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Using Boundary Organizations to Address Complex Environmental Issues: Case Study of the NOAA-AOML Sea Grant Liaison Position

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Using Boundary Organizations to Address Complex Environmental Issues: Case Study of the NOAA-AOML Sea Grant Liaison Position

Pamela J. Fletcher^{1,2} Michael Spranger³ Peter B. Ortner⁴

¹University of Florida, Institute of Food and Agricultural Science, Davie, Florida ²NOAA–Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida ³University of Florida, Youth and Community Sciences Department, Gainesville, Florida ⁴University of Miami-Cooperative Institute for Marine and Atmospheric Studies, Miami, Florida

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UNITED STATES DEPARTMENT OF COMMERCE Mr. Wilbur L. Ross, Jr., Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION RDML Timothy Gallaudet, Acting Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator

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Acronyms

AOML	Atlantic Oceanographic and Meteorological Laboratory
FSG	Florida Sea Grant College Program
MARES	MARine and Estuarine Goal Setting for South Florida
NOAA	National Oceanic and Atmospheric Administration
NSG	National Sea Grant College Program
OAR	Office of Oceanic and Atmospheric Research
SEFSC	Southeast Fisheries Science Center
SFER	South Florida Ecosystem Restoration
USDA	United States Department of Agriculture

Abstract

Boundary organizations can provide a critical link in the management of natural resources. We explore the 20-year evolution of a Sea Grant liaison position structured to act as a boundary organization linking academic, government, and non-governmental organizations to facilitate a common understanding of the South Florida ecosystem and to better inform decision making. The narrative includes the initial concept for the liaison position and how its role evolved over time due to the availability of funding, changes in management structure, and institutional support for the position. We conclude that, as a boundary organization, this liaison position served a genuine need; the products and services co-produced from it through extension education and outreach activities have been useful to the South Florida community.

1. Introduction

1.1 Boundary Organizations Defined

Boundary organizations are defined by Morse (2009) as "formal relational structures that create linkages across traditional boundaries, such as the boundary between science and non-science." Their success is measured by the ability to satisfy the needs of the conjoining organizations, while maintaining their own identity (Guston, 2001). Such organizations can be "permanently defined, criticized, challenged, defended, and adjusted" over time (Boissin, 2009).

Boundary organizations play a unique role in building the relationships and collaborations that link different segments of the population, political jurisdictions, and policy components (Morse, 2009). They can be useful for improving inclusion and supporting adaptive management (Walker and Salt, 2006). These organizations promote a cross-pollination of ideas and facilitate a cascade of interactions to overcome challenges that would otherwise prevent relationships from forming and, therefore, not achieve desired outcomes that require partnership and trust. They build collaborations that explore various domains, such as economic impacts, community development, and resource management, thereby expanding the potential for broader knowledge sharing and the creative ideas required to advance the knowledge base.

In some cases, boundary organizations also preserve the distinctions between participants to protect institutions. This exclusiveness may be useful during consultations with scientific experts and management agencies when a more focused, intimate discussion is needed for strategic policy to avoid both the "politicization of science" and the "scientification of politics" (Guston, 2001; Jasanoff, 1990). In brief, boundary organizations and their activities not only serve to facilitate communication and compile disparate information, but also preserve the independence of the participants and minimize unnecessary angst arising from conflicting aspirations or other external factors such as inherent cultural differences.

Two elements exist within the boundary organization domain: boundary objects and standardized packages (Guston, 2001). Boundary objects can be tangible or intangible; they can exist between organizations or individuals without losing their own identity, such as a patent, or an entire organization, such as the National Sea Grant College Program (NSG) (Star and Griesemer, 1989). The NSG was established in 1966 based on the Land Grant College model, which will be described in section 1.2. Standardized packages can be the linkage between science and politics in co-production activities, but each entity involved is motivated to be in the partnership for their own purposes and possesses or seeks a unique output for their benefit. The boundary organization's objects and standardized packages identify techniques to link people and their institutions through human interactions and trust to produce knowledge and mutually-beneficial outcomes.

Boundary organizations can strategically maneuver between two or more organizations, often in a nonthreatening manner, through casual inquiry and informal meetings, either collectively or with individual participants. Informal interactions help a boundary organization identify potential interests in a non-competitive context and, in some instances, broaden perspective to discover and identify common interests. These common interests can be used to determine the feasibility of developing boundary objects and/or standardized packages focused (in our case) upon sustainability.

1.2 Extension Education as a Boundary Organization

Cooperative extension is a boundary organization (Cash, 2001; Guston, 2001). It is generally associated with higher education in the dissemination (extension) of sciencebased research generated at universities that groups and individuals can use in their daily lives. The best example of this is the U.S. Department of Agriculture's (USDA) Cooperative Extension Service, a part of the Land Grant College System. Land grant colleges are located in all 50 U.S. states. The land grant college system established agricultural colleges in 1862 through the Morrill Act to teach agricultural and mechanical arts. Every state had the opportunity to establish a college, with the federal government providing tracts of land for this purpose. These tracts of land, or the proceeds from their sale, were used to establish the colleges; thus the term "land grant colleges" still in use today. Land grant colleges provided education for the common man as an alternative to private universities. In addition to providing increased educational opportunities, their premise also advanced the economic competitiveness of the nation and enhanced the scientific understanding and practice of agriculture. In 1887, the Hatch Act provided federal funds for agricultural colleges to establish agricultural experiment stations focused on agricultural research (Geiger and Sorber, 2013).

In 1914, the Smith-Lever Act created the "cooperative extension system" (Extension) that became the mechanism for providing technical science from the agricultural colleges and agricultural experiment stations to rural areas (primarily). The word "cooperative" refers to the organizational structure and partnership between the USDA, land grant colleges, and state and local governments. In the Extension system, content specialists at land grant colleges and their agricultural experiment stations provide research, while locally-based "agents" disseminate this information to their user groups. Nationwide, there are currently more than 2,000 campus-based specialists and 8,000 community-based agents who work at 2,900 county or regional offices (Peters, 2014).

A common misperception is that the only role of the Extension is to provide technical and/or scientific knowledge to rural areas for economic gain. However, in the beginning there were also efforts to bring rural people together to address local issues. For instance, Liberty Hyde Bailey, Dean of the New York State College of Agriculture at Cornell, argued in 1907 that the role of Extension was not to be narrowly technical and economically focused, but to also be broadly cultural and political. The idea of Extension operating as a boundary organization to address potential cultural and political conflicts was established in this era. Today, there are a handful of faculty throughout the Extension system who play active roles as

neutral, unbiased, and apolitical scientific experts and public servants. They are equally interested in advancing knowledge in their respective academic fields and in "meeting the needs" of farmers, consumers, states, and the nation. Their engagement in the world beyond the campus is a means of simultaneously pursuing both of these interests. Extension and its associated activities are, therefore, cast as being "mutually beneficial" (Peters, 2006).

The ability of on-the-ground program offices to interact locally and be recognized as disinterested "experts" (not government representatives of some remote "elite") is possible, and they serve as honest brokers in facilitating difficult and/or potential conflicts. The Extension approach of moving between and among constituents and local organizations (e.g., research, industry, agencies, etc.) is boundary work. The research arm can be used to produce boundary objects and standardized packages through products and services developed both independently and in partnership with regional participants. Collaboration encourages co-production, enabling regional experts in a multitude of organizations to produce informative, interdisciplinary products.

2. Case Study from South Florida Ecosystem Restoration

South Florida is a complex socio-ecological system with multiple stakeholders and two national treasures the Greater Everglades ecosystem (including three national parks) and the Florida Reef Tract (including the Florida Keys National Marine Sanctuary) (Figure 1). A significant investment of time and money has been devoted to stewardship of these unique resources by the responsible governmental, non-governmental, and tribal organizations. Monitoring programs have resulted in several restoration success stories, but there are also indications of a systematic decline in ecosystem health.

South Florida Ecosystem Restoration (SFER) is centered on restoring the natural flow of water from the central portion of Florida to coastal areas of the peninsula. The project combines the efforts of multiple agencies, non-



Map of South Florida showing the Everglades (green) and Florida Reef Tract (pink) (Kruczynski and Fletcher, 2012).

governmental organizations, tribes, and stakeholders and has been underway for more than 30 years. In 1993, SFER costs were estimated at \$16 billion dollars, shared between the federal government, the state of Florida, and regional governments and authorities (e.g., water management districts and counties).

In a sense, the history of the SFER effort began in the early 1900s when the vast wetland areas of South Florida were viewed as a wasteland, an area with much potential for development (agricultural and infrastructure) if it were drained. In the ensuing years, the wetlands were drained, roads were built, and agriculture expanded. The area became occupied by a growing population as a result of one of the largest and most complex water management projects in U.S. history. Over time, however, the sustainability and resiliency of the ecosystem deteriorated. It became impossible for water managers to deliver freshwater as a slow moving sheet flow across the South Florida landscape to coastal areas like Florida Bay which, in turn, also degraded.

The ecosystem lost its ability to rebound and adapt to rapidly-changing conditions; it could no longer maintain the functionality and productivity of the ecosystem services upon which much of the regional economy depended. No one can turn back the clock to return this ecosystem to its pre-development condition, especially given its markedly decreased areal extent (less than 50%) and the decades in which its remaining area has experienced a multitude of stresses and attendant impacts. Restoring functionality to the remaining natural ecosystem with respect to sustainability and resiliency, however, is vital for addressing population growth and the local effects of global climate change.

The core of the SFER effort is the Comprehensive Everglades Restoration Project, whose goal is to get the water that flows through the remaining Everglades ecosystem "right" with respect to water quality, quantity, timing, and distribution. Achieving the "right" water flow will go far towards restoring what remains of the terrestrial portion of the Everglades and receiving bodies of water surrounding the southern tip of the Florida peninsula, including Florida Bay and the Florida Reef Tract. Both the marine and terrestrial environments of South Florida are closely linked to the well-being and quality of life for the estimated 5.6 million people living in the region (Palm Beach, Collier, Broward, Monroe, and Miami-Dade counties) (U.S. Census, 2010).

Maintaining a healthy ecosystem is critical to the availability of extractive and non-extractive natural resources such as seafood and wildlife viewing. It is also critical for the marine industry and tourism, both of which support livelihoods and serve as economic drivers in the region. Recognizing the importance of educating stakeholders about the Greater Everglades ecosystem, Florida Reef Tract, and existing scientific information resulted in a state-federal partnership developed to raise awareness about these resources.

This partnership was led by the Florida Sea Grant College Program (FSG) based at the University of Florida and included several National Oceanic and Atmospheric Administration (NOAA) offices located in South Florida the Office of National Marine Sanctuaries' Florida Keys National Marine Sanctuary, the Office of Oceanic and Atmospheric Research's Atlantic Oceanographic and Meteorological Laboratory (AOML), and the National Marine Fisheries Service's Southeast Fisheries Science Center (SEFSC). It also included the University of Miami's Rosenstiel School of Marine and Atmospheric Science. Sea Grant is "NOAA's primary university-based program in support of coastal resource use and conservation. Sea Grant's research and outreach programs promote better understanding, conservation, and use of America's coastal resources. In short, Sea Grant is 'science serving America's coasts" (Oregon Sea Grant, 2000).

2.1 Operationalizing the Boundary Organization through the Sea Grant Model

NOAA offices in South Florida play a critical role in monitoring the marine and coastal areas associated with Everglades restoration. One area of particular interest is Florida Bay due to its high productivity, abundance of marine resources (e.g., pink shrimp, commercial fisheries, and lobster), habitat for endangered species of birds and mammals (e.g., manatees), and access to recreation. Another area of interest is the Florida Keys, given NOAA's management of the Florida Keys National Marine Sanctuary. NOAA's involvement in SFER is through its membership in the SFER Task Force, SFER Working Group, and SFER Science Coordination Team, as well as the leadership it has provided to the Program Management Committee of the Florida Bay and Adjacent Marine Systems Science Program (National Research Council, 2007). The SFER Task Force (and its subcommittees) is responsible for overseeing all of the diverse facets of the Greater Everglades ecosystem, including both upstream terrestrial restoration and downstream nearshore coastal areas such as Florida Bay. A critical aspect of success in the restoration process is engaging the broader public and informing the effort with the best available science. The Sea Grant model, which includes research, extension, and education, was determined to be a near optimal mechanism to meet the SFER's need for education and the dissemination of information.

2.2 Building and Maintaining the Boundary Organization

The original boundary organization in South Florida was created in 1997 after the establishment of the Florida Bay and Adjacent Marine Systems Science Program, whose state and federal members (individuals with program management responsibility) all conducted research within and around Florida Bay. Based in part upon an ongoing dialogue between the local NOAA lead in this interagency program and the director of NOAA Sea Grant, NOAA Sea Grant provided funding to the FSG for a 5-year effort, including the establishment of a Florida Bay Sea Grant office in Key Largo, Florida. The office had three full-time staff members: a Florida Bay education project agent, a communicator, and an educator. In its fourth year, NOAA could no longer fund the project, and two of the three staff members left, leaving only a part-time educator. However, the local community and participants of the Florida Bay Science program expressed a desire for the project to continue. The result was a meeting of the NOAA partners, who not only discussed the needs of Florida Bay, but also the overall South Florida effort and need for extension education as it related to both Everglades restoration and the downstream impacts to Florida Bay and the Florida Reef Tract. With available unspent carry-over funds, the part-time education position was maintained, but the Florida Bay Sea Grant office closed in 2001.

In 2001, the concept of a Sea Grant boundary organization for South Florida was revisited. FSG coordinated a meeting in Miami, Florida with representatives from the NSG (program lead), Mississippi-Alabama Sea Grant (education network), North Carolina Sea Grant (communication network), FSG (extension network), and NOAA/AOML (research). During the 2-day meeting, a facilitated discussion specifically examined the need for a new position, a full-time liaison, to expand the Florida Bay concept to wider South Florida ecosystem issues, including SFER.

The liaison would serve in an "extension specialist" position to act as a conduit, providing NOAA research (both AOML and SEFSC) to specific users throughout South Florida, explicitly expanding the geographical focus from Florida Bay to the entire built (and unbuilt) South Florida region. The position would serve as a boundary organization linking NOAA scientists with South Florida stakeholders and decision-makers. NSG administrators, AOML administrators and scientists, and the FSG jointly decided to rebuild the boundary organization; the decision was also endorsed by the Sea Grant communication, education, and extension networks in the region. NSG

encouraged FSG to submit a grant proposal to fund the position, while a variety of soft funds were provided to keep the position in place. A grant was awarded for jointfunding by the NSG and regional partners, and the liaison became an employee of the University of Florida's Sea Grant College Program with an office at AOML in Miami, Florida.

AOML is one of the seven research laboratories within NOAA's Office of Oceanic and Atmospheric Research (OAR). The NSG also falls under the jurisdiction of OAR, resulting in a natural fit for the Sea Grant liaison position in accordance with OAR's overall goal of serving science to stakeholders. Furthermore, AOML's specific mission to conduct basic and applied research to understand the physical, chemical, and biological characteristics and processes of the ocean and atmosphere, both separately and as a coupled system, in South Florida and Florida Bay was a perfect match for initiating the position (NOAA, 2016). The liaison position would use NOAA research to provide a better understanding of the factors affecting the biophysical and human dimensions of South Florida, thereby providing the best available science to decisionmakers and stakeholders.

Since 2001, these boundary activities have required an entrepreneurial model since the NSG only provided funds for the salary of the liaison position. Beyond a small amount of additional funding provided by AOML, as well as office space, the effort largely supported itself through competitive grants focused on specific issues related to the South Florida ecosystem. For example, since 2006 additional funding was secured from several NOAA offices, including the Coral Reef Conservation Program and the National Centers for Coastal Ocean Science under the auspices of the NOAA Cooperative Institute for Marine and Atmospheric Studies hosted at the University of Miami. Specific funding opportunities were also pursued that meshed with the U.S. National Ocean Policy objectives and the Sea Grant's specific role with regard to improved understanding of the marine ecosystem for informed decision making.

Since 2006, the liaison has developed a project-based outreach program to promote understanding of the South Florida ecosystem by improving science-based communications among researchers, decision-makers, and critical segments of the South Florida population. The Sea Grant liaison position has become a true boundary organization with its physical placement inside a NOAA research laboratory and regular communication and coordination with a multitude of organizations and institutions involved in interdisciplinary ecosystem research and restoration management in South Florida.

2.3 Valuing the Boundary Organization

Boundary organizations such as the South Florida liaison position have the potential to play a vital role in implementing place-based, ecosystem-based management that includes sustainability and resiliency through local governance structures as defined by Christie's (2006) assessment of the National Ocean Policy. There are numerous opportunities for local Sea Grant extension agents to serve as conduits between and among agencies, organizations, and constituents within the research, extension, and education model.

In the case of South Florida, one of the roles of the position has been to liaise among resource managers, decision-makers, researchers, educators, and stakeholders to improve the exchange of information for informed decision making to promote co-learning and the co-production of boundary objects. The Marine and EStuarine Goal Setting for South Florida project (MARES) (http://www.aoml.noaa. gov/ ocdocdweb/mares.html) is one example of the Sea Grant liaison facilitating the development of boundary objects. The liaison was responsible for the program management of MARES from 2009-2014. Over 60 stakeholders participated in the project and contributed to a synthesis of the marine and coastal ecosystem in South Florida. Boundary objects co-produced during MARES included three NOAA Technical Memorandums (see Nuttle and Fletcher, 2013a,b,c), three conference posters, three fact pages, 10 white papers, 15 peer-reviewed publications, a data management system, social media, and a listserv.

Liaising with user groups and participating in and/or coordinating a multitude of meetings, workshops, focus group sessions, and interpersonal communications was an essential part of the MARES project that depended upon the "boundary organization," i.e., the liaison position, to achieve its goals. The boundary organization, acting as an honest broker in these interactions, helped form the foundation for participatory decision support research with more than 124 researchers and managers that contributed to building a consensus on the ecological state and regulating processes of the South Florida marine and coastal ecosystem, addressing both the resiliency and sustainability of the ecosystem.

In addition to the MARES project, over 175 researchers and managers contributed to the development of an educational boundary standardized object, representing a synthesis of knowledge about the overall South Florida ecosystem that included the Greater Everglades and Florida Reef Tract. This science-based product, a peerreviewed book entitled Tropical Connections: South Florida's Marine Environment, consists of over 400 fact pages about the South Florida ecosystem (Kruczynski and Fletcher, 2012). A first-of-its-kind, it highlights the marine and coastal areas of southern Florida with summarized narratives and an abundance of colorful photographs and images. The Environmental Protection Agency and FSG led the project, with numerous contributions from government, non-governmental, and academic institutions. The project was grant funded, and copies of the book were made available to every public library and public school in South Florida. While there is no formal evaluation of this standardized package, praise for it by teachers, students, researchers, and resource managers continue to be reported to the liaison. Its use as a textbook in middle schools, high schools, and colleges attest to its utility as an educational resource.

2.4 Boundary Organization Successes

The South Florida liaison position has resulted in the production of numerous boundary objects and standardized packages, leveraging funds to link researchers, managers, and educators to improve understanding of the South Florida ecosystem. NOAA overall, and AOML specifically, have benefitted from the liaison position with respect to their regional activities. FSG has also benefitted through information sharing and partnerships. These include research activities related to ecosystem-based management, outreach through training programs with the University of Florida's research and education centers in South Florida (e.g., Tropical Research and Education Center and the Fort Lauderdale Research and Education Center), and extension education related to science communications for the South Florida marine ecosystem. Additionally, the NSG has received recognition for its funding support and facilitation of the liaison position. The NSG Advisory Board recently reviewed the South Florida liaison position and has subsequently established additional liaison positions in other NOAA laboratories. The review was positive, and these liaison positions now serve as models for the development of similar positions across the nation (pers. comm., E. Rohring).

3. Conclusions

The Sea Grant liaison model in South Florida has acted as a boundary organization to translate and share information and research in a variety of formats through extension activities with the larger stakeholder community. Its utility has been well recognized, as attested by its replication in other NOAA laboratories. The liaison has developed numerous boundary objects and standardized packages through the development of project-based outreach programs to promote understanding of the South Florida ecosystem, markedly improving science-based communications among researchers, decision-makers, and segments of the South Florida population. By moving between and among regional universities, management entities, and stakeholder groups, the liaison has built an awareness of Everglades restoration activities, regional development planning, and NOAA's ecosystem-based management approach throughout South Florida.

As with any boundary organization, difficulties have been encountered. Boissin (2009) noted that boundary organizations are not necessarily efficient. Boundary objects and standardized packages that are co-produced may have a longer time line to gather input from a broader group of contributors. On the other hand, the participation of multiple players can facilitate information dissemination (and create real consensus) by providing additional conduits of products and services to a larger audience of stakeholders. The boundary organization exists at a frontier, essentially at the edge of the multiple worlds of biophysical science, human dimensions science, government regulators, and private interests and must remain accountable to the divergent interests of all parties if it is to be successful (Guston 1999, 2001). It is, therefore, important to recognize that all sides of the aisle must be willing partners and that there is a fine line between having a mutually-beneficial relationship and one that collapses before specific outcomes are achieved. It is also important to recognize that ecosystem-based management within its core includes social networks; the cooperation of those with an interest in its outcomes is essential to its success (Resilience Alliance, 2010).

From a longer-term perspective, NOAA may reevaluate how it views outreach and engagement within its portfolio. If a major NOAA goal is to support decisionmakers and provide resource managers with the best and most relevant scientific information to address complex, ecosystem issues, a more holistic view of funding for liaison positions would be a valuable investment for the future, as partnerships with those who benefit from boundary objects and standardized packages must be facilitated and encouraged.

The South Florida liaison position described herein was possible due to the persistence of the individuals serving in the liaison position, FSG, NSG, and NOAA support, as well as the entrepreneurial approach of its partners and the good will of local stakeholders over the past 16 years. The success of the liaison is assessed through impacts and outcomes derived from the products and services provided to stakeholders in the region. Using the Sea Grant model of research, extension and education, numerous workshops and meetings resulted in knowledge sharing and informed decision making. The reports and publications are used by decision-makers, educators, students, and residents to learn about South Florida's ecosystem. The boundary objects and standardized packages produced either in part of entirely by the liaison are important in delivering science and realizing the full potential and impact of the science being conducted by the NOAA research community.

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National Oceanic and Atmospheric Administration

OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH Atlantic Oceanographic and Meteorological Laboratory 4301 Rickenbacker Causeway Miami, FL 33149

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