

Century **Adaptation** Florida Government
Institute on Science for Global Policy (ISGP)
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Water **Ice** Coastal **Economic**

Sea Level Rise: What's Our Next Move?

Conference organized and convened in St. Petersburg, Florida, by the ISGP in partnership with the Institute for Strategic Policy Solutions at St. Petersburg College and a local committee of concerned volunteers, the St. Petersburg/Pinellas County Working Group, at St. Petersburg College Seminole Campus October 2-3, 2015

Individual **Sea-level rise** Strategies
Climate Change Accelerating Years
Relocation **SALT** Increase Tax
Communities Rate Wetlands Melt
Property Warming **Mitigation** Scientific
Storm Effective Development **Flooding**

ISGP Climate Change Program (ICCP) St. Petersburg/
Pinellas County, FL

Institute on Science for Global Policy (ISGP)

ISGP Climate Change Program (ICCP):

Sea Level Rise: What's Our Next Move?

Conference organized by the ISGP in partnership with
the Institute for Strategic Policy Solutions at St. Petersburg College
and a local committee of concerned volunteers,
the St. Petersburg/Pinellas County Working Group,
and convened on the St. Petersburg College Seminole Campus
October 2–3, 2015

*An ongoing series of dialogues and critical debates
examining the role of science and technology
in advancing effective domestic and international policy decisions*

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ISBN: 978-09861007-5-8

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Introduction

Dr. George H. Atkinson

Founder and Executive Director, Institute on Science for Global Policy
and

Professor Emeritus, Department of Chemistry and Biochemistry
and College of Optical Sciences, University of Arizona

Preface

The contents of this book were taken from material presented at a conference entitled *Sea Level Rise: What's Our Next Move?* held in St. Petersburg, Florida, on October 2–3, 2015. This conference was organized and convened by the Institute on Science for Global Policy (ISGP) in coordination with the Institute for Strategic Policy Solutions at St. Petersburg College and a local committee of concerned volunteers (the St. Petersburg/Pinellas County Working Group). The conference was the third of a new series of ISGP Climate Change Program (ICCP) conferences being held around the United States.

These ICCP conferences focus on communities that are concerned with how to mitigate and/or adapt to the anticipated impact of changing climates (e.g., drought, sea level rise, severe storms, warming seas and oceans). Special attention is given to how changes in climate may alter personal lifestyle choices and the collective decisions made throughout a community. ICCP conferences, utilizing the ISGP's unusual, if not unique, debate/caucus format, attempt to significantly improve the communication of credible scientific and technological (S&T) understanding to both policy makers and to the public *writ large*. Sustained, broad-based support from all groups is often required to formulate and implement progressive policies that meet the needs of individual citizens and those of their respective communities.

ISGP conferences offer rarely encountered environments in which critical debates and extended caucuses can occur among internationally distinguished scientists, influential policy makers, societal stakeholders, students, and interested citizens.

Based on extensive interviews conducted by the ISGP staff with a national and international group of subject-matter experts, the ISGP invited three highly distinguished individuals with expertise in climate change and sea level rise to prepare three-page, policy position papers (designed for the nonspecialist). On the first day

of the conference, the author of each paper answered questions and commented in a moderated, 90-minute debate involving academics, public officials, individual citizens, and representatives from the private sector and non-governmental public advocacy organizations. Each author was provided with a 5-minute period at the outset of each debate to summarize his/her views.

On the second day of the conference, groups of about 12 participants (debaters and audience) caucused with a moderator to identify areas of consensus and actionable next steps relevant to the significance of sea level rise for individual lifestyle choices and the community-wide decisions under consideration. The results from all the caucuses were presented to a plenary session involving all participants for discussion.

The three policy position papers, together with the not-for-attribution summaries of the debates of each paper (as prepared by the ISGP staff from recordings of the debates), and the areas of consensus and actionable next steps (as developed by all conference participants in caucuses) are presented in this book.

St. Petersburg/Pinellas County Working Group

The St. Petersburg/Pinellas County Working Group was comprised of representatives from St. Petersburg College and leaders from St. Petersburg and Pinellas County area who volunteered to work with the ISGP. These individuals provided invaluable perspectives on the issues that concerned themselves and their fellow citizens with respect to the climate changes facing the St. Petersburg/Pinellas County area. Their contributions were of fundamental importance to structuring the provocative and constructive debates and caucuses that ensued. Biographies of the Working Group members are presented here.

ISGP Climate Change Program (ICCP)

Of the seemingly innumerable societal challenges associated with science and technology (S&T) being debated worldwide, those connected to climate change are among the most challenging and at times, apparently the most intractable. The often-contentious discourse and public uncertainty about climate change characterizes the complexity of the S&T issues and degree of uncertainty found among nonspecialist citizens concerning what can be done to mitigate and/or adapt to the consequences of climate change. While in some quarters the public and political disagreements rage over the even existence of climate change and its relationship(s) to human activities, there are increasing clear physical indications that changes in climates (local, regional, and global) are occurring with a rapidity and severity not anticipated by many credible scientists and societal leaders.

Under these circumstances, it is increasingly important to more effectively engage citizens in discussions concerning the reality of climate change and its potential significance in their lives and the decisions being made in their respective communities. It is also evident that new models for engaging subject matter experts with nonspecialist citizens are required to reconcile opposing views and to obtain practical policies that can be implemented and publicly supported.

To ensure that the societal debates of climate change issues lead to effective governmental and private-sector policies, two types of engagements are needed:

1. It is critical that well-informed, credible scientists and technologists candidly communicate the advantages and risks of practical options for addressing climate changes in the lives of citizens and their communities.
2. Citizens must be able to accurately evaluate recommendations based on the predictions from climate change models against often expensive and difficult alterations in their personal lifestyles.

Since citizens legitimately have concerns regarding the credibility of information provided to them from multiple sources, they deserve the opportunity to question specific recommendations based on their own perspectives and to help formulate and implement those policies that garner broad, sustained public endorsements. These are the egalitarian environments created by the ISGP in its conferences.

Concluding Remarks

The ISGP, a not-for-profit organization, has no opinions nor does it lobby for any issue except rational thinking. Members of the ISGP do not express any independent views on any topic. Rather, ISGP programs focus on fostering environments that can significantly improve the communication of ideas and recommendations derived from credible scientific and technological understanding to decisions makers in both the public and private sectors. It is hoped that all those responsible for formulating and implementing policies will benefit from the information in this report in their efforts to effectively serve their constituents.

Conference Conclusions

Area of Consensus

Because historic records and current projections indicate that sea level can rise significantly within a relatively short amount of time (e.g., lifecycle of a mortgage), it is of vital importance for the economic health and sustainability of the region that policy makers at all levels develop long-term anticipatory plans that (i) create metrics-driven benchmarks for the implementation of policy actions; (ii) identify strategies for addressing the overlapping issues of health, freshwater, food, shelter, infrastructure, and safety; and (iii) consider the potential relocation and/or restructuring of affected communities. Policies need to be developed through extensive community education and engagement, and need to consider social, environmental, and economic issues related to societal inequities and vulnerable communities.

Actionable Next Steps

- Implement a locally focused, scientifically based campaign to educate all stakeholders (i.e., public and private-sector policy makers, property owners/buyers, and the public *writ large*, including school children) concerning the environmental, financial, and social impacts of sea level rise. Such a comprehensive campaign (i) characterizes what can be accurately predicted about sea level rise, including the uncertainty of its rate, (ii) describes specific mitigation and adaptation options, including the relocation of physical structures, (iii) clarifies the potential risks to property owners and buyers in certain areas, and (iv) demonstrates to potential investors how the local community is proactively preparing for a sustainable and prosperous future.
- Disseminate scientifically credible data to assist policy makers, as well as all citizens and public and private sector stakeholders (e.g., property owners/buyers, insurance companies, low-lying neighborhoods), in their decisions concerning sea level rise. Disseminated data need to include (i) regularly updated elevation maps displaying projected sea level rise, (ii) comprehensive vulnerability assessments for infrastructure functionality related to elevations, and (iii) models for the anticipated public costs of supporting coastal communities at different sea levels.

- Require public officials to become, and remain, well informed on the most recent data on sea level rise and climate change, especially with regard to its impact on local decisions. Train publicly supported “navigators” responsible for conveying the scientifically credible information needed to help guide citizens as they decide how to mitigate and/or adapt to the impact of sea level rise in their personal activities (e.g., property purchases).
- Create new and amend existing regulations and policies to discourage growth in areas vulnerable to sea level rise and encourage regional smart-growth management. Such smart-growth initiatives can include incentivizing property owners to relocate from affected areas; modifying zoning laws for new construction; emphasize the impact of sea level rise in insurance and mortgage policies; increase transparency concerning climate change impact in real estate transactions; adjust federal flood insurance rates to reflect realistic assessments of sea level rise; decrease federal support for renourishing beaches; and ensure the true, long-term costs of development are assessed to those who financially benefit. Collectively, such policy and regulatory changes need to encourage diversified economic decisions that commercially favor residential use on ground not susceptible to sea level rise.

Area of Consensus

While recognizing that the allocation of limited resources is often focused on immediate, post-disaster recovery, these short-term decisions need to be made with a view to minimizing the risks from future events. These responsibilities pertain to decisions made by all stakeholders, governmental agencies, private sector, and especially individual citizens. Often these decisions focus on contrasting building-in-place on the basis of maximizing lifestyles choices and compensating for income inequalities versus implementing long-term, precautionary measures that prioritize safety and land preservation over new development (e.g., raising the height of bridges used in evacuations, protecting aquifers, restructuring beaches, relocating private housing and commercial property).

Actionable Next Steps

- In recognition of diminishing budgets, develop broader risk management policies that incorporate planning for the effects of sea level rise into

decisions for all stakeholders (e.g., individual citizens, private sector, governmental institutions). Policies incorporating defined benchmarks controlling implementation provide the adaptability required to address the uncertain timing and degree of sea level rise.

- Realign governmental disaster relief policies to ensure that subsidies do not encourage private sector and individual development on land that can be expected to be at risk by potential sea level rise.
- Conduct a comprehensive federal assessment of the socioeconomic factors in vulnerable communities that influence land use decisions in the face of potentially damaging climate events and adjust federal resource-allocation rubrics accordingly.
- Develop strategies in cooperation with nonprofit organizations that assist in the relocation of low-lying, low-income communities while preserving both their economic and social capital intact.
- Strengthen comprehensive policy planning and local land development and building codes to discourage construction in flood-risk areas and to provide clear benchmarks for removal of structures following disastrous events.
- Utilize innovative design and engineering models to incrementally adapt infrastructure to sea level rise.
- Provide public education and engagement addressing precautionary measures to encourage individuals to take ownership of their responsibilities as citizens living in an area under threat of sea level rise

Area of Consensus

Programs designed to transition property from private ownership into the public domain (e.g., a Shoreline Adaptation Land Trust or SALT) need to be part of a comprehensive suite of long-term options addressing the effects of rising sea levels. The public value of these programs needs to be measured in terms of several competing issues including (i) creation of new recreation areas and ecosystem services, (ii) decreased tax revenues and relationship to income disparities among those affected, (iii) shared funding sources, (iv) impact on public versus private sector land use policies and the utilization of existing structures, and (v) collaborative agreements among local communities.

Actionable Next Steps

- Create in-migration areas for both natural and human populations that meet the economic, social, and environmental needs of local communities and state-wide priorities, especially protecting existing natural ecosystems from both sea level rise and the anticipated impacts of community migration needs.
- Encourage public-private collaboration in the education of citizens by broadly disseminating scientifically credible sea level information via both traditional and social media outlets. Engage teachers by developing workshops, educational aids, and curricular material that describes the science underpinning sea level rise and policy considerations associated with its consequences.
- Require disclosures of the short- and long-term risks posed by sea level rise in all licensed property transactions, including a verification that all parties understand the present and future risks to the property.
- Establish implementable policies focused on diversifying the economy and its associated tax base to reflect the anticipated consequences of sea level rise. These proactive policies need to address an expected decrease in tax revenue by considering both short- and long-term options for property ownership during a transitional period (e.g., reverse mortgages, straight purchases, property donations under land trust agreements, such as SALT). These efforts require identifying legislative requirements for policies that create financially viable compensation programs supporting incentives for adaptive actions by individuals and the private sector.
- Land-use policies and property transfer programs need to be based on principles that balance human management with sustainable habitat: (i) using funds to convert impacted property into sustainable habitats, (ii) disincentivizing at-risk future property ownership/development, (iii) transparently communicating the projected lifetime of at-risk properties, (iv) providing ecosystem services, and (v) offering recreational value to communities.

ISGP conference program

Friday, October 2

7:00 – 8:30 **Registration**

8:30 – 8:45 ***Welcoming Remarks***

Dr. John Chapin, St. Petersburg College,
Dean of Natural Sciences
and

Dr. George Atkinson, Institute on Science for Global Policy
(ISGP), Founder and Executive Director

Presentations and Debates

8:45 – 10:15 **Dr. Harold R. Wanless, Department of Geological Sciences,
University of Miami, United States**

The Coming Reality of Sea Level Rise: Too Fast Too Soon

Moderated by Dr. George Atkinson, Founder and
Executive Director, ISGP

10:15 – 10:45 *Break*

10:45 – 12:15 **Dr. Andy Keeler, Coastal Studies Institute,
University of North Carolina; and Department of
Economics, East Carolina University, United States**

*Adapting to Sea Level Rise: the Tension Between Protection
and Discontinuous Change*

Moderated by Dr. Sweta Chakraborty, Associate Director, ISGP

12:15 – 13:15 *Lunch*

13:15 – 14:45 **Mr. John Englander, Rising Seas Group, United States**

*Shoreline Adaptation Land Trusts: Concept for
Rising Sea Level*

Moderated by Dr. George Atkinson, Founder and
Executive Director, ISGP

14:45 – 15:00 **Wrap-up, caucus information**

Saturday, October 3

7:30 – 8:30 **Registration**

8:30 – 11:45 **Focused group sessions**

11:45 – 12:45 *Lunch*

12:45 – 15:45 **Plenary Caucus Session**

Moderated by Dr. George Atkinson, Founder and Executive Director, ISGP;
and Dr. Sweta Chakraborty, Associate Director, ISGP

15:45 – 16:00 **Closing Remarks**

Dr. George Atkinson, ISGP, Founder and Executive Director

The Coming Reality of Sea Level Rise: Too Fast Too Soon**

Harold R. Wanless, Ph.D.

Professor and Chair, Department of Geological Sciences
University of Miami, Coral Gables, Florida, United States

Summary

The reality of accelerating rates of sea level rise as the result of human-induced global warming is becoming increasingly dire and urgently needs to be addressed. In 2012, the National Oceanic and Atmospheric Administration (NOAA) published the most recent United States Government sea level rise projections as a part of the National Climate Assessment. Those projections, which included anticipated acceleration in ice melt from Greenland and Antarctica, were for 4.1 to 6.6 feet of sea level rise by 2100. That could mean 2 feet by as early as 2048 and 3 feet by 2063. A 2 to 3 foot rise of sea level will make nearly all of the barrier islands of the world uninhabitable, result in inundation of a major portion of the world's deltas, and make low-lying coastal zones like south Florida increasingly challenging communities in which to maintain infrastructure and welfare and to assure protection of life and property during hurricanes and other extreme events.

Current realities

Most of the models projecting future sea level rise assume a gradual acceleration of sea level rise through this century and beyond as Greenland and Antarctic ice melt gradually accelerates. Our knowledge of how sea level rose out of the past ice age paints a very different picture of sea level response to climate change. At the depth of the last ice age, about 18,000 years ago, sea level was some 420 feet below present level as ice was taken up by large continental ice sheets. Subsequent ice melt and sea level rise was not a gradual acceleration and then deceleration. Rather it was a series of very rapid pulses of sea level rise followed by pauses. These rapid pulses of rise, from 3 to 30 feet probably within a century, were fast enough to leave drowned reefs, sandy barrier islands, tidal inlet deltas, and other coastal deposits abandoned across the continental shelf. That is what happens when the climate warms: It destabilizes some ice sheet sector which rapidly disintegrates, resulting in a rapid pulse of global sea level rise.

Our significantly warmed atmospheric climate is resulting in an accelerated ice melt of the surface of the Greenland Ice Sheet. Much of the surface of the Ice Sheet is darkening as the dust and black carbon in the ice concentrate on the melting surface. This accelerates heat absorption, further accelerating surface ice melt — one of many feedbacks not in current models. More importantly, warmed ocean water is accelerating ice melt in both Polar Regions. The warming North Atlantic Ocean and Arctic Ocean have been accelerating ice melt all around Greenland since about 1995 as this dense “warm” ocean water enters the deep outlet glacial fjords and penetrates far into and under the Ice Sheet. Warm ocean water is now also penetrating deeply into fjords under outlet glaciers and adjacent Ice Sheets of both West Antarctica and East Antarctica. Each of these warm waters is only 2 to 4 degrees Celsius, but they are causing a powerful amount of melting. We are creating a basically unlimited supply of warmth to the oceans for this to continue.

The beginnings of this polar Ice Sheet melt are showing numerous positive reinforcing feedbacks, which are rapidly accelerating the rate of melt far beyond anything being projected in current models. For example, because water on the melting ice surface absorbs more heat, surface melt is accelerated; this melt water percolates down through the ice and lubricates the base permitting faster motion, which results in more extensive fracturing. Water percolating through the fractured ice accelerates ice melt and warms the ice, which results in the softening of the ice and even further acceleration. With the rapid melting of the Arctic Ocean pack ice and warming of the Arctic Ocean, release of additional carbon dioxide and methane from decaying organics in the melted permafrost, and melting of methane hydrates on the Arctic continental shelf, the accelerating melt of the adjacent Greenland Ice Sheet seems irreversible. We are most certainly witnessing the onset of a rapid pulse of sea level rise.

In the spring of 2014, NASA’s Jet Propulsion Laboratory, Cal Tech, and the University of California-Irvine all came out with documentation showing that ice melt in from the margins of the West Antarctic Ice Sheet is much less constrained by underlying bathymetry than previously considered (i.e., bottom substrate is much deeper below the ice). The documentation also demonstrates that the numerous fjords penetrating in from the Greenland coast are deeper and extend much further in under the Ice Sheet than previously thought. In 2015, similarly accelerating ice melt has been documented under the East Antarctic Ice Sheet. Each of these findings means that warmed ocean water is now more easily penetrating further under these ice sheets, and accelerating ice melt will be happening significantly faster than previously thought.

In the summer of 2013, I had the opportunity to witness the melting ice sheets, flying about 50 miles onto the Greenland Ice Sheet following the deep channel below

the Jacobshaven Icefjord in western Greenland to an elevation on the ice sheet of more than 6,000 feet. It was like flying up a large, meandering, fractured streambed in the ice surface. The channel was roughly 500 feet below the level of the ice sheet and dramatically fractured from the accelerated ice flow. This was created by melt at the base from deeply penetrating warmed ocean water. As a result of the fracturing and detachment from the bottom, the forward velocity of the ice has accelerated from a couple of miles to more than 20 miles per year. This witnessed event was a spectacular, but disturbing experience.

In light of our improving understanding of ice melt, we probably should be anticipating at least 7 to 30 feet of global sea level rise by the end of the century regardless of what we do. Even if we stopped burning fossil fuels tomorrow, the greenhouse gasses in the atmosphere will keep warming the atmosphere for at least another 30 years. More than 90% of this global warming heat is ending up in the oceans, which have the capacity to capture and store and use this heat for centuries. As a result, ice melt and sea level rise will continue for centuries. Most projections recognize that sea level rise will be accelerating through this century and the next. When we are talking about a 4 to 6 feet rise by the end of the century, this will not be a new fixed sea level. This level will be a single point during a period of continued acceleration of sea level rise, because of the continuing acceleration of ice melt. If we encounter a 5-foot increase at the end of the century, sea level will be rising at a foot per decade.

There is currently a very aggressive building boom underway in south Florida (i.e., on the barrier islands and throughout downtown and in the low western areas bordering the Everglades, presently 230 new condominiums are under construction in Miami-Dade County). South Florida is building without considering the viability of construction or challenge of maintaining a low coastal infrastructure anywhere with that level of sea level increase. There are already areas that will be unlivable and properties that will be unsellable within a 30-year mortgage cycle.

Scientific opportunities and challenges

Several recent papers, including one from the National Research Council, have pointed out that we now have greenhouse gas levels sufficient to cause a 79-foot sea level rise. Our recorded history does not have direct observations as to how fast destabilized ice sheet sectors can disintegrate. Indications from the past and the present are that pulses of sea level rise happen very fast (e.g., 3 to 30 feet per century).

Even with the current projection of 6.6 feet in sea level rise by the end of the century, it is beyond sobering to consider the risk in the present investments. With a further 2 feet of sea level rise (possibly before 2048) most of the barrier islands

(of south Florida and the world) will become abandoned and the people relocated; at the same time low areas (e.g., Sweetwater and Hialeah bordering the Everglades) will become flooded more frequently and therefore become increasingly difficult places to live. Citizens in these areas will lose their freshwater resources, be living in a community with a failing and disconnected infrastructure, and be at increasing risk from catastrophic storm surges, flooding from hurricanes, and failing sewage treatment plants.

Many renowned scientists have concluded that global sea level may rise 15 to 30 feet by the end of the century. However, communities should begin planning using the 2012 NOAA projections for planning (4.1 to 6.6 feet by 2100). With that, they will quickly realize that very serious problems will be occurring very soon. With accelerating sea levels projected through this century and beyond, there is a need to refocus on realistic plans to maintain community stability during relocation and environmental quality during inundation. South Florida cannot consider the option of living below sea level with levees and dikes because the limestone and sand substrate is much too porous and permeable. With planning, using the NOAA projections, it will be easy to adapt to higher and faster rates of sea level rise.

Policy issues

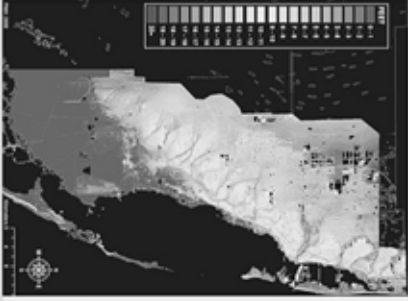
- Counties must aggressively and transparently plan for their future, integrating high-resolution elevation, storm surge, flood risk, and infrastructure elevation maps to determine the timing, costs and economic feasibility for maintaining a functional infrastructure, viable insurance, and human health and safety.
- Maps need to be produced for each 6 inches of sea level rise. With these, intelligent planning can be done to determine what areas and infrastructures are currently at unacceptable risk, and at what thresholds and costs infrastructure will have to be modified to maintain functionality and acceptable risk. These maps can also determine infrastructure services that will have to be discontinued from certain sectors because of unacceptable risk or cost.
- We must act within the framework of the reality before us. As there is little possibility that these sea level rise projections will diminish, it is imperative to:
 - (a) Terminate long-term, infrastructure-intensive development of barrier islands and low-lying coastlines.

- (b) Divert public money from hard or soft shore-protection measures into funds to be used for relocation assistance, cleaning low-lying polluted lands, and removing storm-damaged development and infrastructure.
- (c) Establish firm sea-level-rise thresholds for termination of infrastructure services and for permission to rebuild following storm destruction.
- (d) Establish preplanned sea-level-rise thresholds that stage insurance withdrawal through cooperative public-private agreements.
- (e) Implement the Southeast Florida Regional Climate Change Compact, which has some 1,200 action items to help insure the stability of affected individuals and communities.
- (f) Initiate intensive education for the affected public.

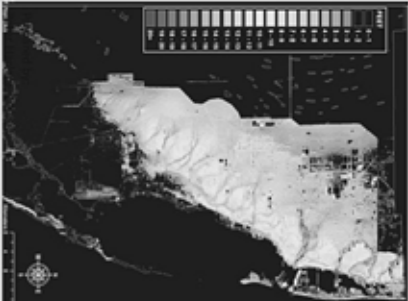
Without planning, there will come a point where society and civilization as we know it will collapse into chaos. We can only prevent this scenario with serious planning and effort. Our children and future civilization deserve much better than we are presently doing.

A policy position paper prepared for presentation at the conference Sea Level Rise: What's Our Next Move? convened by the Institute on Science for Global Policy (ISGP) on October 2-3, 2015 at St. Petersburg College, St. Petersburg, Florida, U.S.

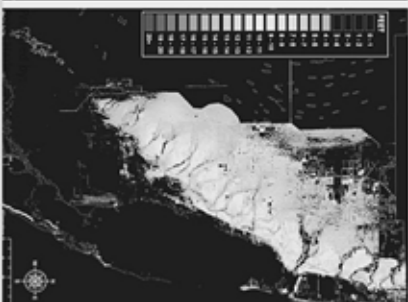
Miami-Dade County This Century



**Present
topography**



**+2 feet
2048-2066**



**+4 feet
2074-2099**



**+6 feet
2093-2121**

WHAT WE WILL LOSE: Freshwater Resource Airports Storm Protection
Sewage Plants Road connectivity Tax Base

Maps provided by Peter Harlem, Florida International University, 2014

Debate Summary

The following summary is based on the transcriptions of recordings made by the ISGP staff during the debate of the policy position paper prepared by Dr. Harold Wanless (see above). Dr. Wanless initiated the debate with a 5-minute summary of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute debate period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Wanless. Although this summary has been written without attribution, the conference itself was open to the public and media and as such, did not restrict participants from attributing remarks to specific individuals. The views comprising this summary do not necessarily represent the views of Dr. Wanless, as evidenced by his policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate conclusions

- Effective long-range adaptation/mitigation planning in anticipation of climate change impacts requires communities to establish (i) where sea-level protections need to be reinforced, (ii) which areas can be saved, and (iii) which areas have a limited lifespan and require transition strategies. Policy recommendations built on a comprehensive analysis of infrastructure, especially with respect to its vulnerability to increasing sea levels (e.g., Southeast Florida Regional Climate Change Compact), need to be implemented immediately throughout the region.
- Given that proactive, protective measures against sea level rise (e.g., shoreline hardening, which is the process of adding structures such as seawalls or jetties) are likely to become ineffective within a few decades as climates change, significant aspects of public investment in adaptation/mitigation measures need to support the relocation of affected populations and the cleanup of abandoned properties and environmental hazards. While rapid, forced relocation creates serious societal and economic challenges, strategies that foster the gradual movement of populations away from vulnerable areas must be an important part of government policies. These strategies need to incorporate a balance among numerous

priorities including direct compensation to affected property owners, development of infrastructure in alternative locations for public services (e.g., fresh water), and promotion of sustainable commercial and agricultural investments.

- Since citizens routinely support policies protecting property rights versus those ensuring environmental quality, the implementation of widely available, scientifically credible mitigation/adaptation strategies for addressing climate issues has been seriously limited, even though the public responsibility for protecting the environment is part of the Florida constitution. Scientists need to more effectively communicate the significance of climate issues to both Florida citizens and tourists (i.e., the tourism industry must be part of these outreach and strategic discussions).
- The economic viability of property at risk to climate changes, and the associated tax system, is a key driver in shaping mitigation/adaptation strategies and its impact on personal lifestyle choices must be communicated to policy makers and citizens (e.g., two feet in sea level rise by 2048 means a house bought in 2016 could be under water during its 30-year mortgage). The insurability of housing must reflect the threats posed by sea level rise both in rates, salability, and even the availability of any insurance. Such consequences provide real-world challenges that demonstrate the significance of climate issues. Governmental agencies need to determine sea-level benchmarks that define the degree of vulnerability of property, and utilize those benchmarks for setting (i) zoning and building codes, structure elevations, and infrastructure design, (ii) policies establishing public versus private sector post-disaster relief options, (iii) insurance costs, and (iv) real estate disclosure requirements.
- Even though practical strategies to rapidly reverse the warming of the ocean and the disintegration of ice sheets have not been identified, slowing the increase of atmospheric warming remains an important step in limiting the degree of sea level rise. The United States has a special role to play in leading the development of new technologies and nurturing international cooperation on formulating and implementing policies to reduce carbon dioxide emissions worldwide.

Current realities

While climate scientists agree that sea levels will continue to rise well past the end of the current century, the rate of rise is uncertain. Although the Intergovernmental Panel on Climate Change (IPCC) projects a smooth linear rise in global sea levels, the geological record shows that sea levels historically have risen in rapid pulses interspersed with stable periods, a pattern consistent with the sudden disintegration of large ice sheets. Given that warmed ocean water is now penetrating deeply under the outlet shores and glaciers of Greenland, and the West Antarctic and East Antarctic sheet areas, accelerated melting can be expected, and sea levels may be on the brink of a large pulse. Even if a pulse does not occur, the current rate of rise is doubling every seven years, resulting in a projected rise of approximately 2 feet by 2048 (i.e., slightly longer than a home-mortgage cycle), and 3 feet by 2065. A rise of 6.6 feet by the end of the century can be anticipated.

South Florida has experienced approximately 1 foot of rise since 1930 (an eight-fold increase over the previous 2,000 years) and the effects are observable during normal high tides, when streets and properties in many communities routinely flood. Much of Florida is low-lying, with areas built on porous limestone that renders dikes and levies ineffective by allowing water to percolate through. Although saltwater intrusion into fresh water areas (e.g., in the Everglades of southeast Florida) largely is being prevented by manmade barriers, a sea rise of 8 inches will result in the failure of 65% of water control structures. With 2 feet of rise, southeast Florida will have no fresh water and Miami Beach will be largely uninhabitable. As rising seas cause more water to pond on land, increased mosquito populations are expected, followed by heightened incidence of vector-borne disease.

Although the frequency of flooding events already is causing some Miami Beach residents to move away from the area, coastal communities cannot afford to simply abandon these areas because tax revenues support key infrastructure, as well as provide revenue needed to address the problem. The tourism industry drives development along the coast. Since current state regulations do not restrict building on land that lies below certain elevations, buyers may be unaware that increased flooding and storm-surge destruction are expected, which will cause insurers to withdraw and make properties difficult to impossible to sell.

Although stringent environmental protections are written into the Constitution of the State of Florida, several lawsuits charge that state lawmakers are not enforcing these protections. Given that residents stand to lose property value and rights if environmental provisions are enforced, it is considered unlikely that lawmakers and the public *writ large* will prioritize environmental protection above protection of property.

Despite evidence that regional climate change has been a foundational cause of societal collapse throughout human history, and despite the vast amount of public exposure to climate change arguments over the past 20 years, surveys show that climate change concerns are low on the public's list of priorities, regardless of political party. This attitude is reflected by Florida county governments, which unanimously accepted and then largely ignored the multitude of mitigation and adaptation recommendations found in the Southeast Florida Regional Climate Change Compact (e.g., conservation strategies, documenting how incremental rises in sea level will threaten infrastructure, determining costs of infrastructure upgrades).

Scientific opportunities and challenges

A critical scientific challenge is that scientists cannot predict when sea rises will occur, and whether levels will rise by 4 feet, 6 feet, or 30 feet by the end of the century. Although there is broad consensus on human contributions to global warming, there still is much in climate-change science that is not well understood. By not incorporating accelerated ice melt into their models, the IPCC projected a lower level of sea rise by the end of the century than some believe likely, thereby contributing to public uncertainty, and potentially, to community inaction.

Recent events (e.g., civil conflict in Syria) show that regional climate change is significantly threatening human access to food and water and creating refugees whose migration heightens political tensions. Sea level rise will exacerbate present and future food insecurity by forcing populations to concentrate inland and reducing the amount of available agricultural land. As levels increase, the world's fertile deltas are at risk of disappearing, raising grave concerns for global agriculture. Science and engineering can help preserve delta areas, and also can advise when deltas cannot be saved (e.g., the winning engineering teams at the 2015 Changing Course Design Competition recommended allowing the disintegrating lower Mississippi River Delta to simply become open water, and trapping sediment in an attempt to maintain the upper delta above New Orleans).

Saltwater intrusion into fresh water resources will complicate not just food production and potable water access, but also electricity generation, a significant water consumer. In addition to devising technological solutions to these challenges, scientists and engineers need to identify effective strategies (e.g., water recycling) that guarantee drinking water is sustainably supplied to relocated populations.

Although flooding of low-lying territory is inevitable, Florida does have elevated land, even along the coasts. Accurate elevation mapping technologies that

accurately depict a community's high and low spots are imperative for efficient, effective adaptation planning.

Scientists need to communicate more effectively with policy makers so they can assist in the implementation of adaptation and mitigation measures, in particular the Southeast Florida Regional Climate Change Compact. Although the Compact's recommendations are scientifically based, they may be perceived by county governments as too broad and overwhelming to implement in a meaningful way. Because scientists are trained to think in terms of probability and variance, while policy makers think more concretely, differences in perspective need to be addressed to engender effective communication. Scientists also must find ways to communicate the dangers of short-term fixes (e.g. beach replenishment) that can result in long-term problems (e.g., increased erosion).

Policy issues

Notwithstanding the lower projections of the IPCC, planning for at least a 6.6-foot rise in sea level by the end of the century will enable communities to effectively scale their efforts up or down depending on the actual rate of rise.

Recommendations found in the Southeast Florida Regional Climate Change Compact need to be implemented immediately by all Florida counties. As a first step, counties and local communities need to conduct open and transparent analyses of their infrastructure and the impact (physical and economic) on that infrastructure with each increment of sea level rise. From this information, reasonable sea level thresholds can be established at which infrastructure maintenance would be discontinued, either because of economic losses or safety concerns. Such analyses will make clear where protections need to be hardened, which areas can be saved, and which areas have a limited lifespan and require transition strategies.

A preference for property rights over environmental protection is preventing the implementation of scientifically rational approaches to solving climate issues. While governments have obligations to maintain roads, bridges and drainage systems for private properties, they cannot be required to maintain infrastructure in areas that are constantly under water. Environmental hazards (e.g., coastal dumps and industrial waste sites) need to be resolved by state legislators as required by the Florida constitution.

Given the rate of new construction in Florida, strict regulations are needed regarding location, elevation, infrastructure, and environmental hazards (e.g., the quality of the concrete). Policy is needed concerning minimum elevations for developing infrastructure, and massive development of low-lying areas and barrier islands needs to cease. Because the tourist trade is incentivizing expensive short-

term fixes to coastline infrastructure, commercial communities that rely on tourism must be involved in dialogues about adaptive planning.

Rather than investing heavily in shore and property protection measures, communities need to redirect funds toward helping affected residents relocate from the coast and cleaning up the pollution and storm-damaged infrastructure that is left behind. While immediate forced relocation is not recommended, incremental phases of relocation can facilitate smooth transitions and limit economic losses. Population relocation strategies can be part of economically viable planning, (e.g., after Hurricane Sandy hit the northeast U.S. in 2012, Governors Cuomo [New York] and Christie [New Jersey] tried to buy out landowners at 115% of their properties' worth because it was cheaper to the state in the long run to acquire public land than to incentivize continuous rebuilding of infrastructure).

Because property owners will be deterred from purchasing coastline property if they can't acquire insurance or are faced with unattractive insurance policies, governments need to work with insurance and re-insurance companies to determine the levels of sea level rise at which areas will lose insurance coverage.

While intensive education efforts need to be directed at vulnerable populations, policy makers also can benefit from effective educational outreach, (e.g., touring the effects of sea level rise first-hand rather than attending a briefing). Communities have a responsibility to educate individuals on the dangers of owning property in low-lying coastal areas so that property owners can assume full responsibility for their decisions.

While there is an imperative to respond to local sea level rise, it also is essential to reduce the anthropogenic acceleration of global warming by decreasing carbon dioxide emissions. Although the warmed ocean cannot be quickly cooled and continued ice melt is inevitable, cooling the atmosphere by reducing greenhouse gas emissions ultimately will help cool the ocean and could constrain the degree of rise, in addition to improving other climate-change effects (e.g., storm severity, heat stress). The United States government needs to lead the way in reducing carbon dioxide emissions.

Adapting to Sea Level Rise: the Tension Between Protection and Discontinuous Change**

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Summary

Communities and individuals can spend money and alter their environments to reduce risks they face from sea level rise (SLR) and other climate-driven risks. These actions can be cost-effective in the short-run, but may encourage patterns of development that increase exposure and disruption over longer timeframes. Public policy and expenditure should address the possibility of long-term discontinuous change as part of short-term decision-making. The timing of transition from protection to relocation is a central but unconsidered aspect of adaptation policy.

Current realities

Communities in low-elevation coastal areas are facing a future of escalating risk from flooding and erosion because of SLR and other climate-related phenomena. The current state of scientific knowledge and likely greenhouse gas (GHG) emissions scenarios imply that risks will escalate over a long, but uncertain, period of time and that sometime in the next 75 to 400 years (roughly) many coastal locations are likely to either become extraordinarily risky to live in or altogether uninhabitable. An understandable rational immediate response is how to “climate-proof” communities by protecting key infrastructure and the built environment with improved technology and in-community changes in location. Priority has also been given to preventing new construction in particularly vulnerable areas. For many coastal locations, it is reasonably likely that these strategies will lose relevance on the scale of one century to four centuries if the West Antarctic and/or Greenland ice sheets collapse.

Taking government actions that “climate-proof” key infrastructure and the built environment (e.g., infrastructure elevation, shoreline protection) and those that subsidize investments and activities at risk (e.g., insurance, disaster relief) can also serve to increase exposure to future hazards. The more protected people feel, physically and financially, from the effects of SLR, the more they will build and invest in coastal areas. The greater the amount of physical capital to protect, the higher the incentives to continue to protect that investment — creating a cycle that

can increase the number of people and value of property at risk if and when risks become significantly larger.

Two opposite and extreme responses are useful to frame the complex choices facing communities. The first is to stop investing in coastal infrastructure and risk reduction, and to encourage residents to abandon coastal locations as quickly as is feasible. This is both irrational and unlikely to occur. Even the most pessimistic projections about SLR and storms leave many years until the great majority of the Atlantic and Gulf coasts become uninhabitable. It would be economically wasteful and socially disruptive to abandon the high levels of physical and social capital that exist in these coastal areas in the short run.

The opposite response is to commit to protecting communities in their current locations, and to maintain transportation and other key infrastructure regardless of what happens in the future. This is both an unrealistic and a dangerous strategy because it risks using vast resources and encouraging unsafe choices when SLR and storm regimes will eventually destroy the built environment.

How to navigate the continuum between these two choices is the essence of adaptation. The question of “what should be done?” cannot be separated from the equally relevant question of “when?” For example, when should property be protected by public policy and expenditure, and when should it be allowed to sink or swim on its own? When should people and businesses live with and try to mitigate risk, and when should they leave for safer locations?

Adaptive responses can be grouped into three categories: 1) making minimal changes and hoping for the best, 2) investments that “climate proof” communities — reducing risk to make it possible to stay in place longer and more safely, and 3) discontinuous change — relocation or drastic change to the built environment. A key fact is that crucial choices will be made both by autonomous actors (e.g., individuals, businesses, universities) and by multiple levels of government, and it is the interaction of those choices that will determine adaptive actions.

While individual and policy decisions are made in multiple contexts, many key decisions about adaptive response are made following dramatic climate events like hurricanes, floods, or disruptive erosion. That is because these events dramatically alter the benefit/cost calculation for property owners — the costs of the *status quo* become discontinuously larger because of the costs of rebuilding and repair, while the benefits of remaining in place stay the same (or possibly diminish if people reassess their view of hazard risk following these events).

Scientific opportunities and challenges

The wide variety of uncertainties, loci of decision-making, and policies make

adaptation to SLR a “wicked problem” — a situation that “defies all-encompassing, definitive, and final solutions; instead, temporary best solutions will have to be sought in the context of an iterative, deliberately learning-oriented risk management framework” (Moser et. al. 2012). At the heart of all this is the fact that fundamental decisions (e.g., whether to stay or go, whether or what housing to build) are made by large numbers of heterogeneous individuals with value systems, scientific assessments, and perceived incentives that are only partially predictable.

There is very significant uncertainty about the relationship between time and risk — rates of SLR are both uncertain and endogenous because they depend on future anthropogenic GHG emissions. In addition, the frequency and magnitude of discrete events that will drive timing of behavioral change (e.g., hurricanes) is also stochastic. What people *believe* about SLR and risk is also highly diverse. There is clearly a payoff to science that reduces uncertainty about the constituent components of this “wickedness” — the rate and consequences of SLR, changes in the storminess regime, resolution of uncertainty about the ability of technology to mitigate risk. There is also value in knowing how specific policies will affect behavior (e.g., insurance products for adverse climate outcomes and disaster assistance policies).

The ability of technology to reduce and manage risk is highly uncertain and significant disagreement exists among experts on its role. For example, many engineers believe that shoreline engineering is effective and efficient at protecting property, while many geologists believe that it is costly, ultimately ineffective, and risks unintended consequences in other locations. Technological advances in protection engineering and “climate-proofing” infrastructure and housing generally increase costs and reduce risk to the existing environment, but may increase risk by encouraging more building. Alternatively, these circumstances may call for technology that reduces risk by adding flexibility and/or reducing financial exposure (e.g., building housing that can be moved at relatively low cost when risks at existing locations become great).

There is also significant value in research that integrates the climatic, physical, policy, and behavioral factors, not because such models can predict what will or should happen, but because they can at least let us explore how complex interactions can produce surprising and even novel results.

A key question in understanding the tradeoffs in short-term protection versus long-term relocation is in specifying how individuals and communities value “place.” If people perceive a relatively low value of living in their current location, then a quicker transition with less additional investment will become relatively attractive. If people have very strong preferences to remain in a particular location, then they will have more tolerance for risk and will tend to spend more on protection and

stay longer. If it is the community and not the location that matters, then a relevant issue becomes the ability of large parts of a community to relocate together.

Policy issues

- Amend FEMA programs to make progress on the “age-old” issue of moral hazard in emergency response policy by not providing post-disaster aid that reduces incentives to take *ex ante* precautions.
- Make both pre- and post-disaster assistance more neutral with respect to returning to the *status quo*. The natural tendency to rebuild, and to rebuild stronger and more resiliently, motivates public discourse, and some FEMA programs are focused on rebuilding. However, in many circumstances, the least costly time to consider relocation is after a disaster. Disaster assistance should at least be neutral in terms of whether resources are used to rebuild or to relocate to areas with significantly lower risk.
- Have FEMA (flood insurance) and states (publicly managed wind pools) base insurance rates on the best assessment of prospective risk and update rates regularly to reflect new information.
- Providing compensation to people disproportionately affected by SLR is likely to be a key aspect of future policies as risks escalate. Payments, subsidies, tax breaks, etc. can skew the protection versus relocation decisions (e.g., subsidizing the elevation of low-lying structures). Finding ways to make compensation more neutral with respect to how it helps people adapt (e.g., increasing employment skills, providing cash transfers in place of specific subsidies and expenditures, not tying compensation to subsidizing specific protective measures) can provide clearer and better signals to guide residents’ choices.
- Be mindful of the tension between policy consistency and flexibility in decisions about protecting infrastructure. Setting clear expectations about what public policy will and won’t do in response to climate-driven hazards is, all else being equal, the way to provide efficient incentives and information for individual decisions. However, the countervailing policy dynamic is the need for adaptive management — the ability to change course and alter policy as new scientific information and technologies alter the nature and consequences of available choices. For example, a commitment to shoreline protection could become a very poor policy if climatic drivers of erosion accelerate more rapidly than expected. Such decisions could be tied to an observable variable whose value reflects

the outcome of uncertain processes (e.g., a number of inches of sea level rise, a particular observed erosion regime). This is a promising technical solution, which is problematic because there is no political certainty that it will be followed.

These policy recommendations have been unavoidably nonspecific for a fundamental reason — the wickedness of SLR adaptation makes assessing any individual policy problematic. It is the combination of policies across multiple areas, combined with unpredictable climatic, technological, economic, and behavioral developments that will determine how successfully communities adapt to rising seas. The best advice is to learn as much as possible, remain flexible, and always keep one eye on higher ground.

References

Moser, S. C., Jeffress Williams, S., & Boesch, D. F. (2012). Wicked challenges at land's end: Managing coastal vulnerability under climate change. *Annual Review of Environment and Resources*, 37, 51-78.

***A policy position paper prepared for presentation at the conference Sea Level Rise: What's Our Next Move? convened by the Institute on Science for Global Policy (ISGP), on October 2–3, 2015 at St. Petersburg College, St. Petersburg, Florida, U.S.*

Debate Summary

The following summary is based on the transcriptions of recordings made by the ISGP staff during the debate of the policy position paper prepared by Dr. Andrew Keeler (see above). Dr. Keeler initiated the debate with a 5-minute summary of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute debate period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Keeler. Although this summary has been written without attribution, the conference itself was open to the public and media and as such, did not restrict participants from attributing remarks to specific individuals. The views comprising this summary do not necessarily represent the views of Dr. Keeler, as evidenced by his policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate conclusions

- The uncertainties surrounding models that forecast the rate of sea level rise, coupled with public concerns over the economic practicality of policy choices, have hampered the development of long-range adaptation/mitigation decisions designed to proactively address anticipated impacts of climate change. Efforts to protect coastal properties from sea level rise can strengthen economic sustainability of at-risk areas, even when their costs exceed immediate economic returns. Mitigation/adaptation policies need to support longer-term economic considerations (e.g., nurturing economic development, sustaining infrastructure, controlling flood insurance rates, ensuring disaster assistance commitments), including encouraging zoning and rebuilding policies that incentivize citizens to abandon endangered shore property.
- Currently, taxpayers *writ large* insulate high-value coastal properties from the realistic costs associated with a changing climate through governmental subsidies of property/flood insurance, shore-protection measures, and commitments for post-disaster relief. Policies are needed that transfer the realistic financial burden of coastal living, both now and in anticipation of rising sea levels, to those individuals owning these properties. Increased taxes for coastal properties need to be accompanied by policies ensuring that the risk of sea level rise be fully disclosed in all real estate transactions and that buyers acknowledge their future economic responsibilities when acquiring the property.
- The financial impact of sea level rise can be expected to disproportionately affect low-income communities in at-risk areas since more affluent and/or commercial property owners often self-insure against all losses. Community governments, as well as faith-based and advocacy groups, need to develop disaster response policies that compensate for these economic disparities by assisting those losing the total value of a property and/or facing forced relocation. These strategies need to equitably apply to a wide range of natural disasters (e.g., rising sea levels and severe storms) while maintaining a realistic tax base and key services throughout the community.
- Since sea level rise is a global phenomenon having significance for international policies, wealthier nations have responsibilities to (i) lead the formulation of mitigation/adaptation strategic policies (e.g., population relocation protocols, governmental agreements on

exchange of information) and (ii) promote and fund the development of the technologies needed to implement effective policies (e.g., disease surveillance and control methodologies, adaptive building techniques, coastal protective measures). The United States has a special responsibility to develop and evaluate policy strategies and technologies for the benefit of not only its own citizens, but also to benefit citizens worldwide.

- As scientists, engineers, and technologists pursue the innovative instrumentation and mechanisms needed to proactively respond to sea level rise (e.g., establishing natural and/or man-made environmental barriers to reduce the impact of sea levels and storm surges), these same individuals also need to address public concerns over the validity of climate change predictions as they pertain to the personal decisions in the daily lives of all citizens. These concerns underpin public hesitation to support climate mitigation/adaptation policies, and its reluctance to use new technologies directly affecting their individual lifestyles. If mitigation/adaptation polices and emerging technologies are to directly influence a citizen's lifestyle choices, public confidence in the personal significance of scientifically credible research and its modeling predictions describing on the impact of climate issues must be greatly increased beyond current levels.

Current realities

Although predictions vary, significant sea level rise is expected over the next 50-250 years, intensifying the risk of coastal living and rendering certain locations uninhabitable. As estuarine shorelines are affected by sea level rise, transitional areas such as wetlands will disappear in many areas. Even if greenhouse gases emissions were to stop immediately, ice sheets will continue to melt well into the future because of the heat stored in the oceans. In responding to this inevitable, although inconsistent, climate phenomenon, communities typically undertake three strategies: (i) Do nothing, (ii) protect coastal developments, infrastructure and shorelines, and (iii) move away from affected areas. Navigating wisely among these three strategies is considered the essence of adaptation.

Although most communities have done nothing up to now, changing conditions are making this option untenable. While the protection of coastal properties already is occurring in some places, it is having the undesired effect of strengthening economic commitment to development in vulnerable areas. Nonetheless, such strategies are likely to be utilized until the costs of protection

outweigh the benefits (e.g., the cost of importing sand outweighs the economic value of beach replenishment), at which point affected areas finally will be vacated.

Although an immediate paradigm shift from disaster relief to proactive approaches with short- and long-term strategies is needed, such a move is currently unsupported by policies, incentives, or sanctions that diminish the attraction of shore living. Instead, owners of high-value coastal properties are insulated from the true costs of risk by insurance subsidies, local and federal incentives, taxpayer-funded shore protection measures, and post-disaster relief. In addition, some wealthy and commercial property owners find it more economical to opt out of paying for wind and flood insurance altogether and to take a financial loss (which may be tax-deductible) in a disaster. Nonetheless, a key time for encouraging policy makers to consider a shift in priorities has been found to be immediately following storm and flood events.

While mitigation and adaptation strategies currently exist, primarily at the national level, they often are not implemented due to a variety of roadblocks (e.g., lack of funds, lack of political support, political corruption). Although the two-year and four-year election cycles contribute to the unwillingness of elected officials to make long-term decisions, the larger problem continues to be the inability of society to decide what to embrace or reject in terms of strategy and technology.

Scientific opportunities and challenges

Although the scale of need at the international level goes beyond what individual citizens feel empowered to address, the United States has the resources to address the problem of coastal sea level rise nationally, and to develop and test relocation strategies and adaptive technologies (e.g., for managing disease outbreaks in warming climates, building mobile shelters, or protecting coastlines). While such developments can benefit vulnerable American communities (e.g. Tampa, Florida), they also can provide valuable assistance internationally.

Although disaster planning is necessary to respond effectively to the immediate impacts of severe weather, to ensure long-term resiliency communities need to engage in proactive planning. While scientific opportunities exist in helping communities maintain environmental buffers and other ecosystem services, scientists first need to confront the challenge of educating communities concerning the necessity of immediate planning despite the uncertain rate of sea level rise.

Since planning requires identifying which of a vulnerable area's key infrastructures should be maintained and for how long, scientific opportunities also exist in helping communities prioritize the maintenance of individual private properties and the protection of key infrastructure, and in identifying locally relevant

benchmarks that signal the need to relocate populations away from the coast.

Concurrent with this challenge is the social-science challenge of ensuring equitable relocation, compensation for and prevention of the loss of cultural and social capital, especially for disadvantaged communities. Novel solutions for relocation are imperative, with the goal of ensuring vulnerable communities, and the local economy as a whole, can adapt to dramatic changes in coastal usage.

Policy Issues

Since sea level rise is an international challenge, it is the responsibility of wealthy nations to lead the way in the development of mitigation and adaptation strategies (e.g., population relocation, disease control, adaptive building, coastal protective measures), and to ensure that communities in need are connected with such resources.

In the United States, post-disaster protocols need to be reformed so they enable citizens to make better adaptive decisions both immediately and for the long term. While government aid (e.g., through the Federal Emergency Management Agency) needs to continue providing post-disaster relief (e.g., shelter, water, food, and other care), such funds should not support projects that encourage living in vulnerable areas (e.g., flood proofing, assistance with rebuilding). It is questioned whether government should continue providing coastal services that aid property owners and real estate investors, since such services incentivize private investment in at-risk areas, at taxpayer expense.

Since gradual nonemergency relocation is preferable to a sudden relocation caused by a disaster, policy makers need to begin considering relocation as a viable option and to build it into planning (e.g., zoning laws) so as to encourage population movement away from the shore. Because migration will raise the price of inland real estate, it is likely that inland counties will welcome coastal residents who raise property values. However, to avoid losing residents and tax revenue, policy makers must create a transitional economy that strengthens key infrastructure, so job centers and limited residential structures are connected through transportation.

Real estate and local businesses are considered driving forces for community change and are expected to have a strong voice in determining implementation of adaptive strategies. Although real estate transactions already have risk-disclosure requirements, information needs to be included about sea level rise and storm surge risk. Property owners need to be required to formally sign that they understand the ramifications of building or living on at-risk coastal property. Because hidden property subsidies (e.g., beach replenishment) pose an enormous economic challenge to communities and states, changes are needed that either raise additional funds

(e.g., amending tax law to treat coastal properties differently) or transfer financial responsibility to coastal property owners (e.g., costs of beach repair or hardening of infrastructure).

Since economically disadvantaged communities tend to be heavily impacted by environmental disasters, such populations have a greater risk than wealthier citizens of being displaced by rising seas and rising costs (e.g., rebuilding, insurance), thereby losing the value of their properties. A mechanism is needed to allocate proper compensation to displaced low-income citizens, perhaps through faith-based and nonprofit social service agencies. If such agencies are to play a larger role in compensation efforts, they need to be included now in planning discussions.

Given that mitigating and adapting to sea level rise will require a gradual series of changes, it would be most effective for communities to create plans that identify specific actions that are triggered by specific observed increases in sea level. However, such long-range planning relies on the cooperation of future politicians and voters in implementing these actions, and historically this has not always occurred. Therefore, it is vital for citizenry and economic interests to focus on medium-term adaptive planning, in which the impacts of changing climate are considered in economic development, local infrastructure (e.g., transportation systems), flood/wind insurance, and disaster assistance plans.

In addition to developing mitigation and adaptation policies, there is a need to address the human-caused conditions that contribute to climate change. While adaptation policies are considered primarily the responsibility of state and local governments, reduction of greenhouse gases is considered a federal responsibility. Although national climate policies are needed (e.g., to reduce greenhouse gases, burn fewer fossil fuels, reduce deforestation), a large challenge to enacting these policies is the reluctance of nations to be the first to act without the assurance that other nations will enact similar policies.

To encourage environmental resiliency, changes are needed in the national taxation system (e.g., taxing carbon emissions, cap-and-trade scenarios, taxing activities that pollute air, land or water). In addition to regulations, and penalties, government action needs to include incentives that reward socially desirable behavior (e.g., a combination of regulation and compensation that incentivizes the development of coastal wetlands).

Shoreline Adaptation Land Trusts: A Concept for Rising Sea Level**

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Summary

Rising sea level is now unstoppable despite the important work to reduce greenhouse gas (GHG) emissions, and the international goals to limit “global warming.” Regardless of those efforts, we must begin adapting to a new era that will feature a substantially higher ocean, with many shorelines moving markedly inland. Financial and tax policies could be an efficient tool for the transition into this new era with multiple meters of sea level rise (SLR). A special purpose entity is hereby proposed, the *Shoreline Adaptation Land Trust* (SALT). SALTs could provide vehicles to facilitate the vast adjustments that catastrophic coastline changes will necessitate.

Current realities

For context, three erroneous concepts need to be clarified: 1) confusion of SLR with storms, extreme tides, other types of flooding, or beach erosion, 2) the idea that it is possible to stop SLR by slowing global warming through GHG reduction or implementing other sustainable behaviors (e.g. conservation, recycling), and 3) a belief that the worst possible sea level this century is 3 feet, or even 6 feet above present. Each of these concepts will be addressed in turn.

Coastal flooding can occur for a variety of reasons that are often confused, but have totally unrelated magnitudes, locations, and timescales. Storm surge, extreme high tides, heavy rainfall, downstream flooding, land subsidence, coastal erosion, and SLR all are different. Tsunamis, caused by seismic activity, would be yet another type and cause. Characteristics such as predictability, relative vertical change, and permanence are quite different for each flood type and need to be understood to have effective policy that is both *resilient* and *adaptive* — two terms that are often interchanged, but here are used with important distinction. *Resiliency* connotes recovering to the pre-event condition, whereas *adaptation* is changing to accommodate a new state of normalcy or stability. Storms, extreme high tides (“king tides”), heavy rainfall, and downstream flooding are familiar events that quickly recede, making it possible to recover and rebuild. They are appropriate to think of in terms of *resiliency*. Beach erosion is different from flooding, being caused either

by storm action, routine ocean currents, or the effect of interrupted sand movement along the shore (as happens with construction of groins or waterway inlets). Such erosion is not actually flooding, though rising sea level and erosion can each increase the effects of the other.

Sea level rises for entirely different reasons. Mostly it is the melting of glaciers and ice sheets on land, plus the thermal expansion of seawater as the ocean warms. As the Earth's average temperature changes over centuries, these forces move sea level up or down by astonishing heights, even hundreds of feet. It is worth noting that contrary to popular belief, sea level does not change because of the melting of *floating ice*, whether in the form of icebergs, the solid polar ice cap around the North Pole, or the fringing sea ice around the island-continent of Antarctica.

All forms of flooding are *additive*. For example, a severe storm will reach greater height and move further inland if it hits at an unusually high tide. Over time, all of those temporary events will be lifted even higher as the base sea level moves upward. SLR and land subsidence are special as the effects will not be reversed for centuries or millennia and therefore should be considered *permanent flooding* or inundation. As the planet warms, melting the great ice sheets and glaciers, we need to recognize this as lasting change to ocean height, which will inexorably work to reshape all the continents. That requires *adapting* to a new normal: an ocean that will rise higher unstoppably, which brings us to the second point of confusion.

Average global temperature has already risen approximately 0.85 °C (nearly 1.5 °F) over preindustrial levels. Current international efforts are striving to set a goal to keep the average global temperature from rising no more than 2 °C over preindustrial levels, primarily by reducing carbon emissions. Yet, from geologic history we know that when ice sheets and glaciers have fully adjusted to temperature changes over centuries, the sea level changes by roughly 20 meters per degree C of average global temperature, or about 35 feet per degree F (Archer & Brovkin, 2008). Thus, even the present elevated ocean temperature means that rising sea level is now unstopable, even with 100% conversion to sustainable, noncarbon-based energy — a point made in the 2015 high-profile paper “Ice melt, sea level rise and superstorms” by Dr. James Hansen et al.

Our ignorance about SLR stems from the fact that it has hardly changed in the last 5,000 years, roughly the span of our civilization's written history. Yet, geologically it is clear that sea level varies in a rather regular pattern — roughly on a 100,000-year natural cycle following the “ice ages” (see below graph spanning 400,000 years). That pattern has been repeating for several million years. Sea level moved up and down 300 to 400 feet with each ice age cycle as global temperature changes by 5 degrees C (9 degrees F). For example 120,000 years ago, sea level was

25 feet higher than present. Now, the truly extraordinary level of carbon dioxide (CO₂) a potent GHG, has triggered a “super warming” phase, putting us on path back towards that previous high-water mark.

Considering the unstoppable aspect of rising sea level and the scale of what lies ahead, many current policies are not sustainable financially. Examples include subsidies to the National Flood Insurance Program, using Federal Emergency Management Agency (FEMA) funds for to protect buildings that are in flood zones, approval of new projects in vulnerable zones, or the concept of “buying out” homeowners from their coastal properties at prestorm values, as was done after Hurricane Sandy in New York. With more frequent flooding events and the increasing awareness of unavoidable submergence, property values will likely start to “go under” before the land actually does. Long before the water rises, we need to chart a course for better public policy recognizing the new reality. Delay will only make things worse for establishing expectations.

Scientific opportunities and challenges

To address the third point of confusion presented in this paper, SLR will be more severe than most people realize. Due to scientific protocol, most numerical projections leave out the largest potential cause of higher sea level — the melting of the West Antarctic glaciers. For example, the authoritative 2013 United Nations Intergovernmental Panel on Climate Change (UN-IPCC) points to as much as 3 feet of SLR by the year 2100, but omits the 10 feet of potential SLR from just the most unstable glaciers (Bamber, *et al.*, 2009) on the basis that it cannot be precisely quantified with probabilities. That inability to quantify does not mean that the risk is not real. We simply cannot predict collapse points for the miles of ice. Also, the wishful idea of a technology “fix” for sea level ignores some basic laws of physics.

One scientific opportunity is to better refine the measurements of melting ice in Greenland and Antarctica. Such research is now one of the highest priorities for the National Science Foundation (NSF), which should improve the models. Nonetheless there are severe limits to what modeling can achieve. Real modeling of *tipping points* (i.e., a *nonlinearity*, or *discontinuity*) generally requires a large data set of measured-samples, or the ability to put the system in a laboratory for test and measurement under controlled variables, something not possible with the Greenland or Antarctica ice sheets. We must recognize that SLR will very likely exceed the projections, due to the uncertainties that cannot be programmed into models. Our challenge is to find ways to facilitate the adaptation that is now inevitable, even if the precise rate of rise is unknowable. Shifting the focus to economics could be one pragmatic path towards adaptation. While real estate write-offs, relocations,

and business interruptions will be valued in the trillions of dollars, there will also be opportunities.

Policy issues

As sea level rises, the options to avoid going underwater are to *elevate, isolate, or relocate*. Isolate often means levees (as used in New Orleans and the Netherlands), though that approach will not work in areas with a porous structure (e.g., much of south Florida, coral-based islands). In limited areas it will be possible to elevate vulnerable land and defend against temporary storm surges. Where that is not feasible, there exists a need for strategic relocation. A Shoreline Adaptation Land Trust (SALT) is one concept that warrants consideration. In brief:

- A SALT is a nonprofit public land trust established *pro bono* for any defined area, (e.g., state, county, community, or in the case of island nations, perhaps the entire country). It follows a well-established concept of conservation land trusts (landtrustalliance.org).
- The purpose is to get property into the public sector in anticipation of its submergence.
- Private and commercial property owners will be encouraged to donate coastal real estate that is vulnerable to erosion and sea level rise, per criteria that may be adjusted.
- The owner would be allowed to continue full use for his/her lifetime, subject only to the progress of SLR and other intermittent flooding.
- The immediate benefit to the donor would be to terminate property taxes.
- A second benefit would be a tax-deductible gift donation for the value of the property, including the land, buildings and infrastructure. To encourage early participation, the percentage of deductibility would decline 2% every year from the inception of the SALT (e.g., 30 years from inception the rate would be 60% less).
- As a further benefit of donating the land to the SALT, there could be a variance to allow certain extraordinary measures to shore up the property from erosion for a limited number of years, suggested to be no more than 30 years from the SALT inception.
- At such time as the relevant jurisdiction declares the property to be uninhabitable, the SALT will endeavor to remove any built structures and remediate environmental damage, recognizing that the property will eventually be part of the marine environment.

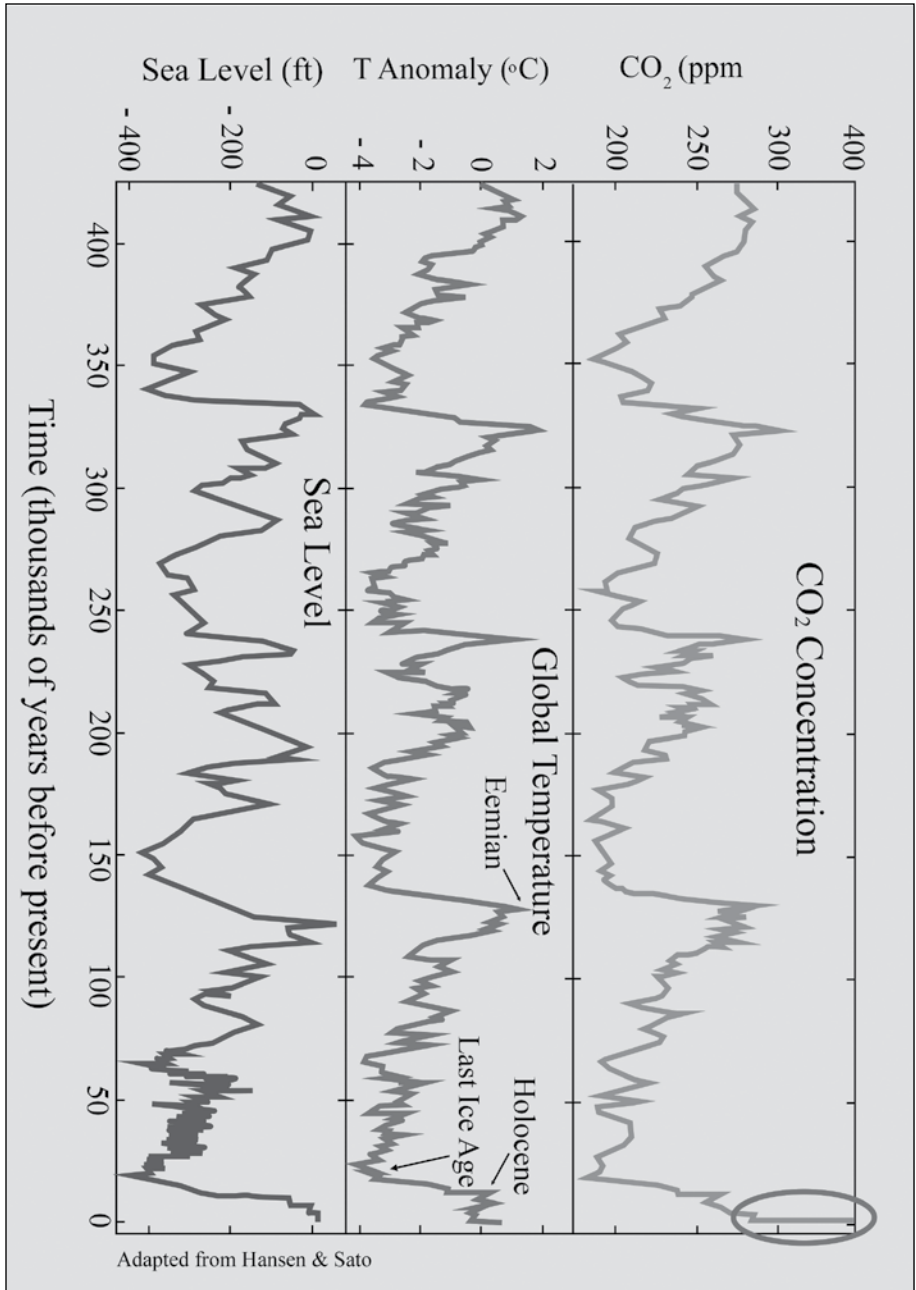
- As a means of developing further value and working capital, the SALT could rent out properties it acquires, after the donating owner dies or abandons the property.
- In addition to such rental income, the SALT could get working capital from the government to facilitate an orderly transition inland. Also, there could be deductible charitable donations from the public, philanthropic and civic organizations.
- The concept and establishment of SALTs could be accomplished at any level of government, though the tax benefits would likely require federal and state legislation.
- Having an actual SALT would be extremely helpful as a model. Accordingly some vulnerable and progressive jurisdiction should be solicited as a prototype. The UN might be a forum to recommend the concept for adaptation internationally.

Strategic Adaptation Land Trusts could be a useful tool and catalyst for this unprecedented transition upwards and inland. We can rise with the tide — if we anticipate it in time.

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****A policy position paper prepared for presentation at the conference 'Sea Level Rise: What's Our Next Move?' convened by the Institute on Science for Global Policy (ISGP), on October 2-3, 2015 at St. Petersburg College, St. Petersburg, Florida, U.S.**



Adapted from Hansen & Sato
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Debate Summary

The following summary is based on the transcriptions of recordings made by the ISGP staff during the debate of the policy position paper prepared by Mr. John Englander (see above). Mr. Englander initiated the debate with a 5-minute summary of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute debate period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Mr. Englander. Although this summary has been written without attribution, the conference itself was open to the public and media and as such, did not restrict participants from attributing remarks to specific individuals. The views comprising this summary do not necessarily represent the views of Mr. Englander, as evidenced by his policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate conclusions

- As sea levels rise, private to public land transfer has been identified as a strategy for the sustainable management of vulnerable shorelines. Land trust programs that encourage residents to donate their land (e.g., the Shoreline Adaptation Land Trust, or SALT) can enable land restoration and enhance shoreline resiliency. However, to be accepted by communities and individual residents, participation in land trusts must be voluntary and demonstrate a clear benefit to the public (e.g., enhanced resiliency, public recreation space). Appropriate incentives (e.g., property tax reductions) need to be identified to induce coastal property owners to donate their land to the trust.
- Given that sea level rise inevitably will cause communities to lose property tax revenue with or without the creation of a land trust vehicle, communities need to immediately begin long-term planning to develop other sources of tax revenue for the continued support of vital services (e.g., utilities, roads, education) that currently rely on property taxes. Planning can include introducing a land trust program first in lower-income, inland areas that experience frequent flooding. Alternatively, there may be advantages to phasing in such program together with reductions

in property taxes over time. Such measures slow the loss of property tax income, provide a mechanism to assist in a staged migration from affected areas, and allow time to develop alternative sources of public revenue.

- Although the degree of sea level rise is difficult to quantify, to successfully implement a land-trust approach or other adaptive strategy requires increased public awareness. Education programs must be widely disseminated that address the causes and effects of sea level rise as well as viable adaptation options.
- To decrease the economic impact of sea level rise on municipalities, especially low-income communities, federal and state financial support is needed (e.g., reimbursement of lost property tax revenue). Because vulnerable communities ultimately will need to be relocated from affected areas, local, state and federal governments need to cooperate on relocation planning and ensure that the costs of retreat from high-risk areas do not disproportionately affect the less affluent.

Current realities

Although the reality of sea level rise is no longer in question, the rate of rise cannot be predicted because there is no mechanism to measure the collapse rate of the Antarctic glaciers. Sea levels may rise between 3 or 13 feet this century. However, it can be stated with scientific certainty that (i) the Earth's land temperature has risen 1.5 degrees Celsius in the past 250 years, (ii) ice sheets are melting, (iii) Antarctic underwater glaciers are eroding, (iv) sea levels are rising, and (v) shorelines are moving. It is recognized that the glacier melt in Greenland has quadrupled in speed relative to earlier measures, and the rate is now doubling every seven years. Although sea level rise does not pose the acute and immediate threat that a severe storm does, it intensifies the impact of storms on coastal areas, and increases erosion and extreme high tides. The trend of rising seas cannot be quickly reversed because of the amount of heat currently stored in the oceans.

Because sea level rise is relatively unknown in recorded human history, people have difficulty in accepting that it is happening. The last time sea levels were higher than today was 120,000 years ago, when levels were 25 feet higher. Sea levels move up and down 400 feet approximately every 100,000 years. The peak of the last ice age occurred 20,000 years ago and the ice from that period has melted over the course of 15,000 years to reach the present level about 5,000 years ago.

Planning for adaptive mechanisms is imperative to coastal community survival. Although it is certain that the current shoreline ultimately will be uninhabitable,

condominiums and homes are being built on coastlines without consideration of the shore's future. Large developments, buildings, and associated infrastructures increase the difficulty of restoration when low-lying coastal areas become inundated. Additionally, many territories have begun restricting the establishment of bulkheads and seawalls that stabilize the shoreline because they have the unintended consequence of increased coastal erosion. Although it is often assumed that high-value waterfront properties face the most risk, affected areas also may be relatively less affluent and inland because water can be directed inland during flooding events.

It is not financially feasible for the federal government to buy all coastal assets at face value. While the federal government has a land exchange program, it is not currently focused on coastline restoration. If an individual owns land in an area where the government desires property, the homeowner can trade for property in another area. Chester River, Maryland, is an example of a successful land trust format that created conservation easements as the government acquired development rights in exchange for tax relief. The key to the success of these programs is that they offered a broad community benefit beyond the benefit provided to individual property owners.

Currently, the topics of sea level rise and climate change are not well addressed in the public education system. In some part of the United States, educators are not allowed to even discuss these topics. In addition, there is a pattern of sudden public interest in the topic followed by public apathy once an immediate threat has passed (e.g., storms, extreme high tides). While sea level rise is likely to inflict significant economic losses, it also is creating opportunities. For example, the largest industries of the second half of the century are predicted to be focused on adapting to sea level rise.

Scientific opportunities and challenges

A critical scientific challenge to adapting to sea level rise is the uncertainty surrounding the rate of glacier collapse. As Antarctica and Greenland melt, an additional challenge is that sea levels will not rise equally everywhere. Rather than leveling out like a swimming pool, levels will vary according to location, with higher levels found where the mass of the Earth is denser. SLR challenges are compounded by land subsidence and uplifting (e.g., Alaska is uplifting, New Orleans is subsiding).

Given that sea levels will continue to rise, even if fossil fuel emissions ceased immediately, because of the heat stored in the oceans, technology need to address mitigation to and, more importantly, resiliency from sea level rise. Scientific opportunities exist in adaptive technology, engineering strategies, and architectural designs for structures that can be easily disassembled and moved when sea levels

get too high. Wetlands, mitigation areas, buffer zones and horizontal levies need to be part of the gradual transition of high-risk areas over the next 30 to 50 years. Although the relatively slow pace of sea rise allows time for gradual adaptation, the ongoing threat of storms also calls for urgent adaptation. Designing resiliency technology at the right height of sea level rise is important, as has been shown by costly large-scale projects (e.g., Venice, the Netherlands) that planned for only a 1-foot rise, which is not enough for future effectiveness.

Concern was raised about the impact of sea level rise on food-producing acreage, manufacturing spaces, and transportation. Salt-water intrusion affects the fresh water table, and thus will have an impact on agriculture. Desalination is an option, but does not come free of its own complications. As the land area shrinks and human population increases, viable agricultural land will be lost. Opportunities exist to develop adaptive agricultural strategies to offset such losses (e.g., by using or creating halophytes, which are plants capable of thriving in brackish environments).

The development of adaptive technologies is impeded by governmental policies that discourage discussion of sea level rise and climate change, such as is occurring in Florida. Science education is essential to public acceptance of adaptation measures. However, clear articulation of scientific information poses another challenge to the scientific community. For example, because the scientific community cannot quantify when the glaciers in Antarctica will collapse, the latest International Panel on Climate Change (IPCC) did not include uncertainty factors in predications of sea level rise, and only readers that searched the fine print were made aware of this important exclusion.

Policy issues

Given the present and predicted rate of sea level rise, both shoreline resiliency (i.e., immediate protection measures) and restoration (i.e., long-term adaptation measures) need simultaneous investment by affected communities.

SALT, a land-trust program, is a vehicle designed to facilitate sea level rise adaptation by incentivizing homeowners to voluntarily donate their property to a trust while still maintaining access and use of the property for a stated period of time (e.g., homeowner lifespan, the length of the mortgage), and receiving a charitable write-off as if the property were being put into a conservation land trust. A primary incentive for property owners to participate in a land trust is exemption from some or all property taxes; additional incentives could include exemption from restrictions preventing shoreline stabilization (e.g., seawalls) for the length of time they live there.

It was emphasized that the key to public acceptance of a land-trust program is the assurance of broad community benefits from the exchange. Three possible

public benefits were cited: (i) reduced beach renourishment and infrastructure expenditures (which also encourages relocation of other residents in high-risk areas by increasing their direct economic risk); (ii) enhanced public rights to use the donated property while the donor is still living there (e.g., access to beaches); and (iii) once the donor vacates the structure, the ability to oversee demolition so as to avoid the severe environmental damage that takes place when abandoned structures wash into the sea.

A strong point of contention with SALT or other land-trust vehicles is that they shift the cost from the private landowner to the public, which ends up paying three times: (i) to acquire the property at its present-day value through tax relief and other incentives; (ii) to demolish and remove structures on the property and restore the lands; and (iii) to provide public services to untaxed homeowners for as long as they live there. Although it was acknowledged that there is no way to avoid lost revenue and restoration costs associated with rising seas, the danger in SALT is that the more affluent will benefit and the less affluent will pay for the government services. It was suggested that properties under the value of \$100,000 receive different treatment than more expensive properties in order to prevent the less wealthy from bearing the brunt of the costs. Because reducing or eliminating property taxes on beachfront properties valued in the millions of dollars would have a severe impact on a community's tax base, SALT could work better if it is first implemented inland on less-expensive properties in low-lying areas that routinely flood. It was suggested that a demolition fund be integrated into SALT, funded by a progressive property tax, that will address the environmental liability left behind when owners finally leave their houses and other structures. It also was proposed that property taxes be slowly reduced for donated properties, rather than all at once. For example, if a homeowner stipulates that the property will go to the state 10 years after it is donated, the owner initially could receive a 30% reduction in property taxes, with larger reductions phased in over time. In such manner, the revenue from property taxes will not be lost as abruptly, allowing time for the development of alternate revenue sources to fund public services.

Federal, state and municipal governments need to cooperate to develop, implement and fund adaptive vehicles such as SALT. One possible source of help is the federal Coastal Zone Management Act, a decades-old program that encourages the management of coastal areas and provides grants to be used in coastal maintenance. Such legislation could be adapted to address the requirements of the current situation in local municipalities.

As an alternative to setting up a land trust program, governments may refrain from artificially intervening in coastal relocation, allow coastal property values

to bottom out naturally, and instead direct new investment to appropriate areas that reflect the least risk. Whether SALT is implemented, mechanisms need to be established to aid vulnerable coastal communities in migrating. It was urged that rebuilding policies be reconsidered, and suggested that below certain elevations restrictions be imposed, such as only allowing the construction of easily removable structures.

The first step to implementing effective adaptation strategies is education, and the second is public acceptance. Regardless whether SALT or some other adaptive strategy is employed, policies to establish education programs to raise awareness of adaptive strategies and the implications of sea level rise need to be adopted. The challenge of raising public awareness is that the population that denies sea level rise and climate change generally does not engage in education campaigns. Meetings and materials to educate the public generally attract the population that already accepts the science. However, it was countered that there are ways to communicate the realities of sea level rise that minimize controversy, such as the agreed-upon fact that ice melts at 32 °F regardless of political party. Policy makers were encouraged to communicate four points to help increase public engagement on the issue: (i) the Earth is demonstrably warmer, (ii) warmer temperatures cause ice to melt, (iii) melted land ice causes sea levels to rise, and (iv) rising waters cause the shoreline to move inland. The logistics of a land exchange trust need to be communicated widely through public relations and/or marketing campaigns. It was emphasized that if state and federal legislators won't move forward, it is up to the citizens, municipalities, cities, and counties to move forward. Education is a means of informing the next generation of developers, policy makers, and citizens and thus a means of encouraging informed engagement.

Acknowledgments

Numerous individuals and organizations have made important contributions to the Institute on Science for Global Policy (ISGP) Climate Change Program (ICCP) and the conference *Sea Level Rise: What's Our Next Move?* convened in St. Petersburg, Florida, on October 2–3, 2015. Some of these contributions directly supported the efforts needed to organize the invitation-only conference, convened in partnership with the Institute for Strategic Policy Solutions at St. Petersburg College and the St. Petersburg/Pinellas County Working Group (a local committee of concerned volunteers). Other contributions aided the ISGP in preparing the material presented in this report, including the three policy position papers prepared by invited presenters, and the not-for-attribution summaries of the views presented in the discussions, critical debates, and caucuses that ensued.

Of special significance were the efforts of the three distinguished subject-matter experts invited by the ISGP to present their views in each of the three concise policy position papers that were debated. The biographies of these three authors are provided here. The ISGP also greatly appreciates the willingness of those in the scientific and policy communities who agreed to be interviewed by the ISGP staff.

The success of every ISGP conference critically depends on the active engagement of all invited participants in the often-intense debates and caucuses. The exchange of strongly held views, innovative proposals, and critiques generated from questions and debates fosters an unusual, and even unique, environment focused on clarifying understanding for the nonspecialist. These debates and caucuses address specific questions related to both formulating and implementing effective public and private sector policies. The ISGP is greatly indebted to the wide range of policy makers, scientists, students, and community members who engaged in the vigorous debates and caucuses that comprise all ISGP conferences.

The members of the ISGP Board of Directors also deserve recognition for their time and efforts in helping to create a vital, increasingly relevant not-for-profit organization focused on addressing many of the most important societal questions of our time. Their brief biographical backgrounds are presented at the end of this book.

The Institute for Strategic Policy Solutions at St. Petersburg College and members of the St. Petersburg/Pinellas County Working Group merit special acknowledgment for their efforts to help organize and convene this ISGP conference. Their contributions in planning the ICCP conference and assembling the diverse

and knowledgeable debaters seated around the table are greatly appreciated. Many Working Group members also participated as debaters and acted as moderators of the small group caucuses. Biographical information of members of the Petersburg/Pinellas County Working Group is provided here.

Thanks also needs to be extended to the conference volunteers from Eckerd College, Stetson University College of Law, St. Petersburg College, and the Connection Partners as well as the ISGP Academic Partnership (IAP) interns from California State University, Sacramento who contributed to the organization and functioning of the conference. Their biographical information is provided in this report.

The energetic, highly professional interviewing, organizing, and writing skills of the ISGP staff were essential to not only structuring the conference itself, but also to recording the often-diverse views and perspectives expressed in the critical debates, accurately capturing the areas of consensus and actionable next steps from the caucuses, and persevering through the extensive editing process needed to assure the accuracy of the material published here. Their biographies are provided in this report.

ISGP programs are financially supported by government agencies and departments and through gifts from private-sector entities and philanthropic organizations and individuals. Specifically, the ICCP conference on *Sea Level Rise: What's Our Next Move?* received funding for the general activities of the ISGP as generous gifts provided by The Sloan Foundation, the MARS Corp., Edward and Jill Bessey, Kenneth Bryant, Miles Croom, Richard Jacobs, Deborah Hirshberg, and an anonymous donor. The Institute for Strategic Policy Solutions at St. Petersburg College generously provided the venue and refreshments.

Dr. George H. Atkinson
Founder and Executive Director
Institute on Science for Global Policy
December 20, 2015

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ISGP conferences on, or related to, Emerging and Persistent Infectious Diseases (EPID):

- *EPID: Focus on Antimicrobial Resistance*, convened March 19–22, 2013, in Houston, Texas, U.S., in partnership with the Baylor College of Medicine.
- *21st Century Borders/Synthetic Biology: Focus on Responsibility and Governance*, convened December 4–7, 2012, in Tucson, Arizona, U.S., in partnership with the University of Arizona.
- *EPID: Focus on Societal and Economic Context*, convened July 8–11, 2012, in Fairfax, Virginia, U.S., in partnership with George Mason University.
- *EPID: Focus on Mitigation*, convened October 23–26, 2011, in Edinburgh, Scotland, U.K., in partnership with the University of Edinburgh.
- *EPID: Focus on Prevention*, convened June 5–8, 2011, in San Diego, California, U.S.
- *EPID: Focus on Surveillance*, convened October 17–20, 2010, in Warrenton, Virginia, U.S.
- *EPID: Global Perspectives*, convened December 6–9, 2009, in Tucson, Arizona, U.S., in partnership with the University of Arizona.

ISGP conferences on Food Safety, Security, and Defense (FSSD):

- *FSSD: Equitable, Sustainable, and Healthy Food Environments*, to be convened May 1–4, 2016, in Vancouver, Canada, in partnership with Simon Fraser University.
- *FSSD: Food Security and Diet-linked Public Health Challenges*, convened September 20–23, 2015 in Fargo, North Dakota, in partnership with North Dakota State University.
- *FSSD: Focus on Food and the Environment*, convened October 5–8, 2014, in Ithaca, New York, in partnership with Cornell University.
- *FSSD: Focus on Food and Water*, convened October 14–18, 2013, in Lincoln, Nebraska, U.S., in partnership with the University of Nebraska–Lincoln.

- *FSSD: Focus on Innovations and Technologies*, convened April 14–17, 2013, in Verona, Italy.
- *FSSD: Global Perspectives*, convened October 24, 2012, in Arlington, Virginia, U.S., in partnership with George Mason University.

ISGP Academic Partnership (IAP) conferences

- *The Socioeconomic Context of Sustainable Agriculture*, to be convened mid-October 2016, in Danbury, Connecticut, U.S., in partnership with Western Connecticut State University.
- *Water and Fire: Impacts of Climate Change*, to be convened April 10–11, 2016, in Sacramento, California, U.S., in partnership with California State University, Sacramento
- *Communicating Science for Policy*, convened August 10–11, 2015, in Durham, North Carolina, in partnership with Sigma Xi, The Scientific Research Society.
- *Food Security: Production and Sustainability*, convened April 24–25, 2015, in St. Petersburg, Florida, in partnership with Sigma Xi, The Scientific Research Society, and Eckerd College.
- *FSSD: Safeguarding the American Food Supply*, convened April 10–11, 2015, in Collegeville, Pennsylvania, in partnership with Sigma Xi, The Scientific Research Society, and Ursinus College.
- *EPID: Focus on Pandemic Preparedness*, convened April 11–12, 2014, in Collegeville, Pennsylvania, U.S., in partnership with Ursinus College.

ISGP conferences on Science and Governance (SG):

- *The Genomic Revolution*, convened September 6, 2013, in cooperation with the Parliamentary Office on Science and Technology of the British Parliament within the House of Lords. London, United Kingdom.

ISGP reports from ISGP conferences on Global Challenges are available to the public and can be downloaded from the ISGP Web site: www.scienceforglobalpolicy.org:

- ISGP Climate Change Program (ICCP): *The Shore's Future: Living with Storms and Sea Level Rise*, November 20–21, 2015, in cooperation with several local partners, including the Barnegat Bay Partnership and the

Barnegat Bay Foundation with financial support provided by the Jay and Linda Grunin Foundation.

- ICCP: *Sea Level Rise: What's Our Next Move*, convened Oct. 2–3, 2015, in St. Petersburg, Florida, in cooperation with the St. Petersburg/Pinellas County Working Group and the Institute for Strategic Policy Solutions at St. Petersburg College.
- ISGP Climate Change Arctic Program (ICCAP): *Sustainability Challenges: Coping with Less Water and Energy*, convened June 5, 2015, in Whittier, California, in cooperation with the Whittier Working Group.
- ICCAP: *Living with Less Water*, convened February 20–21, 2015, in Tucson Arizona, in cooperation with the Tucson Working Group.

Biographical information of Scientific Presenters

John Englander

Mr. Englander is an oceanographer, consultant, and sea level rise expert, working with businesses, government agencies, and communities to help them understand and plan and prepare for long-term sea level rise. His long experience in the nonprofit and private sectors includes serving as CEO of The Cousteau Society, The International SeaKeepers Society, and The Underwater Explorers Society (UNEXSO). Mr. Englander is a Fellow of the Institute of Marine, Engineering, Science and Technology and The Explorers Club, and a member of numerous professional societies. He is working to establish a new nonprofit organization, The International Sea Level Institute. His publications include “High Tide on Main Street” (The Science Bookshelf, 2012) and “Rising Sea Level and The Coming Coastal Crisis” (Trinity, 2015). He blogs at www.johnenglander.net.

Andrew “Andy” G. Keeler, Ph.D.

Dr. Keeler is Program Head of Public Policy and Coastal Sustainability at the University of North Carolina Coastal Studies Institute, and Professor in the Department of Economics, East Carolina University. In addition, he directs the Outer Banks Field Site for the University of North Carolina at Chapel Hill. Dr. Keeler served as the Senior Staff Economist for Environment at the President’s Council of Economic Advisers (2000–2001), where he was a member of the U.S. negotiating team for climate change and a diplomatic representative to the Organization for Economic Cooperation and Development coordinating national sustainability policies. He served on the White House climate change policy teams under Presidents Clinton and Bush. His expertise includes local, state, and national policy, coastal area adaptation policies, and zero-carbon coastal energy projects.

Harold “Hal” R. Wanless, Ph.D.

Dr. Wanless is Professor and Chair of the Department of Geological Sciences at the University of Miami. He was named a Cooper Fellow in the College of Arts and Sciences at the University of Miami in 2010. Dr. Wanless actively interacts with policy and legislative groups at the local to federal levels to guide necessary decisions, including speaking at Everglades Coalition annual meetings, various Florida Legislative committees, environmental and industry executive and steering committees, and the Council on Environmental Quality in the White House. He

was co-chair of the Science Committee of the Miami-Dade County Climate Change Advisory Task Force from 2006 to 2011 and works with the South Florida Regional Planning Council to provide the science background for and projections of sea level rise for the coming century.

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Biographical information of the St. Petersburg/ Pinellas County Working Group

Dr. Kenneth Bryant is a urologist at Bay Pines VA Medical Center. He received his medical degree from the University of Florida and served in the U.S. Army from 1980–1986. He enjoys scuba diving, boating, fishing, hiking, and skiing.

Marvin E. “Gene” Bullington is President, Chief Operations Officer, and Senior Forensic Analyst at Interscience, Inc. with headquarters in Tampa, Florida. He is also a Certified Forensic Consultant. Interscience works with property insurance companies in the investigation into the causes of all types of property losses including water damage mitigation, and makes recommendations concerning risk reduction and subrogation matters.

Peter Clark is the founder and President of Tampa Bay Watch. Under his watch, the organization has coordinated more than 100,000 volunteers, installed 10,000 oyster reef units and 1,200 tons of oyster shell to create more than two miles of oyster shell reef communities, planted more than 1,000,000 salt marsh grasses to restore 200 acres of coastal tidal ponds to Tampa Bay. Before creating Tampa Bay Watch, Mr. Clark served as Director of the Tampa Bay Regional Planning Council’s Agency on Bay Management, an alliance of agencies charged with protecting the Bay.

Miles Croom recently retired after 41 years’ service with the federal government. In his final position, Miles served as Deputy Regional Administrator for the NOAA National Marine Fisheries Service, Southeast Region, in St. Petersburg, Florida. Prior to that, Miles was the division chief in the Southeast Region for Habitat Conservation. During his NOAA career, Miles worked in the NOAA Fisheries Southwest Region as Habitat Conservation field office supervisor, salmon recovery coordinator, and Endangered Species consulting biologist. He recently earned his U.S. Coast Guard captain’s license.

Guy Hancock is a veterinarian who worked in small animal practice and as dean of the school of Veterinary Technology at St. Petersburg College. He is semiretired, consulting and teaching part time, and a active volunteer in climate science, global warming, ecology and environmental sustainability.

Richard “Dick” Jacobs graduated from the University of Wisconsin in 1954, BBA, with high honors, including Phi Beta Kappa, and graduated from Stetson College of Law, 1967, first in his class, *magna cum laude*. Active in several local charities, Dick has authored four books, including *Wonderlust*, released in 2015, a coffee table book about his treks of the seven continents, camera in hand, and the lessons learned about our Earth, its resources and its care.

David Klement, Working Group Chair, is founding director of the Institute for Strategic Policy Solutions at St. Petersburg College. A retired Pulitzer Prize-winning journalist, he had a distinguished, 45-year career with the former Knight Ridder Newspaper Group (now McClatchy News), including a 30-year stint as Editorial Page Editor of the Bradenton (Fla.) Herald. He also served on the Florida Public Service Commission, the regulatory agency for Florida’s investor-owned utility companies. He holds a BA in Journalism and an MA in Mass Communication.

The Rev. Dr. Russell L. Meyer is Executive Director for the Florida Council of Churches and is the Pastor of the New Parish of Tampa / St. Paul and Faith Lutheran Churches, ministries of renewal focusing on urban justice. He chairs the local ecumenism network for the National Council of Churches and leads statewide interfaith efforts on climate, healthcare, juvenile justice and civic engagement. He also serves as the minister for Ecumenism and Advocacy for the Florida-Bahamas Synod of the Evangelical Lutheran Church in America.

Erin Okuno is a licensed attorney who works as the Foreman Biodiversity Fellow at the Institute for Biodiversity Law and Policy at Stetson University College of Law in Gulfport, Florida. She assists with the Institute’s environmental education, research, and service activities.

Linda Ruble is a lifelong Florida resident, who grew up in Pinellas County. She formerly was Senior Administrative Services Specialist to the Provost at St. Petersburg College before retiring after working there for 34 years.

Jacquelyn Schuett is Project Coordinator at the Institute for Strategic Policy Solutions at St. Petersburg College. With a degree in Community Education, she has made a career of educational, community, cultural and civic program development and management. She has worked for the city of St. Petersburg and the Pinellas Education Foundation, as well as arts organizations and community education centers in much colder locations.

Gordon Thomas is a retired optometrist with a doctor's degree in optometry and B.S. degree in Biology and Chemistry. He also has done graduate research on cancer and water pollution. He has been on seven medical mission trips into unusual places such as Uzbekistan, Kazakhstan, Siberia, and Mongolia.

Biographical information of ISGP Board of Directors

Dr. George Atkinson, Chairman

Dr. Atkinson founded the Institute on Science for Global Policy (ISGP) and is an Emeritus Professor of Chemistry, Biochemistry, and Optical Science at the University of Arizona. He is former head of the Department of Chemistry at the University of Arizona, the founder of a laser sensor company serving the semiconductor industry, and Science and Technology Adviser (STAS) to U.S. Secretaries of State Colin Powell and Condoleezza Rice. He launched the ISGP in 2008 as a new type of international forum in which credible experts provide governmental and societal leaders with understanding of the science and technology that can be reasonably anticipated to help shape the increasingly global societies of the 21st century. Dr. Atkinson has received National Science Foundation and National Institutes of Health graduate fellowships, a National Academy of Sciences Post Doctoral Fellowship, a Senior Fulbright Award, the SERC Award (U.K.), the Senior Alexander von Humboldt Award (Germany), a Lady Davis Professorship (Israel), the first American Institute of Physics' Scientist Diplomat Award, a Titular Director of the International Union of Pure and Applied Chemistry, the Distinguished Service Award (Indiana University), an Honorary Doctorate (Eckerd College), the Distinguished Achievement Award (University of California, Irvine), and was selected by students as the Outstanding Teacher at the University of Arizona. He received his B.S. (high honors, Phi Beta Kappa) from Eckerd College and his Ph.D. in physical chemistry from Indiana University.

Dr. Ben Tuchi, Secretary/Treasurer

Dr. Tuchi is chairman of the board of directors of the Arizona Research Park Authority. He received his B.S. and M.S. degrees in Business Administration from the Pennsylvania State University and his PhD in Finance from St Louis University. His full-time teaching career began in 1961 at St. Francis College and continued until 1976 at West Virginia University. From 1976 through 1996 he served in cabinet levels at West Virginia University, The University of Arizona, The University of North Carolina at Chapel Hill, and finally as Sr. Vice Chancellor for Business and Finance of the University of Pittsburgh. During those assignments he was simultaneously a tenured professor of finance. He retired from the last executive post in 1996 and returned to a full-time teaching position as Professor of Finance at the University of Pittsburgh, until his retirement in 1999. For the two years prior to his retirement he

was the Director of Graduate Programs in Business in Central Europe, at Comenius University, making his home in Bratislava, The Slovak Republic.

Dr. Janet Bingham, Member

Dr. Bingham is President of the George Mason University (GMU) Foundation and GMU's Vice President for Advancement and Alumni Relations. GMU is the largest university in Virginia. Previously, she was President and CEO of the Huntsman Cancer Foundation (HCF) in Salt Lake City, Utah. The foundation is a charitable organization that provides financial support to the Huntsman Cancer Institute, the only cancer specialty research center and hospital in the Intermountain West. Dr. Bingham also managed Huntsman Cancer Biotechnology Inc. In addition, she served as Executive Vice President and Chief Operating Officer with the Huntsman Foundation, the private charitable foundation established by Jon M. Huntsman Sr. to support education, cancer interests, programs for abused women and children, and programs for the homeless. Before joining the Huntsman philanthropic organizations, Dr. Bingham was the Vice President for External Relations and Advancement at the University of Arizona. Prior to her seven years in that capacity, she served as Assistant Vice President for Health Sciences at the University of Arizona Health Sciences Center. Dr. Bingham was recognized as one of the Ten Most Powerful Women in Arizona.

Dr. Henry Koffler, Member

Dr. Koffler is President Emeritus of the University of Arizona (UA). He served as President of the UA from 1982-1991. From 1982 he also held professorships in the Departments of Biochemistry, Molecular and Cellular Biology, and Microbiology and Immunology, positions from which he retired in 1997 as Professor Emeritus of Biochemistry. His personal research during these years concentrated on the physiology and molecular biology of microorganisms. He was Vice President for Academic Affairs, University of Minnesota, and Chancellor, University of Massachusetts/Amherst, before coming to the UA. He taught at Purdue University, where he was a Hovde Distinguished Professor, and the School of Medicine at Western Reserve University (now Case Western Reserve University). Dr. Koffler served as a founding Governor and founding Vice-Chairman of the American Academy of Microbiology, and as a member of the governing boards of Fermi National Accelerator Laboratory, the Argonne National Laboratory, and the Superconducting Super Collider Laboratory. He was also a board member of the Association of American Colleges and Universities, a member and Chairman of the Council of Presidents and a member of the executive committee of the National Association of Land Grant Colleges and Universities. He was also Founder, President and board

member of the Arizona Senior Academy, the driving force in the development of the Academy Village, an innovative living and learning community. Among the honors that Dr. Koffler has received are a Guggenheim Fellowship and the Eli Lilly Award in Bacteriology and Immunology.

Mr. Jim Kolbe, Member

For 22 years, Mr. Kolbe served in the United States House of Representatives, elected in Arizona for 11 consecutive terms, from 1985 to 2007. Mr. Kolbe is currently serving as a Senior Transatlantic Fellow at the German Marshall Fund of the United States, and as a Senior Adviser to McLarty Associates, a strategic consulting firm. He advises on trade matters as well as issues of effectiveness of U.S. assistance to foreign countries, on U.S.-European Union relationships, and on migration and its relationship to development. He is also Co-Chair of the Transatlantic Taskforce on Development with Gunilla Carlsson, the Swedish Minister for International Development Cooperation. He also is an adjunct Professor in the College of Business at the University of Arizona. While in Congress, he served for 20 years on the Appropriations Committee of the House of Representatives, was chairman of the Treasury, Post Office and Related Agencies subcommittee for four years, and for his final six years in Congress, he chaired the Foreign Operations, Export Financing and Related Agencies subcommittee. He graduated from Northwestern University with a B.A. degree in Political Science and then from Stanford University with an M.B.A. and a concentration in economics.

Dr. Charles Parmenter, Member

Dr. Parmenter is a Distinguished Professor Emeritus of Chemistry at Indiana University. He also served as Professor and Assistant and Associate Professor at Indiana University in a career there that spanned nearly half a century (1964-2010). He earned his bachelor's degree from the University of Pennsylvania and served as a Lieutenant in the U.S. Air Force from 1955-57. He worked at DuPont after serving in the military and received his Ph.D. from the University of Rochester and was a Postdoctoral Fellow at Harvard University. He has been elected a Member of the National Academy of Sciences and the American Academy of Arts and Sciences, and a Fellow of the American Physical Society and the American Association for the Advancement of Science. He was a Guggenheim Fellow, a Fulbright Senior Scholar, and received the Senior Alexander von Humboldt Award in 1984. He has received the Earle K. Plyler Prize, was a Spiers Medalist and Lecturer at the Faraday Society, and served as Chair of the Division of Physical Chemistry of the American Chemical Society, Co-Chair of the First Gordon Conference on Molecular Energy Transfer, Co-organizer of the Telluride Workshop on Large Amplitude Motion and

Molecular Dynamics, and Councilor of Division of Chemical Physics, American Physical Society.

Mr. Thomas Pickering, Member

Mr. Pickering is Vice Chairman of Hills & Co, international consultants, and Strategic Adviser to NGP Energy Capital Management. He co-chaired a State-Department-sponsored panel investigating the September 2012 attack on the U.S. diplomatic mission in Benghazi. He served as U.S. ambassador to the United Nations in New York, the Russian Federation, India, Israel, El Salvador, Nigeria, and the Hashemite Kingdom of Jordan. Mr. Pickering also served on assignments in Zanzibar and Dar es Salaam, Tanzania. He was U.S. Under Secretary of State for Political Affairs, president of the Eurasia Foundation, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, and Boeing Senior Vice President for International Relations. He also co-chaired an international task force on Afghanistan, organized by the Century Foundation. He received the Distinguished Presidential Award in 1983 and again in 1986 and was awarded the Department of State's highest award, the Distinguished Service Award in 1996. He holds the personal rank of Career Ambassador, the highest in the U.S. Foreign Service. He graduated from Bowdoin College and received a master's degree from the Fletcher School of Law and Diplomacy at Tufts University.

Dr. Eugene Sander, Member

Dr. Sander served as the 20th president of the University of Arizona (UA), stepping down in 2012. He formerly was vice provost and dean of the UA's College of Agriculture and Life Sciences, overseeing 11 academic departments and two schools, with research stations and offices throughout Arizona. He also served as UA Executive Vice President and Provost, Vice President for University Outreach and Director of the Agricultural Experiment Station and Acting Director of Cooperative Extension Service. Prior to his move to Arizona, Dr. Sander served as the Deputy Chancellor for biotechnology development, Director of the Institute of Biosciences and Technology, and head of the Department of Biochemistry and Biophysics for the Texas A&M University system. He was Chairman of the Department of Biochemistry at West Virginia University Medical Center and Associate Chairman of the Department of Biochemistry and Molecular Biology at the College of Medicine, University of Florida. As an officer in the United States Air Force, he was the assistant chief of the biospecialties section at the Aerospace Medical Research Laboratory. He graduated with a bachelor's degree from the University of Minnesota, received his master's degree and Ph.D. from Cornell University and completed postdoctoral study at

Brandeis University. As a biochemist, Dr. Sander worked in the field of mechanisms by which enzymes catalyze reactions.

Mr. Richard Armitage, Special Adviser

Mr. L. Armitage is the President at Armitage International, where he assists companies in developing strategic business opportunities. He served as Deputy Secretary of State from March 2001 to February 2005. Mr. Armitage, with the personal rank of Ambassador, directed U.S. assistance to the new independent states (NIS) of the former Soviet Union. He filled key diplomatic positions as Presidential Special Negotiator for the Philippines Military Bases Agreement and Special Mediator for Water in the Middle East. President Bush sent him as a Special Emissary to Jordan's King Hussein during the 1991 Gulf War. Mr. Armitage also was Deputy Assistant Secretary of Defense for East Asia and Pacific Affairs in the Office of the Secretary of Defense. He graduated from the U.S. Naval Academy. He has received numerous U.S. military decorations as well as decorations from the governments of Thailand, Republic of Korea, Bahrain, and Pakistan. Most recently, he was appointed an Honorary Companion of The New Zealand Order of Merit. He serves on the Board of Directors of ConocoPhillips, ManTech International Corporation, and Transcu Ltd., is a member of The American Academy of Diplomacy as well as a member of the Board of Trustees of the Center for Strategic and International Studies.

Biographical information of ISGP staff

George Atkinson, Ph.D., ISGP Executive Director, founded the Institute on Science for Global Policy (ISGP) and is an Emeritus Professor of Chemistry, Biochemistry, and Optical Science at the University of Arizona. He is former Science and Technology Adviser to U.S. Secretaries of State Colin Powell and Condoleezza Rice and founded a laser sensor company serving the semiconductor industry. He launched the ISGP in 2008 as a new type of international forum in which credible experts provide governmental and societal leaders with the objective understanding of the science and technology that can be reasonably anticipated to help shape the increasingly global societies of the 21st century.

Jennifer Boice, M.B.A., ISGP Program Coordinator, worked for 25 years in the newspaper industry at the Tucson Citizen and USA Today, and was the Editor of the Tucson Citizen when it was closed in 2009. Ms. Boice received her M.B.A. from the University of Arizona and graduated from Pomona College in California with a degree in economics.

Sweta Chakraborty, Ph.D., ISGP Associate Director, received her doctorate in Risk Management from King's College London, and has more than 20 published articles, has contributed to three books, and is author of the forthcoming book "Pharmaceutical Safety: A Study in Public and Private Regulation." She is currently an adjunct assistant professor at Columbia University and a program associate at Oxford University's Centre for Socio-Legal Studies.

Barbara Del Castello, B.A., ISGP Senior Fellow, is a graduate of Eckerd College, St. Petersburg, Florida, with a degree in Biology and a minor in Anthropology and currently is conducting post baccalaureate research on the genetic origins of the thymus at the University of Georgia, Athens.

Christina Medvescek, B.A., ISGP Program Administrator, is an internationally published journalist and editor specializing in health, human development and conflict resolution. She also serves as an EEO mediator for the U.S. Postal Service, and as a mediator, facilitator and instructor for the Center for Community Dialogue, Tucson, AZ.

Joseph Roberts, Ph.D., ISGP Senior Fellow, earned his doctorate in social psychology from The Ohio State University in 2011. His research has examined the influence of mindsets on self-control, planning, and decision-making in health and public policy domains. In addition to his work for ISGP, Dr. Roberts teaches courses in psychology, statistics, and research methods at The Ohio State University in Columbus, Ohio.

Cleo Warner, B.A., ISGP Fellow, is a graduate from Eckerd College in St. Petersburg, Florida, with a degree in literature and environmental studies. Her research interests include food systems, science communication, and other various ways in which society and the environment interact. Ms. Warner has worked on numerous environmental community development projects both in Florida and internationally.

Andrea Vazquez, ISGP Fellow, is a senior at Arizona State University pursuing her bachelor's degree in social work. She is also a College Prep-Assistant at a high school in Tucson, Arizona. Her goal as a social worker is to challenge social injustice and advocate for people who are vulnerable and oppressed, especially youth.

Biographical information of ISGP Academic Partnership (IAP) interns from California State University, Sacramento (CSUS)

Zachary Frese is a graduating senior in CSUS Environmental Studies program with a genuine passion for the environment. From an early age, he has connected deeply with the natural world and been personally invested in the wellbeing of the planet's biodiversity.

Matthew Owens, born and raised in northern California, is a senior at CSUS. He is currently pursuing a Bachelor of Science in Environmental Studies. He has developed a strong interest in water management and policy and restoration ecology throughout his education and is currently conducting research work on strategies for controlling invasive species.

Ericka Soto is a graduating senior at CSUS and will be receive her bachelor's degree in Environmental Studies as well as a minor in Biology in 2016. She has a profound interest in issues pertaining to environmental justice; as an ISGP intern, she is also partnered in leading the community outreach task force.

Megan Weiss is an Environmental Studies student at CSUS pursuing a degree in science. She started her own business at the age of 22 raising and selling purebred White Dorper Sheep. She is applying for master's programs in Sustainable Agriculture to pursue her goal of owning and managing a small sustainable organic farm.

Cheyene Keniston is a CSUS graduate with an associate's degree in social sciences, and a bachelor's degree in environmental studies. She has passions for sustainable development, environmental protection, and improving urban areas. She is experienced in urban agriculture aquaponics systems, California's Traditional Resource Management, and community outreach.

Andrew Hawkins is a member of the CSUS class of 2017 and is pursuing a bachelor's of science degree in environmental studies. He also works in the insurance industry and enjoys practicing Muay Thai and wildlife photography in his free time.

Conference volunteers

Dr. Steve Weppner, professor of physics at Eckerd College

Devesh Nirmul, Sustainability and Energy Management Adviser and Adjunct professor at St. Petersburg College

Katie Wheeler, Student at Eckerd College and former ISGP Student Intern

Dr. Joel Thompson, Professor of Marine Science and Geosciences at Eckerd College

Sharon Joy Kleisch, Principal of The Connection Partners Inc.

Rachael Yorsten, Student at Eckerd College

Rachael Curran, Student at Stetson University College of Law

Lauren Eliopoulous, Student at Stetson University College of Law

Dr. Michelle Stevens, Associate Professor of Environmental Studies, California State University, Sacramento

Julia Street, Student at Eckerd College

Lydia Greiner, Student at Stetson University College of Law

