BIG OCEAN

A Shared Research Agenda for Large-Scale Marine Protected Areas

Prepared By
Big Ocean planning team in collaboration with the Papahānaumokuākea Marine National Monument & UNESCO World Heritage Site (PMNM), NOAA Office of National Marine Sanctuaries

Editor/Author
Daniel Wagner, Research Specialist (PMNM)

Contributing Authors
ʻAulani Wilhelm, Alan Friedlander, Andrew Skeat, Anne Sheppard, Brian Bowen, Carlos Gaymar, Charles Sheppard, Daniel Wagner, Gustavo San Martin, Ian Wright, Jason Philibotte, John Parks, Jolene Bosanquet, Joseph Brider, Kahoane Aiona, Kim Morishige, Liz Wright-Koteka, Naiʻa Lewis, Noeline Brownie, Randall Kosaki, Randi Rotjan, Regen Jamieson, Rob Toonen, Rochelle Constantine, Schannel van Dijken, Sean Anderson, Sue Taei, Tania Temata, Tim Carruthers, Trevor Durbin, Tukabu Teroroko, Tupe Short, Wiriki Tooma and Zeenatul Basher

Reviewers
ʻAulani Wilhelm, Superintendent (PMNM)
Randall Kosaki, Deputy Superintendent for Research and Field Operations (PMNM)
Naiʻa Lewis, Strategic Initiatives Coordinator (PMNM)
Regen Jamieson, Conservation Projects Coordinator (New England Aquarium)

Layout & Graphic Design
Kahi Fujii, Graphic/Web Designer (PMNM)

Art Credit
Naiʻa Lewis, Strategic Initiatives Coordinator (PMNM)

Publication Date
February 2013

Abstract

Big Ocean: A Network of the World's Large-Scale Marine Managed Areas, was established in December 2010. Since its inception, the network has aimed to improve global marine management efforts by increasing our understanding of the world's oceans through sharing information, expertise and resources. To facilitate these efforts, Big Ocean managers and scientists gathered at a three day think tank held in conjunction with the 25th International Congress for Conservation Biology in December 2011. The purpose of the think tank was to produce a framework for a shared research agenda that addresses the unique scientific needs and challenges of large-scale MPAs. The think tank highlighted various unique features of conducting research in large-scale MPAs. In particular, large-scale MPAs contain entire, diverse and relatively pristine ecosystems that can serve as natural laboratories because they are removed from the many anthropogenic impacts that are associated with human population centers. Additionally, large-scale MPAs contain larger scale natural processes, which cannot be studied in their entirety in smaller regions. However, resource limitations magnify when spread over a larger area, and as a result there is greater uncertainty when studying large-scale MPAs. Based on workshop discussions, three main research themes were identified as being most relevant to large-scale MPAs, and included (1) biological and ecological characterization, (2) connectivity and (3) monitoring of temporal trends. Furthermore, a number of potential collaborative research initiatives were identified as being particularly important to the Big Ocean network, and a timeline was proposed to pursue such initiatives over the next two years. While we acknowledge that this is a living document that is subject to change, we hope that this framework will facilitate future joint research efforts between Big Ocean sites, and thereby improve marine management practices worldwide.

1. INTRODUCTION

1.1 The Big Ocean network

The groundwork for the creation of Big Ocean: A Network of the World's Large-Scale Marine Managed Areas, was laid in 2007 at the "Our Sea of Islands" regional forum, a meeting co-organized by the National Oceanic and Atmospheric Administration (NOAA) and the World Heritage Centre of the United Nations Educational, Scientific and Cultural Organization (UNESCO). The forum brought together over 100 leaders from 20 Pacific nations in Honolulu, Hawai'i to highlight current efforts to protect important marine areas in Oceania, to share and expand technical expertise, and to develop balanced management practices by incorporating science and traditional marine management techniques. A primary output of this forum was the "Our Sea of Islands Communiqué", a shared regional statement that called for the collaboration between governments and organizations on the protection, surveillance, monitoring and research of marine managed areas (Our Sea of Islands 2007). In 2009, relationships built at the forum led to a bilateral sister-site agreement between the United States (Papahānaumokuākea Marine National Monument) and the Republic of Kiribati (Phoenix Islands Protected Area). Under the agreement, these two sister-sites reached out to managers from other large-scale marine protected areas (MPAs), and co-convened a day-long meeting on December 6th, 2010 in Honolulu, Hawai'i (Big Ocean 2011). Site representatives of the six largest marine protected areas (MPAs) at that time participated in the meeting, during which they formally agreed to launch Big Ocean (Big Ocean 2011). The six founding sites that were represented at this inaugural Big Ocean meeting were (in chronological order of their establishment; Figures 1-2):

- **The Great Barrier Reef Marine Park** founded by the government of Australia in 1975, and declared as a UNESCO world heritage site in 1981, to protect 344,000 km^2 (134,363 miles^2) of marine habitats along the northwestern coast of Australia.
- **The Papahānaumokuākea Marine National Monument** established by the U.S.A. first as the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve in 2000, then as the Marine National Monument in 2006, and later recognized as a UNESCO world heritage site in 2010; this site encompasses 362,074 km^2 (139,797 miles^2) surrounding the northwestern section of the Hawaiian Archipelago.
- **The Phoenix Islands Protected Area** created in 2006 by the Republic of Kiribati, and distinguished as a UNESCO world heritage site in 2010, to conserve 408,250 km^2 (157,585 miles^2) of reefs and open ocean waters around the Kiribati portion of the Phoenix Islands.
- **The Marianas Trench Marine National Monument** formed by the U.S.A. in 2009 around 246,609 km^2 (95,216 miles^2) of the northernmost submerged lands of the Commonwealth of the Northern Mariana Islands.
- **The Chagos Marine Reserve** (British Indian Ocean Territory) established by the United Kingdom in 2010 to protect 640,000 km^2 (247,000 miles^2) of oceanic waters around the Chagos Archipelago in the Indian Ocean.
- **The Motu Motiro Hiva Marine Park** (formerly known as Sala y Gómez Marine Park) created by the government of Chile in 2010 to protect 150,000 km^2 (57,900 miles^2) around the island of Sala y Gómez in the East Pacific Ocean.

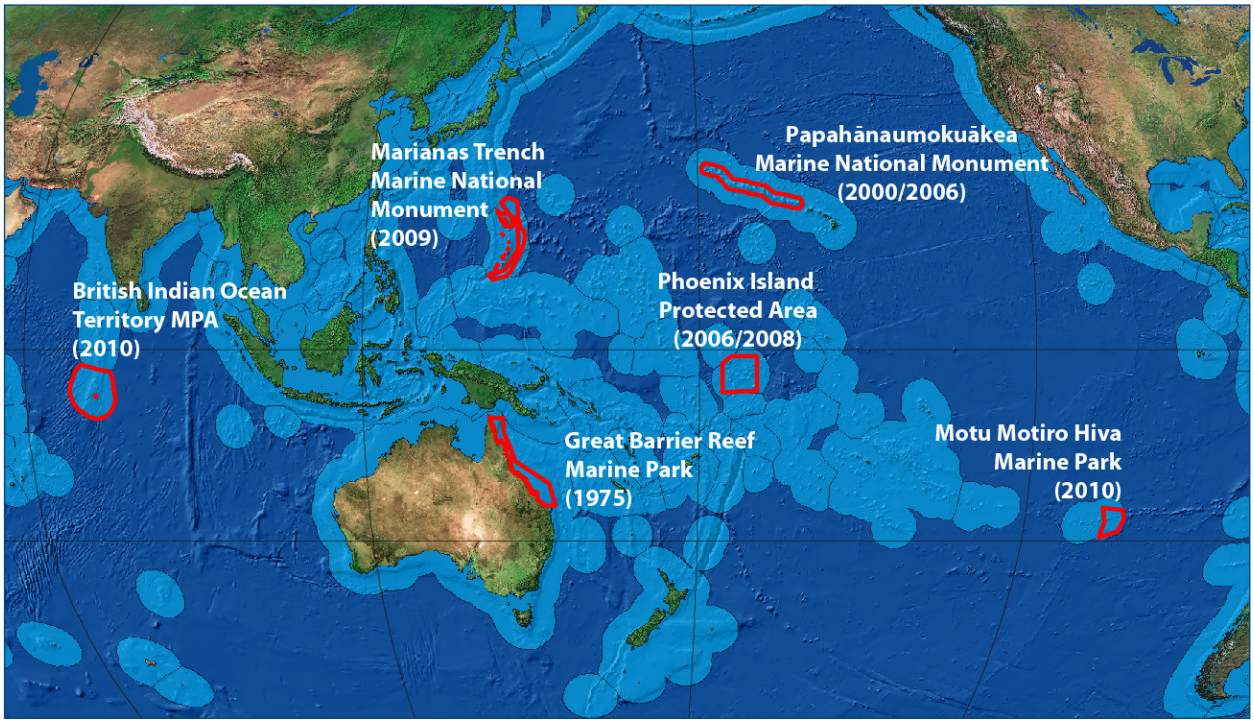


Figure 1: Map showing the geographic location of the six founding sites of the Big Ocean network. Dates in parenthesis indicate the year of designation.

Collectively, these six founding sites encompass more than 2.15 million km^2 (831,861 miles^2) of ocean ecosystems, which is roughly the same size as the Mediterranean Sea, or one-and-a-half times the size of the Gulf of Mexico (Big Ocean 2011). Additionally, at the time Big Ocean was established, these six sites jointly represented over 50% of the surface area of all MPAs worldwide (Spalding et al. 2010; Wilhelm et al. 2011; Fox et al. 2012). Besides formally establishing the network, the inaugural meeting led to the release of another communiqué, this time on the importance, contributions and needs of large-scale MPAs (Big Ocean 2011). As outlined in this communiqué, the goal of Big Ocean is to improve the effectiveness of large-scale management efforts by sharing information, expertise, and resources. Specifically, the network seeks to: (1) promote the development of management guidance by analyzing experiences with past management practices, (2) increase the understanding of the world's oceans by working together and sharing resources to support scientific research, and (3) communicate the conclusions and findings of the Big Ocean network both internally within the network, as well as to external parties that can use this information to guide management (Big Ocean 2011).

Following the inaugural meeting, representatives of Big Ocean sites gathered for a second time on May 13th, 2011 in Victoria, Canada in a meeting that preceded the 2nd International Marine Conservation Congress (Wilhelm et al. 2011; Figure 2). This second meeting identified future steps for the Big Ocean network, and highlighted the particular need of developing a cross-site scientific research agenda that focuses on the unique management challenges of large-scale MPAs (Wilhelm et al. 2011). For this purpose, Big Ocean managers and scientists convened for a third time in conjunction with the 25th International Congress for Conservation Biology (ICCB) in December 2011 in Auckland, New Zealand.

This third Big Ocean gathering included both a business meeting and a three day Think Tank, the latter of which was supported and hosted by the Society for Conservation Biology after being evaluated through a competitive peer-review process (Figure 2). The Think Tank, called "Big Ocean Network: A Research Agenda and Science Dissemination Strategy for Large-Scale MPAs," sought to build the framework for a shared research agenda, by identifying knowledge gaps, scientific needs and research priorities that are shared among Big Ocean and other large-scale MPAs.

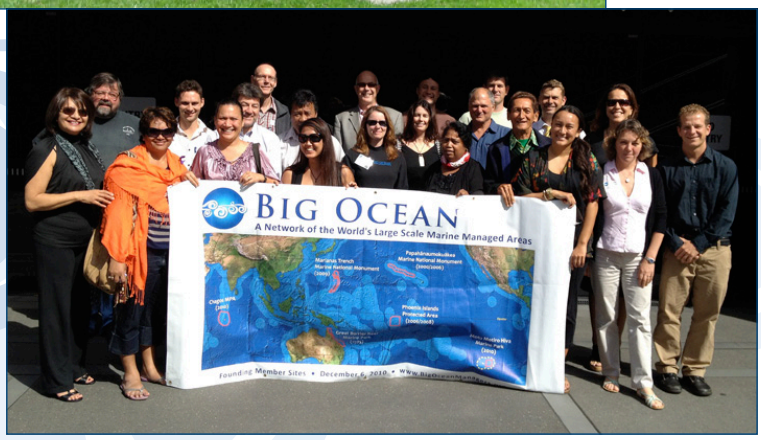


Figure 2: Big Ocean network meetings held between 2010 and 2011. Top: Big Ocean inaugural meeting held in Honolulu, Hawai'i on December 6th, 2010. Middle: Second Big Ocean meeting held in Victoria, Canada on May 13th, 2011. Bottom: Big Ocean network Think Tank workshop held on December 2-4, 2011 in Auckland, New Zealand.

1.2 Survey prior to the Think Tank workshop

In an effort to facilitate discussions on a shared research agenda, managers and scientists representing Big Ocean sites completed an online survey prior to the Think Tank workshop. The survey was designed to identify shared research needs across sites, as well as to foster thoughts on how to collaborate on research efforts across sites. A total of 14 managers and scientists completed the survey, which included representatives of all six of the inaugural Big Ocean sites (Figure 1). A review of the survey responses indicates that there are a number of commonalities in the research needs, priorities and challenges of Big Ocean sites (Figure 3). In particular, the most commonly shared scientific knowledge gaps include: (1) biological and ecological characterization, including a lack of understanding of the abundance and distribution of organisms, habitats and ecosystems; (2) connectivity, including both the biological connectivity through the movement of organisms, as well as physical connectivity through the circulation or air and water masses; (3) climate change impacts, including unknown effects caused by impending changes in temperature, weather, circulation, ocean water chemistry and sea levels; and (4) other anthropogenic impacts, particularly those associated with fisheries, marine debris and invasive species.

The survey also brought to light shared research challenges of Big Ocean sites, which include (1) lack of funding, technical expertise and capacity; (2) accessing study sites, especially geographically remote and deep areas; and (3) obtaining sufficient sample sizes which adequately represent the large scale of the area. According to the survey, the following research themes are most commonly prioritized at Big Ocean sites: (1) biological and ecological characterization; (2) connectivity; (3) climate change impacts; and (4) other anthropogenic impacts, in particular those caused by fisheries, invasive species and marine debris.

In terms of collaborative research, managers and scientists of Big Ocean sites noted the following opportunities: (1) coordinate studies between different sites through the exchange of expertise, methodologies and sample design, in order to allow for the comparison of results across sites, as well as to study various parameters on much larger scales; (2) share expertise, technologies and other resources, including shared research expeditions; (3) partner in fundraising efforts to secure funding for joint research activities; and (4) work together to document the benefits of large-scale MPAs.

Finally, the survey also highlighted some important scientific needs that are uniquely relevant to large-scale MPAs, including (1) accessing geographically remote and deep areas; (2) extrapolating research results to large scales from limited data collected on much smaller scales; and (3) understanding connectivity and other wide ranging processes on large scales.

While the survey pointed out some key commonalities in the research needs of Big Ocean sites, it is important to point out that the questionnaire was limited to the biological, physical and geochemical sciences. The survey therefore did not explore research priorities in culture, archaeology and social sciences, which are important focal points of the research activities conducted at various Big Ocean sites (Our Sea of Islands 2007; Big Ocean 2011; Wilhelm et al. 2011). Furthermore, survey questions were limited in number and scope, therefore creating various other inevitable biases.

Figure 3: Summary of the research needs and priorities that are shared among Big Ocean sites according to a survey completed by 14 Big Ocean managers and scientists prior to the Think Tank.

- **Scientific knowledge gaps**
  - Biological and ecological characterization
  - Connectivity
  - Climate change impacts
  - Other anthropogenic impacts (invasive species, fisheries effects, marine debris)

- **Research challenges**
  - Lack of funding, expertise and technical capacity
  - Access to remote and deep study areas
  - Large scale of study area

- **Research priorities**
  - Biological and ecological characterization
  - Connectivity
  - Climate change impacts
  - Other anthropogenic impacts (invasive species, fisheries effects, marine debris)

- **Collaborative research opportunities**
  - Coordinate studies to allow for comparison of results
  - Study different parameters on much larger scales
  - Share expertise, technologies and resources
  - Fundraising partnerships
  - Collaboratively document the benefits of large-scale MPAs

- **Unique scientific needs of large-scale MPAs**
  - Accessing geographically remote and deep areas
  - Issues of extrapolating research results to larger scales from limited data
  - Understanding connectivity on much larger scales

2. BIG OCEAN NETWORK: A RESEARCH AGENDA AND SCIENCE DISSEMINATION STRATEGY FOR LARGE-SCALE MPAs

2.1 Key objectives and principles

The foremost objective of the Big Ocean Think Tank was to demonstrate the value of large-scale MPAs, through the development of a shared scientific research agenda, specifically for those established and proposed sites that form the Big Ocean network. Managers and scientists representing all six founding Big Ocean sites (Figure 1) attended the workshop, as well as representatives of two large-scale MPAs that were in the process of being proposed at the time of the Think Tank: the Cook Islands Marine Park, proposed by the Cook Island government around the Southern Cook Islands, and the Kermadec Ocean Sanctuary, intended by the government of New Zealand around the Kermadec Islands (see Appendix 1 for complete list of workshop participants). Group discussions focused on identifying knowledge gaps, scientific needs and research priorities that are shared among large-scale MPAs, and on ways to improve access to relevant research information by managers and scientists.

The primary aims of such a shared research agenda identified at the outset were to:

1. capitalize on collaborative and comparative research opportunities that are based on the scientific needs shared by large-scale MPAs, and
2. identify a set of research priorities to be jointly addressed by Big Ocean sites.

While the shared agenda would primarily address mutual research needs of the Big Ocean network, this workshop highlighted that it would also be more broadly applicable to management efforts and scientific studies conducted on large, ocean-wide scales. In this context, executive decisions about the shared research agenda would be the responsibility of the managers of Big Ocean sites, while additional stakeholders would include all those interested in the science and management of large-scale MPAs, including managers, scientists, policy makers, economists, historians, archaeologists, cultural practitioners, and educators from federal and state agencies, academic institutions, community-based organizations, non-governmental institutions, cultural groups and private organizations.

The workshop started with participant introductions, along with a discussion on the key principles and aspirations for a shared research agenda. All workshop participants (Appendix 1) were invited to share their expectations, which were largely consistent with the objectives of the Big Ocean network outlined during its inaugural meeting (Big Ocean 2011); to *link, learn and lend*:

1. to *link* and reinforce connections between Big Ocean sites,
2. to *learn* about the unique scientific and management challenges of large-scale MPAs, and
3. to *lend* information, expertise and resources between sites and broader audiences in order to build capacity to improve future management efforts.

Based on the identified principles and aspirations for the shared research agenda, the group composed a set of key driving questions for the effective integration of science into the management of Big Ocean sites:

1. What makes our sites unique?
2. How much do our sites, individually and collectively, contribute to the greater good of the ocean?
3. How much do our sites depend on what's taking place outside the MPA boundary?
4. What does a site contribute to the welfare of people?
5. What are our management lessons learned and how could they be used by other sites?

Additionally, the group recognized that documenting the benefits and challenges of large-scale MPAs should be an essential priority of the shared research agenda. Finally, the Think Tank emphasized that as shared research priorities are identified, it is critical to determine upfront how the research will be beneficial to managers.

2.2 What makes research in large-scale MPAs unique?

Many of the discussions at the Big Ocean Think Tank focused on identifying factors and assumptions that differentiate research conducted in large-scale MPAs from scientific investigations conducted on smaller scale protected areas (Figure 4). The group recognized that a shared research agenda for Big Ocean should address and exploit features that are unique to large-scale MPAs (Figure 4). In particular, large MPAs contain entire ecosystems, including widespread pelagic and deep benthic ecosystems, which are generally not present in small MPAs. Additionally, due to their vast size, most large-scale MPAs are removed from human population centers and their many associated environmental impacts. As a result, large-scale MPAs contain comparatively pristine ecosystems which can be used as modern day baselines to quantify human impacts in other more populated areas. In this regard, large-scale MPAs serve as natural laboratories where ecosystems can be studied in the absence of many of the local stressors associated with human activities. This absence of local stressors makes large-scale MPAs particularly useful for research on global anthropogenic impacts like climate change, because the effects of climate change are not confounded by other local anthropogenic impacts. Furthermore, due to their size, large-scale MPAs contain ocean-scale natural processes, which cannot be studied in their entirety in smaller regions. This is particularly true for studies on connectivity, which generally require large study areas to adequately document the movement and interaction of all system components. On the other hand, studies on large-scales are also confronted with unique challenges. Mainly, resource limitations magnify when spread over a larger area. As a result, sample sizes are typically much smaller in relation to the entire area in large-scale than in small MPAs. This disparity creates more uncertainty when studying or managing large-scale MPAs.

Figure 4: Factors differentiating research conducted in large-scale MPAs from scientific investigations performed in smaller protected areas.

- Encompass entire ecosystems
- Contain a greater diversity of ecosystems (e.g. pelagic and deep benthic habitats)
- Removed from human population centers and their impacts
- Contain relatively pristine ecosystems (natural laboratories) which serve as control sites for comparison to inhabited areas
- Include larger scale processes
- Resource limitations magnify when spread over a larger area

2.3 Priority research themes

In an effort to identify research priorities that are shared among Big Ocean sites, one representative from each site presented on the research achievements, scientific gaps and research opportunities of their respective site at the beginning stage of the Think Tank. Additionally, results from the online survey (see section 1.2) were reviewed in order to foster discussions about what research themes should be prioritized in a shared research agenda.

While the group recognized that priority research themes are often overlapping, the following main themes were identified as being most relevant and shared amongst large-scale MPAs:

1. biological and ecological characterization, including studies on the abundance and distribution of organisms, habitats and ecosystems;
2. connectivity, including biological, physical and anthropogenic connectivity; and
3. monitoring of temporal trends, including patterns caused by both anthropogenic sources and natural variability.

In other words, these three research themes would focus on characterizing what natural resources are present at the sites, how these natural resources are connected to each other as well as to external sources, and how these natural resources change over time (see below for discussion on these three research themes).

It is imperative to point out, however, that discussions at the Big Ocean Think Tank focused solely on the biological, geochemical and physical sciences specific to the marine realm. The group therefore emphasized that an analogous workshop should be held in order to review the shared research priorities in the cultural and social sciences, as well as to examine the science needs of adjacent terrestrial and freshwater systems of large-scale MPAs.

2.3.1 Biological and ecological characterization

The objective of this research theme is to quantify the individual and collective contributions of Big Ocean sites to the total biological and ecological diversity of the globe. For this purpose, new statistical and graphical summaries must be developed. These summaries will need to take into account the highly three-dimensional scale of large MPAs, as pelagic and deep-sea environments, which are often absent from small MPAs, are abundant and widespread within all Big Ocean sites. The group further recognized the need for standardization in methodologies, so that information from different geographic regions can be compared. This does not mean that methods are universally standardized, but that comparable classification systems are used across sites. The first step in quantifying site contributions to the global scale will be to conduct a thorough synthesis of information available for each site, so that information gaps can be identified and addressed through future research activities. Given their enormous geographic scale, Big Ocean sites will need to explore new technologies such as autonomous vehicles and remote sensing, as well as invite technology developers to work closely with their research needs.

2.3.2 Connectivity

The purpose of this research theme is to understand the linkages of Big Ocean sites within their own site, amongst sites, as well as to adjacent regions. In this context, connectivity does not solely refer to the biological connectivity through the movement of organisms and their larvae, but also encompasses physical connectivity through the circulation of winds and currents, as well as anthropogenic connectivity through the spread of man-made impacts. In this regard, connectivity could also be viewed in a more narrative sense in terms of the degree of isolation or uniqueness of a particular place. Due to their large-scale, Big Ocean sites offer a much better opportunity to study connectivity over large geographic distances, as well as over wide depth ranges (Toonen et al. 2011). Additionally, Big Ocean sites are generally dominated by apex predators and other large animals, and their biological connectivity can thus be studied much more readily in large-scale MPAs than in smaller MPAs, where these large organisms are much less abundant. Identifying the range of movement of such large and highly mobile organisms has important implications on the effectiveness of a particular large-scale MPA in protecting these species, and is critical to establishing the minimum sizes of large-scale MPAs intended to protect these species. Furthermore, studying the range of movement of fishery species has important implications for MPAs as sites of food security. Many fisheries concentrate their efforts on the boundaries of MPAs (Roberts et al. 2001; Murawski et al. 2005), providing evidence that these large protected areas work to increase the abundance of some important fishery species.

2.3.3 Monitoring of temporal trends

The objective of this theme is to characterize historical baselines and understand temporal trajectories of ecosystems, so that resource population levels can be fore and hind casted at various times. Due to their remoteness, large-scale MPAs contain relatively pristine ecosystems that are virtually unaffected by local anthropogenic impacts. In this regard, ecosystems within Big Ocean sites provide control sites to which other systems can be compared, as well as temporal baselines for comparison to other time periods. Big Ocean sites thus serve as sentinel sites for human impacts. One of the first steps would be to identify historic and ongoing data sources for each site and to synthesize this data. Identifying what variables are measured and their sampling frequency is essential to understanding how temporal trends are being quantified at each site.

2.4 Criteria for the selection and prioritization of Big Ocean research efforts

Given that research resources are limited, the shared research agenda will need to allow managers to evaluate potential collaborative research efforts to determine which projects should be prioritized. Collaborative research projects will need to: (1) have clear defined objectives which are achievable with the available resources, (2) benefit Big Ocean sites, as well as the network as a whole, and (3) provide a global contribution to the understanding of the world's oceans (Figure 5). Only those projects meeting all of these criteria should be prioritized by the Big Ocean network. Additionally, these three research criteria should be used to rank potential research projects, with the highest priority projects being those that are most easily achievable with the available resources, provide the greatest benefits to the Big Ocean network and its sites, and represent the greatest global contribution.

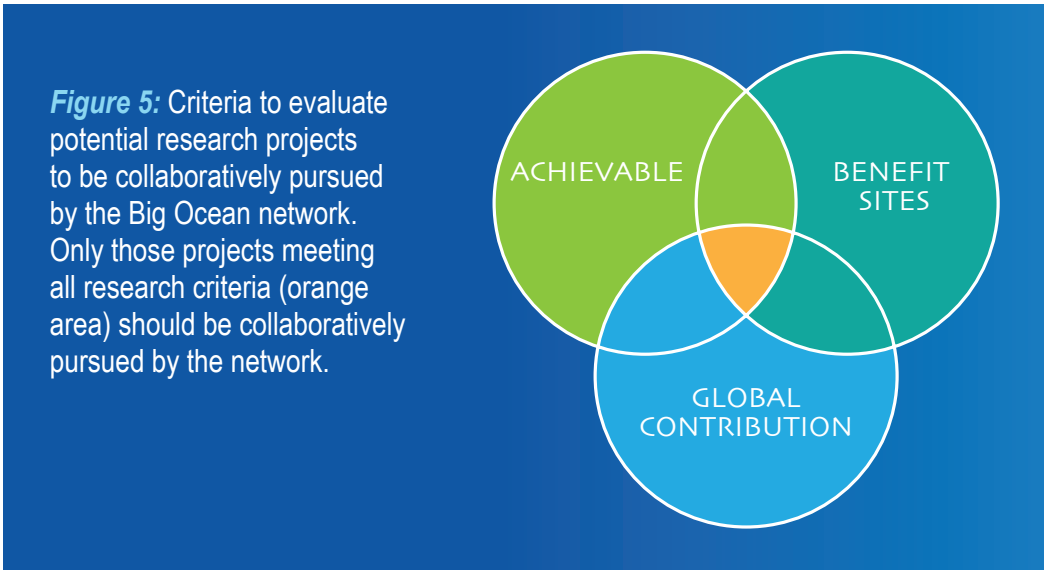


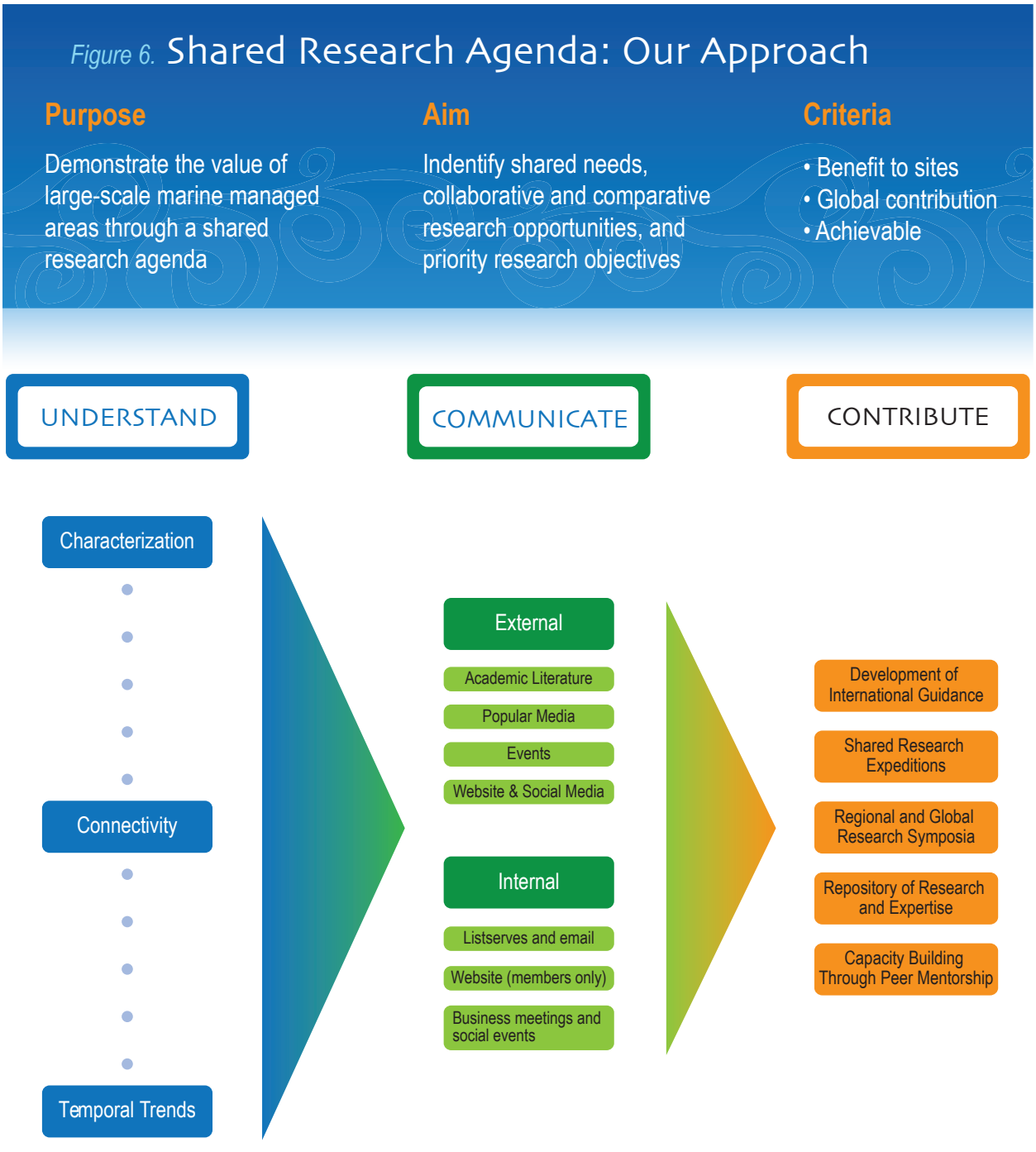
Figure 5: Criteria to evaluate potential research projects to be collaboratively pursued by the Big Ocean network. Only those projects meeting all research criteria (orange area) should be collaboratively pursued by the network.

2.5 The approach

After discussing both the priority research themes and criteria used to evaluate collaborative efforts, the Think Tank group agreed to an approach that included three underlying purposes and benefits of the research agenda which motivate the group to: (1) understand, (2) communicate, and (3) contribute. The group agreed that these three core benefits would collectively guide the shared research agenda for Big Ocean.

Identifying characterization, connectivity and monitoring of temporal trends as the core content focus of the shared agenda was critical in defining what exactly Big Ocean is trying to understand about the benefits and challenges of large-scale MPAs. It was agreed, however, that understanding was not enough, therefore a key objective of the agenda was to communicate the findings and outcomes of the shared research both internally within the network to build capacity and foster shared learning, as well as externally to conservation, scientific and broader audiences. But why? It was further agreed that neither increased understanding or communication were the group's end-goals. The primary motivation for a

shared research agenda was to ensure that the work of Big Ocean contribute directly and purposefully to marine conservation and the broader efforts to protect the oceans around the globe (Figure 6).



2.6 Potential collaborative initiatives

With this approach in mind (see section 2.5), the Think Tank group identified a set of potential collaborative initiatives that would meet all of the selection criteria (see section 2.4), and therefore be important in the development and strengthening of the Big Ocean network:

2.6.1 Peer-reviewed scientific articles

The publication of peer-reviewed scientific articles would greatly benefit Big Ocean by increasing the network's scientific credibility and thereby leverage funding for joint research projects. These peer-reviewed articles should target both marine science and marine policy journals, and evaluate the value of large-scale MPAs, as well as what factors differentiate them from smaller scale MPAs in terms of science and management needs.

2.6.2 Popular literature articles

In addition to publishing articles in scientific journals, the group recognized that exposure in the popular literature (e.g. Time Magazine, National Geographic) would communicate the value of large-scale MPAs to much broader audiences. Several Big Ocean sites have already been featured in popular literature publications, but there is a lack of articles discussing the value and unique characteristics of large-scale MPAs.

2.6.3 Guidebook for the management of large-scale MPAs

Despite of the fact that the International Union for Conservation of Nature (IUCN) has previously published several guidebooks on the management of MPAs (e.g. Salm et al. 2000; Pomeroy et al. 2004; Wells and Mangubhai 2005), these have all focused on smaller scale MPAs and do not discuss the unique challenges associated with the management of large-scale MPAs. Through the collective experiences of Big Ocean sites, the network and its associated managers and scientists could produce a guidebook on the management and science of large-scale MPAs.

2.6.4 Shared research expeditions

The Think Tank emphasized that sharing research expeditions could lower costs and provide scientific information that is relevant to more than one site. Creating a calendar with future research expeditions and their respective goals would be the first step towards shared expeditions. Such a calendar could minimize the risks of duplicating efforts, and start conversations about sharing expertise and personnel on future research expeditions.

2.6.5 Shared research symposia

Effective communication between scientists and resource managers is essential for the integration of science into management, and research symposia offer an important platform for this exchange. Several Big Ocean sites organize research symposia showcasing their scientific and management achievements, and these could be expanded to include research conducted throughout multiple large-scale MPAs.

2.6.6 List of publications and registry of expertise

Reviewing past research efforts is the first step in designing any research program, and the group recognized that compiling a comprehensive list of publications and registry of expertise for each site would be crucial for this effort. The list of publications should not be limited to peer-reviewed scientific journals, but also include historical and management documents, as well as articles from the gray literature and cultural knowledge. Such a comprehensive list of publications could support efforts to synthesize what has been studied in the past, thereby identifying knowledge gaps. Additionally, the list of publications could identify scientific experts, which could then be consulted when developing future research projects.

2.6.7 New site design and development of technical assistance

Recognizing that establishment of new large-scale MPAs is only the beginning of the management journey, both managers and scientists alike identified the critical importance of proper upfront design of a site using best available science and management. As requested by an interested nation, Big Ocean members can contribute to new site development through site diagnostic workshops and onsite technical assistance.

2.6.8 Capacity building via peer mentorship program

The Big Ocean network could be used to leverage funding to develop a peer mentorship program to build capacity among young managers and scientists. In particular, student and mentor exchanges between sites could be used to build capacity to improve future management efforts.

2.6.9 Internal network communications

Continuous communication within the network will be essential to achieve any of the above collaborative research initiatives. The Think Tank emphasized that the Big Ocean listserves and website (http://www.bigoceanmanagers.org) will need to be continuously updated and expanded in order to achieve joint research activities, with contributions made by each member site in order to be most effective. Additionally, Big Ocean members will need to continue to hold business meetings at upcoming conferences in order to solidify the network and undertake joint research projects.

With these potential collaborative research initiatives in mind, the Think Tank ended with a discussion on the near-term objectives and activities to be pursued under the shared research agenda for Big Ocean. While the group recognized that this is a living document that is subject to change, a two year work plan was developed which includes objectives, activities, success indicators and lead personnel for various collaborative research initiatives.

3. CONCLUSION

Encompassing more than 2.15 million km^2 (831,861 miles^2) of ocean ecosystems, Big Ocean sites represent over half of the surface area of all MPAs worldwide. Since the network's establishment in 2010, Big Ocean has contributed to the global understanding of the unique needs and challenges of large-scale MPAs. Big Ocean therefore serves as not only a source of information, expertise and resources, but also as a peer-support group for assisting in the establishment of new large-scale MPAs. Discussions at the Big Ocean Think Tank generated consensus on the shared scientific needs and challenges of large-scale MPAs. While we recognize that this is a living document that is subject to change, our goal is that this document will facilitate future collaborative research efforts among Big Ocean sites, provide guidance and encouragement to prospective Big Ocean members, and improve marine management efforts worldwide.

4. ACKNOWLEDGEMENTS

The Marine Conservation Think Tank on "Big Ocean: A Research Agenda and Science Dissemination Strategy for Large-Scale MPAs" was hosted and supported by the Society for Conservation Biology and the International Congress for Conservation Biology. Additional support for the Think Tank was provided by National Oceanographic and Atmospheric Administration's Office of National Marine Sanctuaries, the National Marine Sanctuary Foundation, Conservation International, the New England Aquarium, the Hawai'i Institute of Marine Biology and Marine Management Solutions. Special thanks to 'Aulani Wilhelm, Alan Friedlander, Andrew Skeat, Anne Sheppard, Brian Bowen, Carlos Gaymar, Charles Sheppard, Daniel Wagner, Gustavo San Martin, Ian Wright, Jason Philibotte, John Parks, Jolene Bosanquet, Joseph Brider, Kahi Fujii, Kahoane Aiona, Kim Morishige, Liz Wright-Koteka, Nai'a Lewis, Noeline Brownie, Randall Kosaki, Randi Rotjan, Regen Jamieson, Rob Toonen, Rochelle Constantine, Schannel van Dijken, Sean Anderson, Sue Taei, Tania Temata, Tim Carruthers, Trevor Durbin, Tukabu Teroroko, Tupe Short, Wiriki Tooma and Zeenatul Basher for their valuable contributions to this document.

APPENDIX 1

List of workshop participants and contributors of the Big Ocean Think Tank held in Auckland, New Zealand on December 2-4, 2012. The purpose of this workshop was to produce a shared research agenda for large scale MPAs.

NAME	AGENCY
ʻAulani Wilhelm	Papahānaumokuākea Marine National Monument, U.S.A.
Alan Friedlander	Hawaiʻi Cooperative Fishery Research Unit, U.S.A.
Andrew Skeat	Great Barrier Reef Marine Park Authority, Australia
Anne Sheppard	Chagos Conservation Trust, United Kingdom
Brian Bowen	Hawaiʻi Institute of Marine Biology, U.S.A.
Daniel Wagner	Papahānaumokuākea Marine National Monument, U.S.A.
Gustavo San Martin	Undersecretary for Fisheries, Chile
Ian Wright	National Oceanographic Center, United Kingdom
Jason Philibotte	Conservation International
John Parks	Marine Management Solutions, U.S.A.
Jolene Bosanquet	Te Ipukarea Society, Cook Islands
Joseph Brider	National Environmental Services, Cook Islands
Kahoane Aiona	University of Hawaiʻi, U.S.A.
Kim Morishige	University of Hawaiʻi, U.S.A.
Liz Wright-Koteka	Cook Islands Government
Naiʻa Lewis	Papahānaumokuākea Marine National Monument, U.S.A.
Noeline Brownie	Cook Islands
Randall Kosaki	Papahānaumokuākea Marine National Monument, U.S.A.
Randi Rotjan	New England Aquarium, U.S.A.
Regen Jamieson	New England Aquarium, U.S.A.
Rob Toonen	Hawaiʻi Institute of Marine Biology, U.S.A.
Rochelle Constantine	University of Auckland, New Zealand
Schannel van Dijken	Conservation International
Sean Anderson	California State University Channel Islands, U.S.A.
Sue Taei	Conservation International
Tania Temata	Cook Islands Government
Tim Carruthers	Secretariat of the Pacific Regional Environment Programme, Samoa
Trevor Durbin	Rice University, U.S.A.
Tukabu Teroroko	Phoenix Islands Protected Area, Republic of Kiribati
Tupe Short	Koulū Nui, Cook Islands
Wiriki Tooma	Ministry of Environment, Republic of Kiribati
Zeenatul Basher	University of Auckland, New Zealand

5. REFERENCES

Big Ocean (2011). Communiqué. December 6, 2010. Honolulu, Hawai'i. 3 pp.

Fox HE, Soltanoff CS, Mascia MB, Haisfield KM, Lombana AV, Pyke CR and Wood L (2012). Explaining global patterns and trends in marine protected area (MPA) development. Marine Policy 36: 1131-1138.

Murawski SA, Wigley SE, Fogarty MJ, Rago PJ and Mountain DG (2005). Effort distribution and catch patterns adjacent to temperate MPAs. ICES Journal of Marine Science 62: 1150-1167.

Our Sea of Islands (2007). Our Sea of Islands Communiqué – A regional Forum for Oceania on Marine Managed Areas and World Heritage. 29 January – 2 February, 2007. Honolulu, Hawai'i. 4 pp.

Pomeroy RS, Parks JE and Watson LM (2004). How is your MPA doing? A guidebook of natural and social indicators for evaluating marine protected area management effectiveness. Gland, Switzerland and Cambridge, U.K.: IUCN. 215 pp.

Roberts CM, Bohnsack JA, Gell F, Hawkins JP and Goodridge R (2001). Effects of marine reserves on adjacent fisheries. Science 294: 1920-1923.

Salm RV, John RC and Siirila E (2000). Marine and coastal protected areas: a guide for planners and managers. Washington D.C., U.S.A.: IUCN. 371 pp.

Spalding M, Wood L, Fitzgerald C, Gjerde K (2010). The 10% target: where do we stand? In: Global Ocean protection: Present Status and Future Possibilities (eds. Toropova C, Meliane I, Laffoley D, Matthews E and Spalding M). Brest, France: Agence des aires marines protégées; Gland, Switzerland, Washington, DC and New York, U.S.A.: IUCN WCPA; Cambridge, U.K.: UNEP-WCMC; Arlington, U.S.A.: TNC; Tokyo, Japan: UNU; New York, U.S.A.: WCS. 96 pp.

Toonen RJ, Andrews KR, Baums IB, Bird CE, Concepcion GT, Daly-Engel TS, Eble JA, Faucci A, Gaither MR, Iacchei M, Puritz JB, Schultz JK, Skillings DJ, Timmers M and Bowen BB (2011). Defining boundaries for applying ecosystem-based management: A multispecies case study of marine connectivity across the Hawaiian Archipelago. Journal of Marine Biology: Article ID 460173.

Wells S and Mangubhai S (2005). A workbook for assessing management effectiveness of marine protected areas in the Western Indian Ocean. Nairobi, Kenya: IUCN Eastern African Regional Programme. 62 pp.

Wilhelm A, Taei S and Teroroko T (2011). Big Ocean: A Network of the World's Large-Scale Marine Managed Areas. Second International Marine Conservation Congress. May 17, 2011. Victoria, Canada. 13pp.