to use El Niño knowledge for sustainable development purposes. This sparked an interesting discussion about the relative weights (that is, attention, concern, level of importance) that should be given to an El Niño event as opposed to climate variability and climate risk on the annual time scale.

The idea of "getting things back to normal" also received attention in this session. It is often the objective of emergency response personnel to get the affected populations back to their normal routine in the first several months following a disaster. However, in many of the regions affected by El Niño "normal" does not mean a return to a good life. So, getting health conditions back to normal in a poor country may be a goal for emergency workers, but is not necessarily the best goal for those interested in improving the human condition. The notion of normal with regard to affected populations should be revisited in light of the needs for enhancing the well being of at-risk populations.

To reduce the adverse health impacts of El Niño episodes in general and of a specific El Niño event in particular, the underlying factors that increase vulnerability (which could be viewed as the "inability" to adapt to adverse impacts) and also reduce resilience (which could be viewed as the ability to rebound from adversity) of a society must be addressed. In this regard, it is necessary for impacts researchers to continue to try to separate out the adverse impacts that can be blamed on El Niño events from those that must be attributed to decisions made by policy makers. The bottom line is that the realization that pre-existing societal conditions, before a climate anomaly takes place, play a strong role in the potential impacts on humans and on ecosystems of that anomaly.

> The irregular occurrence of El Niño and La Niña events has implications for public health. On a global scale, the human effect of natural disasters increases during El Niño. The effect of ENSO on cholera risk in Bangladesh and malaria epidemics in parts of South Asia and South America has been well established. The strongest evidence for an association between ENSO and disease is provided by time-series analysis with data series that include more than one event. Evidence for ENSO's effect on other mosquito-borne and rodent-borne diseases is weaker than that for malaria and cholera. Health planners are used to dealing with spatial risk concepts but have little experience with temporal risk management. ENSO and seasonal climate forecasts might offer the opportunity to target scarce resources for epidemic control and disaster preparedne**ss (Kovats et al., 2004)**.

Agriculture, rangelands and water

There already exists a considerable amount of literature, and it is growing, on the use or value of El Niño forecasts in the agriculture, rangelands, and water sectors for dozens of societies. In fact, most concerns (and searches for benefits) about the use of El Niño forecasts have been for these sectors of society. El Niño forecasts, while far from perfect, can provide farmers, rangeland managers and water resources managers with useful information in their decision-making processes on how to cope with El Niño-related anomalies. Studies have also compared the ability of small farmers in poor countries and rich farmers in industrialized countries to cope with the forecasts as well as with the impacts.

In each country the public appears to have some difficulty in understanding probabilistic climate and weather forecasts. They tend to view forecasts as having been either right or wrong. They tend to blame forecasters if their forecasts do not match real conditions each and every time. Whether proven to have been a good forecast or an erroneous one, people react first to a forecast before they respond to its impacts. And there are risks and consequences for those who take actions based on the forecasts. This is a tricky business for those in operational decision-making positions. The climate system is a non-linear one with many interacting processes. Forecasters have to make decisions based on probabilities, while their constituents must bear the costs (or benefits) of the decisions. There are some clear downsides to an El Niño forecast for the agricultural sector. For example, if drought conditions in a given region are expected to accompany an El Niño, local banking institutions have been known to withhold loans to farmers and ranchers because, in the event of drought, those borrowers would not have been able to pay off their loans.

Examples were provided from various countries. In Central American countries, various forecasters come together periodically to determine the likelihood of the onset of an El Niño and to discuss its progress as well as its potential impacts on various sectors of their societies, especially on agriculture and water. They integrate various types of data, downloadable from the Internet, and combine it with GIS. In Ecuador there are monthly meetings of an El Niño study group. In the Pacific Island countries local groups get together to discuss the various forecasts (some are locally produced while others are produced in the US, Australia, Japan or the UK). NOAA's forecasts of El Niño are particularly influential in distant lands. However, to NOAA forecasters El Niño is a process (part of the ENSO cycle), whereas many in Ecuador view El Niño as an event.

Sustainable development programs require strategic responses to El Niño episodes and not just a series of ad hoc, reactive (e.g., tactical) responses. While any subset out of a range of tactical responses to a specific El Niño can help a government or society to minimize the impacts of El Niño, the ones that ultimately are chosen to make up that set should not impede or set back the drive toward sustainable development objectives.

A presentation was made about El Niño in Ecuador and its impacts on agriculture. On 11 July 2002, NOAA issued an El Niño forecast with the headline "El Niño makes its official return." When people in Ecuador heard this forecast, they reacted but it soon became clear that what NOAA forecasters and modelers consider to be an El Niño, people on the west coast of South America might not. Heavy rains coming earlier than expected were forecast, but they did not materialize. Those most adversely affected by the forecasts were the small farmers in rural areas. Also, the media became confused by the forecasts. NOAA is focused on the central Pacific for changes, while those in South America are primarily concerned about changes in the coastal waters. It was suggested that El Niño forecasts should be labeled in the following way: basin-wide El Niño, coastal El Niño, and a "Dateline" El Niño.

It was noted that when the forecasts from different sources conflict, people in Ecuador get together to discuss these differences. The media have been invited to these discussion sessions, but they rarely attended, preferring to get their information from the Internet (this gives some credence to the misplaced believe that "experts come from out of town"). It was noted that forecasts need to be contextualized, i.e., tailored to the needs of the specific users, such as agriculture, fishing, health, rangelands and livestock, etc.

Researchers tend to favor the Southern Oscillation Index (SOI) because it provides decision makers with a longer lead time than does changes in sea surface temperatures in the central and eastern Pacific, the indicator focused on by North American forecasters. In Australia the goal of cascade forecasters is to encourage farmers, rangeland and water resource managers to hedge against the potential (e.g., likely) impacts of an El Niño; that means taking tactical moves to lessen, if not avoid, the impacts ("lean toward rather than leap to," when it comes to making changes in one's crop portfolio). For example, farmers have an option not to plant every third row of cotton or sorghum in order to provide more soil moisture for the two remaining rows later in the season. The water is available later in the season when it is most beneficial for yield development, because the roots require time to grow into the not-planted area and exploit this resource at a time most valuable to the crop. Not to do so runs the risk of losing the entire crop to poor seasonal conditions. However, should growing conditions turn out to be exceptionally favorable, crop yields from such "skip-row" planting configurations will be lower than those for conventionally planted crops. This is a clear example of how El Niño knowledge can be integrated into existing risk management frameworks.

For Australia, Indonesia, the Philippines and other Pacific Rim countries and island nations, even weak El Niño events (in terms of sea surface temperature anomalies) can wreak havoc on their national economies, while a "strong" event might have few impacts. As noted earlier, no two El Niño events are the same in terms of their impact.

Fisheries

Participants acknowledged at the outset of this session that a considerable literature exists on the impacts that climate and that El Niño events have on the marine environment and especially on living marine resources.

While many examples can be found of serious adverse effects on fish stocks and fishing sectors, there are also many examples of benefits to some fish stocks and fishing sectors. In other words there are winners and losers among fish populations and fisheries as well during an El Niño episode. One country's loss of access to a certain favored commercial fish population may prove to be another country's gain. Also, some fish populations that favor warm water benefit from El Niño, while those requiring cool waters for survival lose out in that particular location. A concern and a potential benefit for sustainable development with regards to the fishing sector would be to devise long-term strategies for coping with impacts in a designated El Niño-related fisheries hotspot.

Strategic thinking involves using El Niño knowledge drawn from experiences and lessons learned for a given fishery, as well as fisheries elsewhere that are subjected to environmental changes similar to those that often accompany an El Niño. El Niño knowledge also includes fisheries' responses to the various El Niño forecasts that are issued from its onset to its decay. Again, there are several examples of societal responses to El Niño forecasts in Pacific Island countries (e.g., tuna fisheries), in South American countries (e.g., anchovy, sardine, mackerel, shrimp fisheries) and in North America (e.g., salmon fisheries).

There are several competing models based on assumptions about fish population dynamics: recruitment, maximum sustainable yield, safe yield, optimal yield, and so forth. It was suggested that these models are often used for purposes beyond which they were originally intended: as an input to a decision-making process, or as ***THE*** input on which a decision is to be based. Despite the enormous literature on fish populations and fishing industries, it appears that the lessons learned from one fishery's experience by another, or within the same fishery but at different points in time, are often not applied. As a consequence, fishermen and scientists argue over the relative adverse contributions of fishing pressures and of natural variations to the long-term health of commercially favored fish populations. Management strategies are developed that are dependent on a manager's perceptions about which factors to blame, for example, for fish recruitment failure and for fish population collapses resulting from other causes.

So much information on fisheries exists that it was suggested that the problems with managing the exploitation of fish stocks, scientific uncertainties notwithstanding, were based more in institutional arrangements and decision-making processes than on reliable forecasts. The concept of "tragedy of the commons" has been used in a fisheries context at least since 1954 (Scott, 1954). There are also many theories about how best to exploit a common-property fish population in a sustainable way. So far it seems that just about every fish population that has taken on a commercial value is stressed or has collapsed.

Adding to the pressure on fish of overfishing, R.C. Murphy (1954) suggested that "man is the only insatiable predator."

An example of the impacts of El Niño on a Pacific island fishery was provided. An El Niño can literally mean going from a good economy and easy fishing of tuna to a condition of no tuna at all and a poor economy (i.e., no income for many in the fishing sector such as those in canneries). Because the tuna population has migrated eastward, those in the eastern part of the Pacific basin benefit. It was proposed that ***all*** would benefit if those dependent on the tuna fisheries could devise an arrangement where they share in the benefits as well as losses of each other, throughout the impacts of the extremes of the ENSO cycle. Using El Niño knowledge (not just a specific forecast), planning in the region can be done in a more cooperative, supportive, and sustainable manner.

During this session, a representative of the CPPS (Permanent Commission for the South Pacific) presented a brief history and description of activities of the organization. CPPS, created in 1952, is devoted to an improved understanding and management of living marine resources in the eastern equatorial Pacific along the western coast of South America. CPPS is responsible for the maritime policies of its member states (Colombia, Chile, Ecuador, and Peru). He discussed the structure and functions of this regional organization and commented on a wide range of issues related to marine affairs (El Niño, fisheries, management, research, etc.).

His presentation generated considerable discussion about fisheries management and the models used as management tools. He made it clear that fish population exploitation in the face of El Niño (or in the face of any variability or extreme of climate for that matter) must be considered in a multidisciplinary context. Decisions made about land use, as much as changes in the ocean or in the atmosphere, can be a destructive force as far as the sustainability of living marine resources are concerned.

World Conference on Disaster Reduction

A presentation was also made by the representative of the ISDR. He described the World Conference on Disaster Reduction (WCDR), which is to be held in Kobe, Japan in mid-January 2005. This conference aims to increase the profile of disaster risk reduction in development planning and practice by promoting a strategic approach at the national level to address vulnerabilities and reduce risk to natural hazards. Human and economic losses to natural disasters continue to rise and remain as a major obstacle to sustainable development. The conference will build on the findings of the Yokohama Strategy and Plan of Action (ISDR, 1994).

Based on the objectives set out by the UN General Assembly, the main outcome of the conference is foreseen in the following areas: (1) increased awareness, recognition, and political endorsement for implementing disaster risk reduction and mobilizing local, national, and international resources; (2) clearer directions and priorities for action at

international, regional, national, and local levels to ensure implementation of the ISDR and to support the achievement of the objectives of the Johannesburg Plan of Implementation and the Millennium Development Goals; (3) adoption of a set of goals and policy measures to guide and stimulate the implementation of disaster risk reduction, both on what to achieve and "how-to-do" risk reduction; and (4) launching of specific initiatives and partnerships to support the implementation of the ISDR.

Roundtable: El Niño's Impacts on Flora and Fauna in the Galapagos

An evening roundtable, open to the public, was held on "El Niño's impacts on flora and fauna in the Galapagos." Opening remarks were made by Jose Luis Santos from CIIFEN, and Mayor of Isla Santa Cruz Alfredo Ortiz Cobos. Two presentations by CDRS (Charles Darwin Research Station) scientist Stuart Banks and Hernán Vargas (Oxford University) were included. Banks provided an overview of the marine and coastal environment, its exploitation and the major threats to living marine and terrestrial resources of the Galapagos Islands. (*Note*: the full text of Banks' presentation is included in Appendix B.) Hernán provided an overview of the impacts of El Niño on the terrestrial biodiversity of the islands and discussed the importance of including knowledge of el Nino and climatic variability in wildlife management.

The Galapagos Marine Reserve (GMR), spanning an area of more than 138,000 square kilometers, lies approximately 1,000 kilometers from the Ecuadorian coast, in the heart of the equatorial eastern Pacific. This recently declared UNESCO World Heritage Site (2001), famous for being a living laboratory, lies in what is often referred to as the "epicenter" of warm and cool ENSO extreme events. Thanks to great advances in ocean in-situ and remote-sensing technologies, such recent events around the equatorial Pacific have been well documented, particularly regarding large spatial and temporal patterns. Conversely, effects at small scales relevant to biodiversity and sustainability within the GMR are only beginning to be understood.

ENSO warm and cold events have local effects specific to Galapagos, suggesting as with other areas, that a sub-setting of the large scale predictive models would be appropriate. As an El Nino develops across the Pacific, the warm pool in the central region that generates a NOAA warning may never reach the islands, although when it does, the effects had generally been felt earlier than on the South American coast. Nonetheless many consequences echo those of the Californian and Peru upwelling systems. Negative marine impacts are typically associated with the ENSO warm events (El Niño), while increased rainfall greatly augments plant growth and the proliferation of invertebrates in the terrestrial environment. During these periods, introduced species (representing the greatest threat to the isolated natural state of the Galapagos), such as the *Scinax* tree frogs, fire ants, rats, cats, goats and dogs all tend to establish themselves.

Today Galapagos is hurtling into the future with greatly increased human population and unprecedented exploitation of its marine resources, making the conservation of the Reserve a very real challenge. Humans have only recently formed part of the

perturbations associated with ENSO. There is a new level of ecological, socioeconomic, and political complexity combined with natural variability. If the Galapagos National Park Service is to protect these globally unique ecosystems we need to turn our attention to the difficult challenge of differentiating often compounding anthropogenic impacts from climate and the impacts of climate change.

A review of the evening session took place on Wednesday morning. It was noted that many local people came to the roundtable. The session was a very lively one, and was presented in both English and Spanish. The question of winners and losers came up repeatedly during the evening session: there are winners and losers related to responses to the forecasts, as well as winners and losers related to the impact of El Nino. **One participant put forth the following interesting idea that governments might be convinced to divert 10% of what they think the impacts will cost them in an attempt to prevent at least half the impacts.**

Winners and Losers Issues Related to El Niño

In the short term, for a given event there are winners and losers, as a result of El Niño's impacts and the decisions to use or not use El Niño forecast information. Heavy precipitation may bring good news to some (e.g., hydropower) and bad news to others (destruction of infrastructure, erosion and disease outbreaks). The good and bad news can be in the same country, with one sector benefiting and another losing out. A participant noted that this can happen even within one sector: unusually heavy rains in winter/spring (often La Niña-related) can cause havoc for the wheat industry, but are a blessing for cotton – on the same farm! Or it can be between countries (good rains can also lead to two crops in a year); it can lead to an increased market share of a given commodity, if a competitor is hard hit by impacts, such as in the case of coffee.

In the longer term, which relates to sustainable development, those who can use El Niño knowledge to their advantage can benefit over those who ignore it. It may be ignored by choice (e.g., the skill is not seen as high enough for use in decision making or the information and knowledge has not as yet been shared with those who need it). Those with access to high-tech communications can benefit from the increased knowledge acquired *between events*, as well as benefit from a given forecast for a given event. Those without access to that knowledge (e.g., it is often not broadcast in the local media or not translated into the local language or not expressed in user-friendly terms) would not have the benefit for their land-use activities of this knowledge.

The issue of trust appeared again with regard to the use of forecasts related to El Niño or its cascade of forecasts. Trust between researchers and forecasters, users and forecasters, between stakeholders and forecasters, and between stakeholders and governments, is very important when it comes to encouraging increased use of forecasts. Trust, however, has to be developed (or better, earned) between forecasters and users, users and forecasters, users and other users (in various sectors of society that may be dependent in some way on each other, such as farmers or fishermen and the banks that provide them with loans), and

forecasters and other forecasters (in the chain of forecasts spawned by the forecast of El Niño's onset).

Lessons to be Learned from Lessons Already Learned

> *The Compact Oxford English Dictionary: Definitions*
>
> *lesson* – noun: **1** a period of learning or teaching. **2** a thing learned. **3** a thing that serves as a warning or encouragement, etc.
>
> *object lesson* – noun: a striking practical example of a principle or ideal.

At the outset, it is important to say that many people do learn lessons from past experiences: their own and the experiences of others. However, with regard to hazards and disasters, there are many lessons that have been identified for application, but for a variety of reasons — some political, some financial, some cultural — have not been applied. This may be more true for intermittent, aperiodic events and for creeping, incremental changes that it is for recurrent quick-onset events in known locations. The European Environment Agency (EEA) produced a report entitled *Late Lessons from Early Warnings* (EEA, 2001) that provides a dozen cases where scientific uncertainty causing environment-related problems had been used to block the passage of policies to alter human behavior. That raised the proverb, "If you stay on the path you are on, you will get to where you are going." An Irish variation on this proverb is that "If you want to go to Dublin, I wouldn't start from here." The point is that, in the absence of changing harmful behavior in various types of environments, bad consequences are likely to result. In other places or in other times, the end impact on the environment and on society of the same type of bad behavior can be witnessed.

Many reasons can be identified as to why lessons are not necessarily used by successive policy makers, governments, or generations. Some people believe without question that the most recent scientific articles are better than earlier ones. This is an example of "discounting the past." The chairperson drew attention to the distinction that needs to be made between ignorance and "ignore-ance." The former refers to a condition in which the information is just not available and people just don't know, whereas the latter refers to a situation in which the information is available but purposely has not been used.

In many instances, those affected by the impacts of El Niño are not directly involved in policy decisions about how to deal with forecasts, with impacts, and with reconstruction following adverse impacts. However, those involved in the process, that is, those having some ownership in the outcome, are more likely to apply the lessons that they helped to identify. Governments change from time to time, and new governments usually want to remake the bureaucracy in their own image. As a result, good lessons from previous governments are sometimes discarded, regardless of their level of effectiveness or success.

As an aside, NASA has a website devoted to lessons learned. It contains information on the specific problems of the engineering kind that NASA has had to face and the solutions undertaken to fix those problems. The site is open to the public and is labeled as the "Public Lessons Learned System (PLLS) Database." As one might guess, some of

those lessons have been hard-earned. For the most part, these are engineering problems for which lessons have been learned: failure of mechanical parts or processes that require engineering or technology fixes (http://llis.nasa.gov/llis/plls/).
And maybe, while there have been management decision-making problems at NASA, there have been lessons learned on how better to make decisions that carry lower risk for others, such as astronauts and space craft launchings and re-entries. They, however, are not listed on the website. So, I think one could effectively argue that lessons are generally not only *learned* but also *applied*, when it comes to engineering and technological problems. If an engineering system fails it is ***in everyone's interest*** to identify the reasons for the failure and to learn from the engineering mistakes.

There are identifiable reasons why people (society, government, etc.) often do not pay heed to lessons identified earlier as a result of the adverse impacts of a similar hazard. Lessons are identified but not necessarily learned; lessons learned are shelved and forgotten; lessons learned and known are ignored; lessons known are rejected.

> About 5 years ago I was the Principal Investigator for a 16-country study on the use of El Niño forecasts in various sectors of these different societies. When preparing the lessons-learned section of the report for this project, I looked back at other reports related to natural hazards and disasters to see how those PIs had reported the "lessons learned" from their disaster assessments. I looked at some reports only a few years old along with others published ten or twenty years ago or more. To my surprise, our study had come up with several of the same lessons that had been learned as a result of earlier floods, droughts, fires, volcanic eruptions, earthquakes, even El Niño events, and so forth. That raised a concern for me: Are we misusing the word "learned"? I have come to a personal conclusion that in many instances of coping with a previous hazard, several of the lessons allegedly learned by a society, government or researcher had really not been learned. They had only been identified. For lessons to have been learned would mean that societal behavior (more generally, decision making) in the face of similar hazards would be different than it had been in earlier situations. **--M.H. Glantz (2001)**

The reason that some learned lessons are not applied might include, for example, a belief that in the intervening time between hazards (or disasters) society (and decision makers) had become more knowledgeable about those hazards and how to deal with them, and that our scientific understanding *must have progressed* might be a typical perception. But, had it? Would having had that knowledge in hand in advance of the second occurrence of a similar hazard have made a difference with respect to the hazard's impacts on environment and society? Another reason that lessons might not be applied is because *other* researchers, governments, companies, and cultures identified them. This rejection of identified lessons relates to the "not invented here" problem. Some people only put trust in their own work.

Participants asked the question, "Who learns from whom?" They then suggested that a top-down approach alone has not been effective in their parts of the Pacific Rim, and that community-to-community communications on hazards such as El Niño worked best. Most likely it will be a mix of top-down, bottom-up and a "bottom to bottom" sharing of

information (providing and receiving) that will be the most effective way to use El Niño knowledge for strategic sustainable development planning.

Another reason might be that lessons learned are sometimes taught to people who are not in a position to use them. People attempt to teach some lessons to people with whom they have not developed rapport and, hence, those lessons are not taken as seriously as those provided by local people whom they know or to whom they can relate. Lessons (e.g., knowledge) acquired over time by trial and error at the local level can be used to inform higher-level decision makers in a given society. It is necessary to find ways to "scale up" local knowledge, as the locals have insights into coping with climate-related risks; it is simply not enough for decision makers to call for better interactions with "stakeholders." They must treat them as ***equal*** partners in an ongoing dialogue.

As one participant correctly noted, learning lessons also comes from the process on communication. Decision-making is a process, the end of which is not only the decision itself. The process of decision-making continues with feedback as to the appropriateness of the decision for the given situation. Adjustments to the original decision need to remain as a constant possibility. The notion of an "end to end" process (forecast to policy) can be misleading because it suggests a process that starts in science and ends in a policy statement. It should really be an "end-to-end-to-end" process in which feedback to the policy is taken into account in case there is a need to modify it in light of existing realities in a given society.

Lessons can come from a variety of places and, if used properly, can stimulate a range of possible responses. Before one judges the correctness of a response to an El Niño forecast, one must first review the setting is which the decisions to respond in certain ways were reviewed. For example, the 1997-98 El Niño event that had been forecast officially in mid-June 1997 evoked very different responses from the governments in Kenya, Costa Rica and in Peru (see Glantz, 2001).

It is necessary to remind the public and decision makers that, though we often refer to ***an*** El Niño forecast, we are really talking about a process in which there are several El Niño forecasts issued in series. Several forecasts refers to (1) the fact that there are several organizations, legitimate and otherwise, that issue forecasts (in the strict sense of the term) as well as issue their perspectives on what might be happening with regard to sea surface temperatures or sea level pressure across the Pacific, and (2) pronouncements that the public would consider a forecast — an outlook, a diagnostic, a projection, a watch, etc. With regard to (2), once there is a hint that an El Niño episode might occur, the public is bombarded with a stream of forecasts that are constantly updated throughout the development, duration, and demise of the episode. Most attention of the general public, one could argue, focuses on the forecast of the onset of an event, whereas different users (stakeholders) tend to focus their attention increasingly on the succeeding forecasts and projections they receive from a range of sources.

Why known lessons may not be used by others is a question that demands reflection, discussion and immediate consideration. Societies (sectors and individuals in climate-

sensitive activities or regions) can learn from history, their own and that of others in similar situations (i.e., by analogy) or they can learn the hard way, that is, from direct experience of the adverse effects of recurring El Niño events and their teleconnections.

It was proposed that for those decision makers not yet convinced of El Niño's influence on their economies, it would be necessary to identify for them the economic interests of their society in improving its knowledge about the ENSO cycle, its extremes and its impacts. As suggested earlier, activities related to learning about and studying known lessons are best undertaken *between* El Niño events and not in the midst of one of them. After 30 years of awareness of El Niño in the forecasting community and in governments, societies have still not learned well how to cope with a climate-related phenomenon whose frequency is irregular (it can recur anywhere from 2 to 10 years apart). Apparently, the forewarned are not always the forearmed. **A bottom-line research question is the following: *Why is it that some lessons identified are learned and applied by some people and not others?***

The participant from Australia provided an example of a situation in which a lesson has been identified, learned, and applied. He noted:

> Lessons are learned and applied once they influence the existing risk management framework of a decision maker or sector. "Skip-row" is now, for instance, a part of the general crop risk management on the Darling Downs. Whenever a farmer plants cotton, sorghum, or even chickpeas, she asks the question: "should I go double-skip, single-skip, or solid?" Which option is taken depends on current conditions, risk aversion, and experience of the decision maker and, possibly, a forecast. However, the skip-row lessons arise from our understanding of the impacts of climate variability.

The Media and Early Warnings

The Compact Oxford Dictionary: Definitions

media

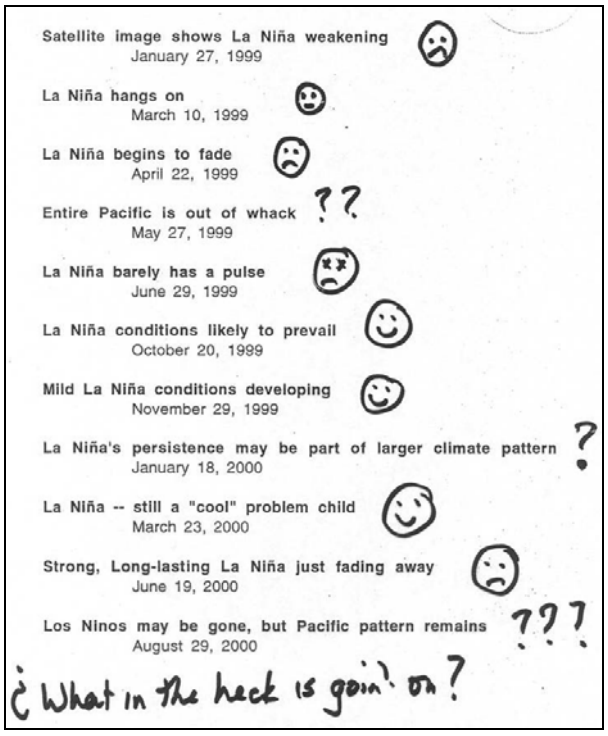
• **noun 1** the means of mass communication, especially television, radio, and newspapers collectively. **2** plural of medium.

When we refer to the "role of the media," it is apparent that each medium may have its own set of roles and rules, despite some common basic functions that each must perform to be classed as media. To the definitions of media, one must add the Internet as a contemporary vibrant means of mass communication.

Some people believe that the media have responsibility to educate the public. In fact some parts of each of the above-noted media do take on that responsibility; for example, National Public Radio, or National Public TV. For the most part, however, the media are businesses. They sell products through advertising on the airwaves or in print. It is necessary to cultivate that aspect of the media that can (or already does) serve to educate the public.

Media editors and reporters are eager to capture headlines of newsworthy events. Usually such headlines fall into the "doom and gloom" category. The media also do well with timely topical and quick-onset events. El Niño events are episodic and irregular, as noted earlier. This infrequent occurrence poses a problem for constant media coverage. It is also problematic for the media to cover slow-onset, creeping changes of any kind, and especially those that are environmental. With few exceptions, the media tend to focus on abrupt changes as opposed to creeping ones. To be fair, there have been some creeping environmental changes that the media have covered with increasing frequency, e.g., ozone depletion and global warming. In general, though, they tend to view warnings coming out of the environmental community as suspected of the "crying wolf" syndrome, and that every environmental problem is a crisis to environmentalists. As a result, media editors tend to discount much of what the environmentalists want them to put into print or on the airwaves. In this regard, the Internet fills in the gaps left by the other media sources.

When it comes to forecasting, there are many people who make their projections about El Niño known to the media, and that includes the Internet. To be first and correct with a forecast adds to the credibility of the media outlet reporting it. However, the pressure (or desire) to be first among forecasts runs the risk of announcing erroneous forecasts, or "jumping the gun." Look at the following memo (private communication to Glantz) received about the projections related to the other ENSO extreme, the 1998–2000 La Niña. The happy face symbol identifies when the forecast turned out to be correct and when it was not. This represented the forecasts issued by one government group, among the many operating at the time. The recipient who made the graphic below was a potential forecast user.



Forecasting El Niño's onset is quite difficult, despite the constant monitoring of air-sea interactions in the tropical Pacific. As noted earlier, once an event locks in, however, it becomes easier to project its development over the course of the next several months. Attention then shifts to forecasting its intensity and its distant impacts. The media jump on impacts, as they are often timely, newsworthy and potentially disastrous (e.g., "doom and gloom") to different regions around the globe. As a result, most of the El Niño impact stories are about negative impacts. It is very difficult to get the media to cover its positive aspects, wherever they may arise.

The media can generate and lead the interest of the public and can also follow the interests of the public. They believe that they are giving the people the kind of information that they want. There are stories occasionally about creeping environmental changes such as tropical deforestation in the Amazon or about the drying out of the Aral Sea in Central Asia. However, they do not see it as their responsibility to monitor such changes on a constant basis. Media also tend to follow the leader; that is, the first in the media to release a story that generates public interest will soon be followed by other media.

Meshing together the above comments suggests that the media in theory have a role in the use of El Niño knowledge as early warning for sustainable development. However, the best time to undertake an educational campaign for the public (and policy makers) is when there is no event in play, as pointed out in the previous workshop session on lessons learned, as well as in previous workshop reports. Between events is when decision makers have the appropriate lead time to make strategic changes to the way their societies cope the El Niño's impacts. During an El Niño episode, the focus of decision makers shifts to tactical responses to those impacts. Tactical responses in some cases conflict with sustainable development objectives.

It was generally acknowledged that the media taken as a whole have performed much better in recent times when reporting science and environment issues. Some media are excellent, objective, and fair in their portrayal of climate-society-environment interaction. For the forecasters' part in communicating science to the public, they should avoid using terms that are likely to be misinterpreted, even though the concept might work in a specific situation, such as "drought-proofing," "weather-proofing," and, more generally, "hazard-proofing" through engineering and technology alone. Every time such a notion has been mentioned, nature has undermined it. Hence, a credibility problem inevitably arises between researchers and forecasters on one side, and policy makers and the public on the other side.

There is, in some locations, limited ability to "drought-proof" agricultural systems. They require superior management skills, but can be extremely profitable without negative environmental impacts. What you cannot achieve is drought-proofing an entire region or sector. As with so many things, it is a matter of scale. Some farms can be "drought-proofed," whereas regions cannot.

Vulnerability and Resilience

A considerable body of writings relates to the concepts of resilience and vulnerability and to their operational use in hazard, disaster, and risk studies. Some observers say that resilience is the opposite of vulnerability. Others say it is not. There are many definitions of both concepts. Both concepts are of value to making more effective the use of El Niño knowledge as early warning for sustainable development.

Susan Cutter (1996) identified three distinct clusters of definitions of vulnerability: (1) as risk of exposure to hazards, (2) as a capability for social response… and (3) as an attribute of places (e.g., vulnerability of coastlines to sea level rise). To Cutter, "vulnerability is the likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazards of place (risk and mitigation) with the social profile of communities" (p. 532).

Simply stated, vulnerability is the openness to adverse impacts. It implies a lack of societal flexibility as well as a lack a variation in response possibilities. Resilience, simply stated, is the ability to absorb negative impacts without reducing long-term performance after adverse impacts have occurred. But resilience should be more than that. Resilience is a rich concept.

There are alternative approaches to vulnerability assessment such as the social construction of risk. For example, deforestation and desertification, processes in which human activities are integrally involved, contribute to risk in a given area. The deconstruction of risk involves separating out the societal factors that contribute to a society's level of risk from the non-societal factors.

The ability of a society to adapt to short-term environmental variability and extreme events is a key to sustainable development. A societal capability to identify potential climate-related hazards, such as El Niño events, can go a long way toward its ability to adapt in a pro-active way to such recurrent, potentially disruptive, climate-related anomalies. Several participants said that it was more important to focus on communities as opposed to focusing on events.

Environmental Justice Issues: Using Hurricane Mitch as an Example

Workshop discussion on this topic centered for the most part on issues related to inter-generational equity, also referred to as eco-justice and distributive justice. Which generation should be the focus of concern: the present affected generations or future generations? Glantz and Jamieson presented an overview of the impacts of Hurricane Mitch in Central America in general and in Honduras in particular, based on a paper they published in *Risk Analysis* (Glantz and Jamieson, 2000). The impacts in Honduras, as an example, were devastating, with well over 10000 deaths and several billions in damage: banana crops lost, large percentage of the infrastructure destroyed, out-migration from the country, etc.

Disaster and humanitarian assistance groups went to Honduras immediately to get things back to "normal." Normal was that Honduras had at the time been the fourth-poorest country in Latin America. Several months later when the development experts went to Honduras, they found that many people had been placed back in similar at-risk locations. This raised concern about how to mesh short-term disaster response to longer-term sustainable development activities. Hurricane Mitch also demonstrated what "La Red" (the Latin American Disasters Network) refers to as "manifest risk," or risk that is waiting to be exposed.

Considerable argument and support exists for aiding future generations. In practice, however, there is a "now generation" bias against it. There are many examples of a bias against investing in future sustainability in favor of getting near-term rewards. One example is that the present generation and its needs and wants are real, whereas those of future generations are allegedly unknown. Economic considerations are also biased against the consideration of future generations because of the "discount rate." Compounding this is the bias in favor of consumerism. There is also a feeling (a belief, a hope, or just blind faith) that future generations will be better off than present ones partly because of a pervasive confidence in scientific and engineering ingenuity to produce a better future, at least technologically.

Adverse climate-related events such as El Niño could generate opportunities for some people, agencies, organizations or societies. For example, in Nicaragua water pipes were brought in to replace reliance on well water in some locations. Putting a positive spin on a hazard, El Niño could provide a learning experience that could help society to avoid such damages in the future. Hurricane destruction requires reconstruction activities in the impacted area. An optimist might suggest opportunities for everyone; a pessimist would suggest opportunities only for the upper class.

Mitch also disrupted regional trade by destroying roads and bridges, destroyed crops in the field, prompted (as noted earlier) considerable cross-border migration, putting pressure on the economies of neighboring countries, increased the cost of transportation, etc. The Meteorological Service of Honduras followed the events of Hurricane Mitch on CNN. Although $11 billion was pledged to reconstruct Central American countries damaged by Mitch, only $5 billion was eventually delivered. Pledges are often made in the immediacy of a disaster, but as time passes, the desire to fulfill the pledge wanes. As reconstruction and development efforts were progressing slowly, the Hondurans remained vulnerable to near-term perturbations in the regional climate system, even low-level perturbations on the positive side. In sum, responses to Hurricane Mitch, or lack thereof, set up Hondurans to be even more vulnerable to expectable future departures from normal of rainfall.

The regional devastation of Hurricane Mitch encouraged several Central American countries to work more closely together on climate issues. Now regional climate outlook forums re convened at their own initiative and expense. This is an example of "disaster diplomacy" (Kelman, 2003). Knowledge of the impacts of El Niño events within

countries and across borders can help decision makers to pursue regional tactics as well as strategies that favor sustainable development.

There are lessons to be learned not only from this disaster in Central America in late October 1998, but also from generalizations made after years of dealing with a range of disruptive climate- and weather-related hazards and disasters. A report of the International Federation of Red Cross and Red Crescent Societies (World Disasters Report, 2003) identified the following set of ethical challenges to national to local level capacity building which can interfere with achieving the objective of sustainable development:

- Failure to match external aid supply systems to people's needs
- Unequal partnerships between outsiders and local organizations
- Imposition of outsiders' predetermined aid agendas
- The unintended, sometimes adverse consequences of interventions
- How far can and should agencies go in addressing the root causes of vulnerability to disasters
- The risk that the presence of international agencies will undermine local organizational capacities
- How to work with government institutions in an effective and politically neutral manner
- The difficulty in measuring success

The notion of "superstorms" was also raised in this session. In the 1990s, the label of superstorm had increasingly been attributed to extreme events: Superstorm '93 in the United States, the Super Cyclone that struck Orissa in India in 1999, SuperTyphoon Maemi in Korea (2003), the 1997-98 El Niño of the Century," among other events. Climate change researchers have proposed that there is likely to be an increase in the frequency and intensity of extreme meteorological events in a warmer global climate regime. Hurricane Mitch was not labeled as a superstorm, but its impacts were similar to those that might be expected of a superstorm.

After the Galapagos workshop was held in mid-September 2004, four hurricanes made landfall and impacted the state of Florida in just six weeks, and Japan had received a record-setting tenth typhoon to make landfall in a single season. Thus, societies have to not only worry about the single superstorm but also from the likelihood of a season of superstorms, however one chooses to define them, in addition to the possibility of a multiple, sequential hit involving several "normal" storms strike one after the other. Such blockbuster events can derail development prospects for several years. It is better to anticipate them and their potential impacts in order to strengthen societal resilience and, at the same time, reduce vulnerabilities (www.fragilecologies.com).

Other similar conflicts between emergency ad-hoc responses and strategic long-term sustainable development prospects were provided by various participants: China (dust storms), Korea (Typhoon Rusa), slow-moving typhoon-related floods and societal responses in the southern Philippines, and Typhoon Waca landfall and impacts in the

Pacific nation of Tonga. While the catalysts to disaster were, for the most part, related to atmospheric processes, the true extent of death and destruction depended in large measure on socioeconomic factors.

Climate Change & the Pacific Rim and Islands

The literature that relates climate change (e.g., global warming) to adverse impacts on societies, ecosystems and on the environment in Pacific Rim countries and island nations is substantial, and it continues to increase on a monthly basis. Some consequences of global warming are well known, such as melting glaciers and sea level rise. Sea level rise puts low-lying coastal areas around the Pacific basin at risk and puts many Pacific island nations at great risk to inundation or storm surges. This is of dire concern to the inhabitants and leaders of the island nations, because sea level rise will eventually lead to the forced abandonment of some Pacific island nations.

There is less certainty about how global warming will actually influence typhoon storm tracks, frequencies, intensities, and landfall. This too is crucially important to island nations, since water supply for many islands comes from rainfall during typhoons, not ground water. Water in the islands is one of the most important natural resources that sustain settlements. Coral reefs are endangered by warmer atmospheric and sea surface temperatures, because such temperature changes along with other factors cause coral bleaching.

All of the Pacific Islands in the region are affected by El Niño. During El Niño episodes, many islands suffer from the severe lack of rainfall; drought means little water for agriculture, domestic use, and industrial purposes. Certain vector-borne disease outbreaks also occur on the islands during El Niño. Fish populations shift from their usual habitats, and the needs for port or fish processing capacity decline during an El Niño, thereby adversely affecting employment. Tourism tends to decline, as people choose other tourist hotspots to visit out of fear that El Niño would likely disrupt the tropical conditions they seeking to enjoy for their vacation. Clearly, the inhabitants and the economies of the Pacific island states are at high risk to El Niño-related adversities. They exist at El Niño's "ground zero."

Earth's climate is in a state of flux. Whether in terms of relatively short-term shifts, called climate variability, or long-term climate change associated with greenhouse gases, consequences of changing climate conditions appear unprecedented. Losses due to weather-related disasters have soared recently — especially in the Pacific, where island environments, societies, and infrastructures are particularly vulnerable. For generations, human response to climate events has been just that: response after the fact to phenomena that neither residents nor scientists adequately understood. Now, a growing body of information about the causes of climate events is enabling Pacific Islanders and others to anticipate events and move past being victims to become informed planners. This new knowledge can only be successfully applied via dynamic partnerships between science and society. Particularly promising is the emerging field of climate risk management, in which disaster management and climate science communities unite, forming model partnerships to plan for the inevitabilities linked with the planet's variable and changing climate.

Developing countries shoulder the brunt of impacts from such disasters; especially hard hit are small-island developing states of the Pacific, Indian Ocean, and Caribbean. These islands have always been vulnerable to the short-term shifts scientists call climate variability, but until recently not even scientists understood in detail how these phenomena operated or how to predict them. Now, with burgeoning scientific knowledge regarding climate variability and its effects, Pacific Island communities have an opportunity to shape the future. To do so, they must move past being *victims* and embrace the challenge to be *planners* who are preparing for the inevitable consequences of climate variability. This approach is also the most prudent preparation for the effects of climate change which may amplify the effects of climate variability and bring additional environmental hazards, such as sea level rise.

--Eileen Shea

Eco-justice issues must also be addressed as a result of climate changes in the Pacific region. For example, if islands are overtaken by sea level rise, inhabitants will be forced to move to other countries. Arrangements are already being made if islands like Tuvalu become submerged by the ocean or destroyed by tidal surges; Tuvalu has made such arrangements for re-settlement with New Zealand.

Creeping environmental problems (CEPS) are important to island nations and to Pacific Rim countries. They tend to occur at levels of change that are imperceptible on a daily and on even a monthly basis. After a few years, however, their adverse impacts become quite obvious; for example, mangrove destruction, mining coral for construction materials, salt water intrusion, the accidental introduction of disease-bearing vectors or other pests, increasing levels of water pollution, waste disposal, and so forth.

Climate change will most likely affect the ENSO cycle in ways not yet identified. It will also change the characteristics of El Niño and La Niña events in terms of altering their frequency, intensity, duration, location, and timing of their distant (teleconnected) impacts. Learning about the impacts of global warming on El Niño events in particular and on air-sea interactions in the Pacific in general will enhance society's El Niño knowledge that can be applied to planning for sustainable economic development in future decades. [See Appendix C, *Small Islands Voice*]

Right-sizing El Niño Early Warnings

An original question posed at the Galapagos workshop was the following: What is the right scope for early warnings related to El Niño in the Pacific Basin? There are several reasons for posing this question. Today, NOAA in the USA issues El Niño forecasts globally. We have heard from other countries with official forecasting groups that NOAA's forecasts on the likelihood of an El Niño event in addition to their obvious benefits can generate problems for them by adversely affecting relations with their own governments: "Why are we funding our activity when we are hearing about the onset of El Niño from the USA?" Or "Why can't we issue a forecast for ourselves before the Americans?"

This is a concern to national meteorological services worldwide but especially to those influenced directly or indirectly, physically or financially, by an El Niño. Local forecasters whose reputations, if not jobs, are on the line locally tend to be more conservative in their forecasts than are agencies outside of their countries. At the first hint of a possible event, scores of forecasts spring up in the media and especially in newsprint and on the Internet. The WMO organizes and issues, with the support of the IRI and in collaboration with the major ENSO prediction agencies, regular El Niño Updates. This is done to provide a global consensus-based outlook on the likely evolution of ENSO conditions worldwide, and is particularly valuable when different (highly reputable) national agencies and research centers may be issuing apparently conflicting information to the public. Because of the global approach in the WMO El Niño Updates (where the needs of any one region do not predominate), they may appear more conservative than the output of any individual country or agency. It is important to note that the Outlooks always advise the user to contact an appropriate National Meteorological Service for local assessment of the upcoming conditions and possible impacts.

There is a need to improve ways to downscale the global (general) forecast to the different levels of social and political users (e.g., a cascade of spatial forecast detail) – regional, national, sub-national regions, local. In some areas an institutionally based ***regional*** downscaling process has already occurred (in sub-Saharan Africa; in Central America; in South America; in the Pacific Islands, among others). There is another possibility that needs to be pursued, and that is upscaling local forecasts to those issuing the global forecasts. This would provide them with the local details and calibration of their global data that their projections lack.

This is a dilemma for NOAA in the sense that it is doing its job by issuing a forecast of El Niño, based on its models and its expertise. It forecasts are newsworthy and are printed in many media outlets around the globe. These articles generate local concern about possible impacts. As a result, the pressure mounts on local forecasters and decision makers in climate-sensitive socioeconomic sectors of society. As noted with the El Niño hotspots maps (first produced by NOAA in the mid-1980s), they lack detail usable for decision makers at the local to national level. How then is one to downscale in time and space the warning to the world that an El Niño is likely on the way?

When NOAA issues forecasts related to El Niño, it influences activities in other countries. As one example, national meteorological services are bombarded with requests for information about impacts locally and about the forecast itself. This puts them in a difficult position because the national to local level decision makers have to be more cautious in their immediate reactions to those foreign NOAA projections. They are the ones that are on the proverbial firing line if anything that is related to the forecast goes wrong. They are the ones that have to participate in deliberations on how to mesh tactical responses to the forecast and likely impacts with the needs of their countries for sustainable futures. To the national meteorological services it is much more important to be correct than to be first with the forecast of onset, in the absence of a NOAA global forecast about El Niño.

The expression that "the devil is in the details" is as true for El Niño forecasts and El Niño knowledge as it is for political or economic agreements. Attention needs to be focused more heavily on the problems of downscaling knowledge from global to local and upscaling knowledge from local to global. ***Scale matters —*** geographical, political, institutional and economic **—** when it comes to communicating the right level of detail of El Niño knowledge for sustainable development purposes to the scale of the intended recipients. Policy makers specifically, and decision makers more generally, do not want to be surprised. Getting the correct level of detail to the appropriate administrative level of decision making is a real challenge to those who produce the science and forecasts of El Niño and those who translate it for use by the public. Having noted that scale matters, the responsibility for getting information to and from users at all scales rests with the national government.

It was also proposed several times that El Niño events should be de-dramatized, a process that would most likely have to begin first ***within*** the scientific community. Scientists have been relatively successful in capturing the attention of the media in this recently "discovered" phenomenon. The downside of its success, however, has been the tendency of some scientific organizations and the media to "hype" El Niño and its possible impacts using provocative headlines and scary scenarios. A good starting point would be to introduce this material into middle and secondary school curricula and textbooks.

The current level of existing El Niño knowledge does provide added skill for forecasting and therefore preparing for likely "downstream impacts." However, El Niño is only one manifestation of variability in the global climate system. Now that we have captured the attention of the public and a wide range of decision makers as to the value of forecasting El Niño (and in general of El Niño knowledge), it is, as suggested earlier, time to put El Niño events in a more realistic light; in other words, to ***"put El Niño back into the climate variability box."***

It was pointed out that, when it comes to issuing El Niño forecasts (about the phenomenon and about its likely impacts) and forecast-related products (news releases, warnings, workshops and other meetings, etc.), right-sizing the institutions involved is crucial. That means right-sizing to the regional level, either geographically, topically, or functionally defined. Topical right-sizing refers to the aspect of the warning that interests

the user: for example, effect on rainfall, cyclones, storminess, or sea level change. Functional right-sizing refers to coordination of those engaged in similar socioeconomic activities worldwide that could be affected by an El Niño episode (such as specific climate-sensitive commodities; fish, oil palm, coffee, sugar, grains, or specific sectors such as transportation or communications).

This is one aspect of "right-sizing" – finding the institutions and processes to match the climate-sensitive sector to be targeted. The other aspect is to target the appropriate level within the value chain of that particular sector. Take sugar: the exporter concerned about bulk shipping would require vastly different value-added information compared to the miller, concerned about an even distribution of cane volume for crushing versus the producer (of sugar cane), who has concerns about whether or not to ration varietal selections or planting dates. Different types of institutions and expert knowledge need to be connected to provide such information in a way that adds to the existing risk management framework of this sector (Meinke and Stone, 2005).

Once again, the idea was raised to view El Niño as another, albeit important, aspect of climate variability in the context of right-sizing El Niño knowledge for early warning. Month to month and year to year, people at the local to national levels are coping with variability and its extremes. ***Coping with El Niño may be a special case of having to cope but it is clearly not the only case of variability.*** In this discussion, phrases such as "de-dramatize" and de-hype" the El Niño phenomenon were used. This will not be an easy task, but it will be essential before El Niño knowledge will be incorporated into the overall risk management approaches of individuals, businesses, and governments.

One concern is how to rate the level of success of the series of El Niño forecasts following its onset and of the cascade of El Niño-related forecasts likely to follow. Some participants suggested that a change in behavior of decision makers is a good indication of forecast use and, therefore, value to society. However, it is important to note that forecasts can also reinforce existing correct behavior and that no change in behavior of decision makers may occur. Evaluating the impacts of a forecast (in terms of benefits to society) is a difficult and daunting task.

The Pacific Rim countries and islands represent considerable diversity in terms of information needs and in terms of capabilities to respond to El Niño forecasts and to impacts. There are countries with considerable expertise, scientific and applied, that would be willing to share it with others in the region. There are also sub-regional groupings as well, such as East Asia, Southeast Asia, the Pacific Island nations, the

countries in Central America, and those in CPPS in South America. A network of such networks could be developed virtually, with the active and innovative use of the Internet and satellite-based radio waves, e.g., RANET (www.ranetproject.net and Aidworld at www.aidworld.org).

Prospects of Linking across the Pacific

The participants were asked to discuss in plenary session the strengths, weaknesses, opportunities and constraints (a SWOC assessment) of networking across the Pacific Basin for the purpose of using and sharing El Niño knowledge for sustainable development.

Strengths and Opportunities

Linking activities related to El Niño across the basin can bring together people, groups, and institutions with a diversity of experiences in coping with El Niño events as well as with coping strategies and tactics for dealing with climate variability and its related impacts (e.g., droughts, floods, forest and bush fires, vector-borne disease outbreaks, heat waves, etc.). Some countries around the basin have had more experience in dealing with El Niño forecasts and impacts than others. Those ahead of the El Niño learning curve can help to build human capacity among those below them on that curve, e.g., capacity building by proxy.

It provides a reason for serious attempts to gather climate-related knowledge at the local levels around the Pacific region and then to share it. There is considerable local and traditional knowledge that could be collected, exposed, recorded, and shared. Enhancing cooperation across the basin would encourage collaborations about the science of El Niño and its societal aspects (impacts and response tactics and strategies).

It would regionalize, i.e., right-size, the El Niño forecast system, as those in and around the Pacific are likely to suffer similar adverse impacts of El Niño. For example, some countries will suffer from drought and other countries from floods. Some may share in the loss in productivity of their fisheries, while others may benefit from an influx of commercially valuable fish stocks. Lessons can be learned from the experience of other countries. Regionalizing El Niño early warning and response strategies would spark a more effective way to share in the exploitation of migrating living marine resources.

Coral bleaching from natural causes and human impacts on coral is often transboundary as well as a national problem. Regional guidelines have been established by the WMO that foster the virtual operation of regional climate interactions. In this regard, through virtual arrangements, a sharing of climate-related data would take place around the Pacific.

Weaknesses and Constraints

There are political constraints to the sharing of data. Some countries are willing to do so while others are not. There are sub-regional functional and geographic institutions that might feel that their jurisdictions are being violated. Long time series for El Niño and other climate-related phenomena and their impacts on ecosystems and society do not exist in many local communities. Language barriers do exist, which could require greater expenditures for the translation of shared information; there is no *lingua franca* for the Pacific region. The cost of bringing participants from around the basin to a specific venue for face-to-face meetings, as opposed to using teleconferencing and other forms of workshop interaction, can be quite costly and time-consuming. There is a lack of shared awareness of knowledge about the Pacific region's institutes and organizations that are wholly or partly involved in climate-related activities.

Putting together this Galapagos workshop exposed problems that could arise from linking on a more permanent basis physical, biological, and social science researchers, disaster managers, and policy makers from around the Pacific Rim and the islands. For example, the costs and time required to bring people together are quite high, when compared to available resources. If such a linking cannot be shown to provide positive advances in forecasting and responses to the impacts of ENSO forecasts, then perhaps it would be better to let the two sides and the middle of the Pacific focus their interactions with others in their respective hemispheres. In such a case, once again the islands would be left to fend for themselves. In this regard, a popular belief holds true: the whole is greater than the sum of its parts. Link when you can and when it makes sense to do so for mutual benefit for the parties seeking to link.

The Grand Challenge: Dynamics of Humanity on Earth

The NSF participant introduced the notion of "Grand Challenge," a term coined by Ken Wilson, Nobel Prize-winning physicist. In the early 1990s, the term was used to connote a fundamental problem in science whose solution is dependent on more computer power than is currently available. It has taken on a wider meaning in subsequent years and now is frequently used in connection with extremely complex problems, the solution to which will benefit society. Recently the National Science and Technology Council (NSTC) Sub-committee on Social, Behavioral, and Economic Sciences Working Group on Portfolio and Priorities has tasked each of its members (which includes the National Science Foundation) to identify grand challenge questions for the social, behavioral and economic sciences. Although not an original focus of this workshop, our discussion led to the framing of a Grand Challenge problem.

Understanding the Dynamics of Humanity on Earth. Humans are most influential species in the history of the planet. There are three powerful forces driving humankind today, i.e. The Triple Bottom Line (TBL): **society, the economy and the environment.** Society depends on the economy - and the economy depends on the global ecosystem, whose health represents the ultimate bottom line. Each TBL factor is shaped by complex and dynamic interactions at the interfaces of technology, a new world economy, societal latency and responsiveness, political agendas, public health, the uneven and changing application of justice and ethics, and environmental changes. These factors collide in unpredictable ways and with frequent unintended consequences. *The grand challenge is to understand the complex interaction of these factors and its impacts and on the human condition on the planet.*

--Cliff Jacobs

Sustainable development encompasses many different aspects, but the notion of a "triple bottom line" of economic impacts, social impacts, and environmental impacts suggests that sustainable development is a negotiated tradeoff among these three elements.

One participant suggested weaknesses with the Triple Bottom Line model. For example, rather than suggesting that society depends on the economy, it would perhaps be better stated that society is fashioned to depend on the economy. Furthermore, society also depends directly on the environment, while both society and the environment have previously functioned without an economy of the sort seen in the modern world. Thus, today's paradigm and approach to society and the environment necessitate mentioning the economy as being of equal importance to society and the environment. In reality, even within the Triple Bottom Line, the economy is often seen as being more important than society or the environment and is often managed at the expense of society and the environment.

A participant set the pace for the discussion of notion of the Grand Challenge Problem by proposing that one could frame the problem in terms of the 3 Cs: community, climate and conservation. He proposed looking at the problems that societies face with climate and the conservation of resources from a community perspective. That is why community was posed as the first "C." The challenge was how to get communities to develop a different underlying relationship with climate as opposed to their reactions to climate-related extreme events and other anomalous behavior of the atmosphere.

It was then suggested that the second "C," climate, be broadened to the concept of climate risk. Society needs to know better how the climate system works and interacts with human and ecological systems in order to more correctly identify the vulnerable populations in a given society. He suggested that the real challenge was how to reduce risk through applied science and a variety of effective approaches to risk reduction.

Yet another participant suggested that a fourth "C" be added to the original suggestion – communication. Throughout the workshop it was strongly noted in a variety of sessions and contexts that communication was ***the*** major problem with regard to issuing forecasts and with using El Nino knowledge for proactive development purposes. She noted that

the lack of effective communication to, from and with the local level by those at higher political levels puts the local communities unnecessarily at greater risk to climate-related impacts.

The Australian participant underscored the often neglected point of interacting with industries as ***equal*** partners. They need the knowledge of the climate community and the climate community needs their knowledge to better serve potential users with their products. Along these lines, fisheries were also proposed as a grand challenge problem. The sustained health of fish populations is subjected to many intervening variables, environmental, societal and variables intrinsic to fish population dynamics.

The addition to the workshop of the notion of a grand challenge problem in the context of climate generated interesting discussion and comment. It served to challenge participants to think outside of their traditional problems areas.

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Appendix A: Shanghai Early Warning Systems (EWS) Highlights

- While warning systems look great on paper as organization charts or as input-output diagrams, they run into difficulties (bottlenecks) at various locations (nodes and arrows) in the flow of warning preparation to communication to action.
- Several honest scientific disagreements exist about what an EWS should do for a government or a society.
- One officially designated early warning system cannot meet all societal needs.
- At every stage in the early warning process, there will be ethical and equity issues that must be addressed.
- Hazards and threats can change over time not only in intensity, frequency, and in location and duration, but also in importance and interest.
- Those affected by hazards can be far removed from the disaster site and not just in the disaster zone.
- It is necessary to keep the definition of an EWS broad to allow for a wide range of interpretations and flexible to accommodate for the likely recognition of new hazards and development of new EWS technologies.
- Scenarios can help to uncover potential impacts of hazards that might otherwise have caught decision makers by surprise.
- Many early warnings knowingly and unknowingly activate other early warnings, as the time gap between a warning and the onset of a hazardous event shortens. This process can be referred to as a cascade of early warnings.
- However large or complex the formal early warning system, there exists an even larger early warning network which encompasses many more elements of society than one might realize.
- Creeping environmental changes are in need of early warning systems because the impacts of incremental but cumulative changes on society in the long run may be more costly and disruptive than the quick onset hazardous events.
- EWSs should also report on advances in hazards research, advances in the development of early warning systems, and in new technologies and techniques that can improve the effectiveness of existing EWSs.
- Each stage in the warning process from monitoring to responding must be interactive in such a way as to keep the warning timely, understood, and providing enough lead-time for responses.
- As new earlier warning technologies and techniques have been developed or new monitoring methods devised, EWSs have had the opportunity to become more effective in their spatial coverage and in the lead timing of the warning.

- Because of limited resources (human and financial) in many countries, it is important to distinguish between what is desirable for an effective EWS and what is essential.
- EWSs need to be treated as subsystems embedded and integrated into larger socioeconomic and political systems. Stakeholders need to be involved in the development of new EWSs or redesigning existing ones.
- Stakeholders can provide important insights into how warnings might best be prepared and delivered to the public, the media, and even to the governments at different levels.
- Transparency is important for building up credibility in the outputs of EWSs.
- Early warning systems for food security, for example, need to use all kinds of information as inputs, even rumors, to assure that the earliest warning possible can be made for potential food-related problems.
- The selection of indicators is very important, because monitoring will center on them. The wrong indicators can lead to wasted time, effort, and resources.
- There will be surprises with respect to hazards with regard to timing of onset, intensity, location and duration and even impact.
- Early warning system operators face a dilemma: they are often criticized for a missed or erroneous warning, but are infrequently praised for having been correct.
- The psychological aspects surrounding EWSs are more important than generally realized. The way that people view early warning systems will affect how effective the EWS might prove to be.
- Discounting the value of information has a negative effect on the many lessons identified from the impacts of previous hazards and disasters.
- While perceptions of reality may not accurately reflect reality, the actions taken based on those perceptions will have real consequences.
- The impacts of hazards need not be surprising, if the appropriate warning mechanisms are in place.
- It is essential to identify societal processes that can affect the impacts of hazards (quick onset and creeping), so that governments and individuals can better warn about and prepare for likely impacts.
- Each government has the responsibility to identify what it is that makes societies more or less vulnerable and more or less resilient.
- Early warning of hazards combined with the early warnings of underlying societal problems and processes can lead to a strengthening of resilience and a reduction in vulnerability.
- How well prepared a society is in order to be proactive in the face of early warning of a looming hazard determines how well people might respond to the hazard.

- Climate change will have impacts that add to the list of yet-unknown underlying processes that can affect hazards and societal vulnerability to them.
- It seems that EWSs are more likely to receive blame for missed or erroneous warnings than praise for successful ones. Memories of successes are short-lived and easily overshadowed by the next disaster.
- There should be multiple expressions of a warning. Foreseeability can be viewed as yet another way to express an early warning of potential harm, even if it is not used in an operational way.
- It would be useful to collect lessons of the past for evaluation by present and future EWSs. It is important to identify and then apply lessons so that the victims in previous disasters do not become victims without a legacy.
- Disasters get the lion's share of attention from the media when compared with "ordinary" adverse impacts resulting from seasonal climate variability. As far as early warnings are concerned, it is useful to talk about the "seasons of disaster."
- The seasonality of such hazards already provides policy makers with a clear warning for regions potentially at risk. However, a significant increase in global warming of the atmosphere is expected to alter the characteristics of the seasons in ways that are yet to be determined.
- Disaster priorities in a given location will likely vary over time as new hazards appear, as old forgotten hazards reappear, and as existing hazards known to inhabitants of one region appear in new unsuspecting areas.
- While the public might not understand quantitative probabilities, they do understand what it means to "take a chance" or to "take risks".
- Early warning systems have an important contribution to make by "warning" that normal conditions are likely to prevail.
- An early warning system is an important tool in a government's program to achieve sustainable development. In fact sustainable development prospects are very dependent on the effectiveness of the many early warning systems.
- Early warning systems must partner with the media in a mutually beneficial way. A key problem is that disasters are media-friendly; creeping changes are not.
- There is a need for an intermediary to act as a translator of the warning's technical contents and background to the media.
- Not every warning is meant for public consumption and may be only for the eyes and ears of specific target audiences, such as relevant government agencies.
- The early warning system must take full responsibility for the warning when it presents its messages to the public, the media and the government.
- Human capacity exists in just about every country. What is needed is a desire and a mechanism to bring people together and to support them as they enhance their existing early warning capabilities.

Appendix B: Roundtable: El Niño's Impacts on Flora and Fauna in the Galapagos

An evening roundtable, open to the public, was held on "El Niño's impacts on flora and fauna in the Galapagos." Opening remarks were made by Jose Luis Santos from CIIFEN, and Mayor of Isla Santa Cruz Alfredo Ortiz Cobos. A presentation by CDRS (Charles Darwin Research Station) scientist Stuart Banks was included. Banks provided an overview of the marine and coastal environment, its exploitation and the major threats to living marine and terrestrial resources of the Galapagos Islands. (*Note*: the full text of Banks' presentation is included in Appendix B.)

The Galapagos Marine Reserve (GMR), spanning an area of more than 138,000 square kilometers, lies approximately 1,000 kilometers from the Ecuadorian coast, in the heart of the equatorial eastern Pacific. This recently declared UNESCO World Heritage Site (2001), famous for being a living laboratory, lies in what is often referred to as the "epicenter" of warm and cool ENSO extreme events. Thanks to great advances in ocean in-situ and remote-sensing technologies, such recent events around the equatorial Pacific have been well documented, particularly regarding large spatial and temporal patterns. Conversely, effects at small scales relevant to biodiversity and sustainability within the GMR are only beginning to be understood.

Notwithstanding the extreme warm events, normally warm currents that come from the Panama Bight to the southwest sustain species-rich tropical and restricted coral reef systems in the north of the archipelago. A strong upwelling eastward flowing toward the Cromwell undercurrent deviates north and south across the equator, bringing nutrients and high levels of productivity to the far west and to the western shores of the Galapagos archipelago. This generates a distinct biogeography which has been recently redefined into 3 main regions and 2 subregions (Edgar *et al* 2003). Cold-water-adapted species such as the Galapagos penguins are juxtaposed at the edge of their habitat ranges alongside tropical and temperate species. During a strong El Nino year the sea temperature differential, seasonality and high primary production that defines the physical environment (in turn defining the boundary conditions for local ecosystems) disappears, leading to bottom up starvation of the food web, high mortalities in species with restricted habitat and foraging range, and offshore migration of mobile species.

ENSO warm and cold events have local effects specific to Galapagos, suggesting as with other areas, that a sub-setting of the large scale predictive models would be appropriate. As an El Nino develops across the Pacific, the warm pool in the central region that generates a NOAA warning may never reach the islands, although when it does, the effects had generally been felt earlier than on the South American coast. Nonetheless many consequences echo those of the Californian and Peru upwelling systems. Negative marine impacts are typically associated with the ENSO warm events (El Niño), while increased rainfall greatly augments plant growth and the proliferation of invertebrates in the terrestrial environment. During these periods, introduced species (representing the greatest threat to the isolated natural state of the Galapagos), such as the *Scinax* tree frogs, fire ants, rats, cats, goats and dogs all tend to establish themselves.

Such generalizations however, although convenient, are far from accurate – compounding effects are often species specific, because all ecosystems are interconnected in some way and have a temporal component. They also often show evidence of having coped, probably even adapted to these events over evolutionary scales. Coral dating and isotope analysis suggest strong cold and warm events have occurred in the islands' history, similar in magnitude to the large 1982/83 and 1997/98 episodes that fall within historical and paleo-oceanographic observations.

Towards the end of the 1997-1998 El Niño, NASA-SeaWiFS ocean color data revealed a huge ecosystem response; immense phytoplankton blooms that developed over a period of just 2 weeks, providing trophic input to a starved system as the upwelling process became reestablished. The rapid switch to the alternate cold, drier La Nina event, hit local farmers hard, as herds of cattle that had previously been sustained by high rainfall and vegetation growth began to suffer. These farmers then petitioned the GNPS to encroach their "El Niño-augmented" cattle herds into the highland Reserve. This opened the grassland that reduces threatened native plant species and left niches for introduced species to invade (having proliferated in the warm episode).

Within the marine environment, ENSO sustained elevated temperatures and sea levels, reduced marine primary productivity and increased surge damage have undoubtedly shaped the islands' unique flora and fauna that we see today. An estimated 97-99% of reef building corals were bleached during the 1982/83 and worsened in the 1997/98 warm event; recovery is likely to be extremely slow. Opportunistic sea urchins such as the now-ubiquitous pencil urchin *Eucidaris galapagensis* and increased wave surge combined to rapidly break down the structural complexity of these reefs that previously provided enough ecological niches to encourage biodiversity and reduce interspecific competitions.

Top-level pelagic predators such as sharks presumably moved offshore into deeper waters in search of food, while Galapagos sea-lion colonies showed 50% mortalities between December 1997 and June 1998 in the centre of the archipelago. Marked individuals of the green sea turtle *Chelonia mydas* dropped from 1961 to just 89 individuals over the 1982/83 event. Extensive beds of macroalgaes, such as the endemic *Bifurcia galapagensis,* disappeared under thermal stress within a few months generating drastic changes in marine community structure. Sea level changes effected distributions in the intertidal zone, and species such as the damsel fish *Azurina eupalama* have not been seen since. Some animals such as the seastar *Heliaster cumungii* the queen scallop *Nodipectens magnificens*, and 2 species of cup coral have been recorded recently in protected coves after being thought locally extinct for the last 20 years. Pockets of cold water refugia may play important roles in the continued survival of Galapagos flora and fauna throughout these cycles.

Local artisenal fisheries for white fish, lobster and sea cucumber (*Isostichopus fuscus*), despite being presently heavily overfished, showed short term increases in catch at the beginning of the recent 1997/98 El Niño. Catches rapidly deteriorated under increased

fishing effort. Many macroinvertebrate species, including lobster and sea cucumber, however, show evidence of high recruitment during the warm periods, presumably before the adults were stressed. Galapagos fisheries are fairly unique in that high biomass extraction comes from a very low trophic level (*Isostichopus*). In such circumstances you might expect a lag in detrimental effects to bottom feeders, and even augmentation of reproductive potential, as detrital fallout to the benthos is increased in the early stages of an ENSO warm event. Direct and indirect impacts are speculative and warrant further investigation, although the implications for the local human community are obvious; ENSO cycles need to be integrated into an enforced management policy.

Today Galapagos is hurtling into the future with greatly increased human population and unprecedented exploitation of its marine resources, making the conservation of the Reserve a very real challenge. Humans have only recently formed part of the perturbations associated with ENSO. There is a new level of ecological, socioeconomic, and political complexity combined with natural variability. If the Galapagos National Park Service is to protect these globally unique ecosystems we need to turn our attention to the difficult challenge of differentiating often compounding anthropogenic impacts from climate and the impacts of climate change.

Appendix C

Subject: [SIV Global:] Climate is changing: what can we do?
Date: Wed, 25 Aug 2004 15:26:00 +0100
From: smallislandsvoice@sivglobal.org
Reply-To: notify@sivglobal.org
To: notify@sivglobal.org

SMALL ISLANDS VOICE

Do you live in a small island?
Tell us what you think.

****

The rising sea is eating at the shores of low-lying Funafuti, a small mound of coral and coconut palms in the remote Pacific, midway between Hawaii and Australia. Nervous islanders watch as fingers of ocean travel beneath the sands, resurfacing inland in startling places. 'It used to be puddles. Now it's like lakes' said Hilia Vavae, local meteorologist.

People were especially worried when the runway flooded. 'That's new' Margaret Bita told a visiting reporter after Sunday church services. The church and the little airport lie on the broadest part – 600 yards across – of slender, steamy 7-mile long Funafuti, home to about half the 11,000 people of Tuvalu, an impoverished nation getting by on fees from foreign fishing fleets, international aid and money sent home by Tuvaluan merchant seamen.

The main island narrows elsewhere to a mere 50 yards of sand, with swaying palms and a roadway between the lagoon and the sea. Its elevation is seldom more than a few feet. When February's high tides washed out a small causeway, children swam to school.

As recently as the 1980s, Vavae said, the peak high tides came only in January and February, now she said they crash ashore from September to May. But it is the quiet seepage from below that most alarms Tuvaluans. Because of intruding salt water, many have abandoned their gardens and crops. On the nearby islet of Vasafua, the coconut trees are dying. Another small, uninhabited island has vanished beneath the waves. 'It went underwater in the cyclone of 1997' Vavae said.

Similar events are taking place in the Marshall Islands, 1,250 miles away, and in Kiribati to the north of Tuvalu. And it is not only the low-lying atolls that are being affected. On Kosrae, a high island of volcanic peaks in the Federated States of Micronesia, the people have always lived along a flat coastal strip, but some are now dismantling their simple homes and heading for the hills as recommended by the government. People across the Pacific feel sure that something unusual is happening. 'I don't know' said a government worker in Kosrae 'but I think it is because of green something'.

Like the glass of a greenhouse, carbon dioxide, methane, nitrous oxide and other gases in the atmosphere let sunlight in but tend to warm the earth by trapping the heat inside the earth's atmosphere. Concentrations of carbon dioxide, a by-product of fossil fuels burned

in everything from cars to electricity plants, reached record levels in the atmosphere this past winter, a Hawaii observatory reported in March 2004. This global warming is expected to change regional climates in powerful ways such as melting ice caps, intensifying storms and raising ocean levels.

The 'greenhouse effect' and climate change have languished on the world's agenda since the 1970s, a seemingly distant threat. But year by year, inch by inch, it is rising to the top – as ocean islets flood, glaciers retreat, Arctic permafrost melts, and leading voices raise new alarms. The long-stalled 1997 Kyoto Protocol, that aims to reduce the world's greenhouse gas emissions, is opposed in Washington where US government and industry object that emission controls would handicap the US economy. Meanwhile signs of global warming mount.

And Pacific islanders aren't alone. Rising seas are a growing threat from Alaska, where Eskimos are relocating a coastal village further inland, to New Orleans in the USA and Shanghai in China – coastal cities already below sea level, sinking on their own and further endangered by expanding oceans.

Back in Tuvalu, devoutly Christian since missionary days, many talk not of greenhouses, but of Genesis, reminding each other of God's promise to Noah: As long as rainbows cross the sky there will be no more great floods. 'God will protect us' one woman churchgoer assured a visitor. Saufatu Sopoanga, as Tuvalu's prime minister, must look into the future, not the Bible. He is talking to New Zealand about a kind of 21st century Noah's Ark – a standby plan for a mass migration there. 'In 50 or 100 years, the islands are expected to go under water. What can we do?' Tuvalu's leader asked, on a day when a tropical morning downpour soon gave way to a rainbow in a blue, very warm sky.

Adapted from 'Mercury and tides climb, as climate change rises on global agenda' by Charles J. Hanley in San Juan Star newspaper, Puerto Rico, Caribbean, 23 May 2004

Title: Climate is changing: what can we do?
Author: Charles J. Hanley
Date: Wednesday, 25 August 2004

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Final Agenda

Monday, 13 September 2004

8:30am–9:30am: Welcome to the workshop and the Galapagos by representatives from Ecuador, Galapagos National Park, Charles Darwin Research Foundation (CDRF), Puerto Ayora, and the sponsoring agencies.

Sponsoring agencies: NCAR, CIIFEN, NSF,CDRF, WMO, ISDR, and UNESCO/IOC.

9:30am–10:00am: *Why We Are Here*:

To identify the value of ***linking*** between:

- Early warning and sustainable development
- Disaster response and development
- El Niño and climate-related hazards (e.g., teleconnections)
- Identify El Niño information uses for development
- Early warning effectiveness: pronouncements vs. actions
- The Asian side of the Pacific and the Western Hemisphere
- Identify high-risk sectors and segments of society
- To share experiences (including lessons identified at other locations and times)

Something to think about:

"I said I wasn't clever. I was just noticing how things were, and that wasn't clever. That was just being observant. Being clever was when you looked at how things are and used the evidence to work out something new." (Mark Haddon, 2002)

10:00am–10:30am: *Linking Application to Scienc*e: Sustainable development (www.un.org/esa/sustdev)

Indicators of sustainability vary:

- From definition to definition
- From country to country
- From sector to sector
- From culture to culture
- From time to time

Linking Science to Application: Why sustainability science? (www.earthethics.com/Sustainability%20Science.htm)

- Science needed a "fundamentally different approach" if the goal of sustainability was to be achieved.
- Modern science could be described as "islands of understanding in oceans of ignorance." Many environmental problems were the "direct result of applying narrow specialized knowledge to complex systems."
- Instead we need to work backwards from undesirable outcomes to identify pathways to avoid these problems.
- "Scientists and practitioners have to work together to produce trustworthy knowledge that combines scientific excellence with social relevance." (Ian Lowe, Australia, 27 June 01, *Science in the News*)

10:30am–11:00am: BREAK

11:00am–12:15pm: *ENSO Science: El Niño & La Niña*: What is El Niño?

- What are the indicators?
- How reliable is forecasting?

- How credible are the models?
- Whose responsibility is it for an overarching ENSO Early Warning System? For the science, for the forecasts, for communication among components, for responses, for oversight/review, for accountability?

12:15pm–2:00pm: LUNCH

2:00pm–2:45pm: *ENSO-Related Hotspots in the Pacific Region:*
- What constitutes a "hotspot" in the Pacific? (hot, hotter, hottest spots)
- Hotspots can be singular or a combination of political, economic, environmental, health, demographic, meteorological, and cultural factors, among others (e.g., complex environmental crises).

2:45pm_3:45pm: *Strengths, Weaknesses, Opportunities & Constraints* (SWOC) of El Niño forecasts as early warnings for sustainable development

Participants divide into two groups for the SWOC discussions:
Group A: Suggest strengths and weaknesses
Group B: Identify opportunities and constraints

3:45pm–4:00pm: BREAK

4:00pm–4:45pm: *Plenary discussion*:
- The SWOC assessment for El Niño knowledge and forecasts as early warning for sustainable development in the Pacific region (Groups A and B)

Tuesday, 14 September

8:30am–9:15am: *El Niño Forecast Cascade: Hazards*
- What are the hazards of concern? How similar are they from country to country? From East and Southeast Asia to South, Central, and North America?
- How does El Niño generate or influence them (positively or negatively)?
- First-order and second-order impacts

9:15am–10:00am: *El Niño Forecast Cascade: Health*
- Health and health-related concerns in the Pacific region
- The role of El Niño knowledge and forecasts in or influence on health early warnings in the short and long term

10:00am–10:45am: *El Niño Forecast Cascade: Agriculture*
- The use of El Niño "climatology" and forecasts in agriculture and range management

10:45–11:15am: BREAK

11:15am–12:00pm: *El Niño Forecast Cascade: Fisheries*
- The impacts of El Niño on fish populations and on fishing sectors
- The use of El Niño knowledge and forecasts to foster sustainable development processes

12:00pm–12:30pm: *World Conference on Disaster Reduction (WCDR) 2005*
- Overview of the goals of the World Conference on Disaster Reduction (to be held January 2005 in Kobe, Japan)
- Potential input to the Plan of Action of the WCDR

12:30pm: LUNCH and free afternoon

5:30pm–7:00pm: *Galapagos Public Roundtable*:

- El Niño's impacts on flora and fauna in the Galapagos
- Convener: Mayor Alfredo Ortiz Cobos (mayor of Isla Santa Cruz)

Wednesday, 15 September

8:30am–9:15am: *Linking Disaster Reduction and Development Policies*

The influences of disaster responses on:

- Mid-term development prospects
- Sustainable development
- Identifying good practices and gaps to reduce El Niño-related impacts

9:15–10:00am: *Lessons to Be Learned... From Lessons Already Learned*

- What might Pacific Rim countries and islands learn from other regions that have coped with El Niño (forecasts, impacts, and responses)?
- Does the /Once Burned, Twice Shy/ report supply any usable lessons? (NCAR/UNEP/UNU/WMO)
- (www.esig.ucar.edu/un/)

10:00am–10:30am: BREAK

10:30am–11:15am: *Media and Early Warnings*: For quick-onset and creeping environmental changes

- Role of the media in El Niño Early Warning in the region (Should the media be expected to educate the public and policy makers about El Niño's impacts in a region?)
- Reporting on El Niño (ad hoc intermittent, or sustained reporting on the El Niño phenomenon)
- What are the sources of the warnings? Which ones are to be believed and acted upon?

11:15am–12:00pm: *Mid-Workshop Review*

- Where have we been?
- Where are we?
- Where are we going?

12:00pm–2:00pm: LUNCH

2:00pm–2:45pm: *Vulnerability and Resilience*:

Underlying aspects of

- Vulnerability (political, economic, cultural, stability, environmental)
- Resilience (Is resilience the opposite of vulnerability? Is the notion of resilience useful in El Niño impacts studies?)

2:45pm–3:30pm: *From Hurricane Fifi to Hurricane Mitch: An Example of Climate Affairs*

From hurricane to hurricane:

- Who to help?
- When to help?
- How to help?
- Why help?

What issues does this case study raise?

3:30pm–4:00pm: BREAK

4:00pm–4:45pm: *Climate Change and the Pacific Rim*

Projected climate change impacts in the Pacific Rim countries and islands

- Extreme events (droughts, floods, fires, infectious diseases and other health effects, etc.)
- Sea level rise (island nations, non-island low-lying coastal rural and urban areas)

Thursday, 16 September

8:30am - 9:00am: *Right-Sizing El Niño Early Warnings*

What is the right scope for early warnings related to El Niño in the Pacific Basin?

- Geographical scope (national, regional, hemispheric, global)
- Functional scope (sectoral)

9:00am–9:45am: *SWOC Groups on Prospects of Linking across the Pacific*

Participants divide into two groups: Group A: suggests strengths and weaknesses; Group B: Identify opportunities and constraints

9:45–10:30am: *Linking across the Pacific: Is the Pacific Ocean a barrier or a bridge?*

- Discussion of the SWOC for linking (early warning systems, sustainable development, Asia and the Western Hemisphere)
- Problems and prospects of linking across the Pacific (Is it worth the effort? Words vs. actions)

Something else to think about:

> "He said that it was difficult to become an astronaut. I said I knew ... But I said that you could still want something that is very unlikely to happen." (Mark Haddon, 2002)

10:30am-11:00am: BREAK

11:00am–12:15pm: *Where Should We Go from Here?*

- Next Steps? (Report in English and Spanish)
- ENSO/EWS/Sustainable Science-related research and application needs of Pacific Rim countries and islands

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