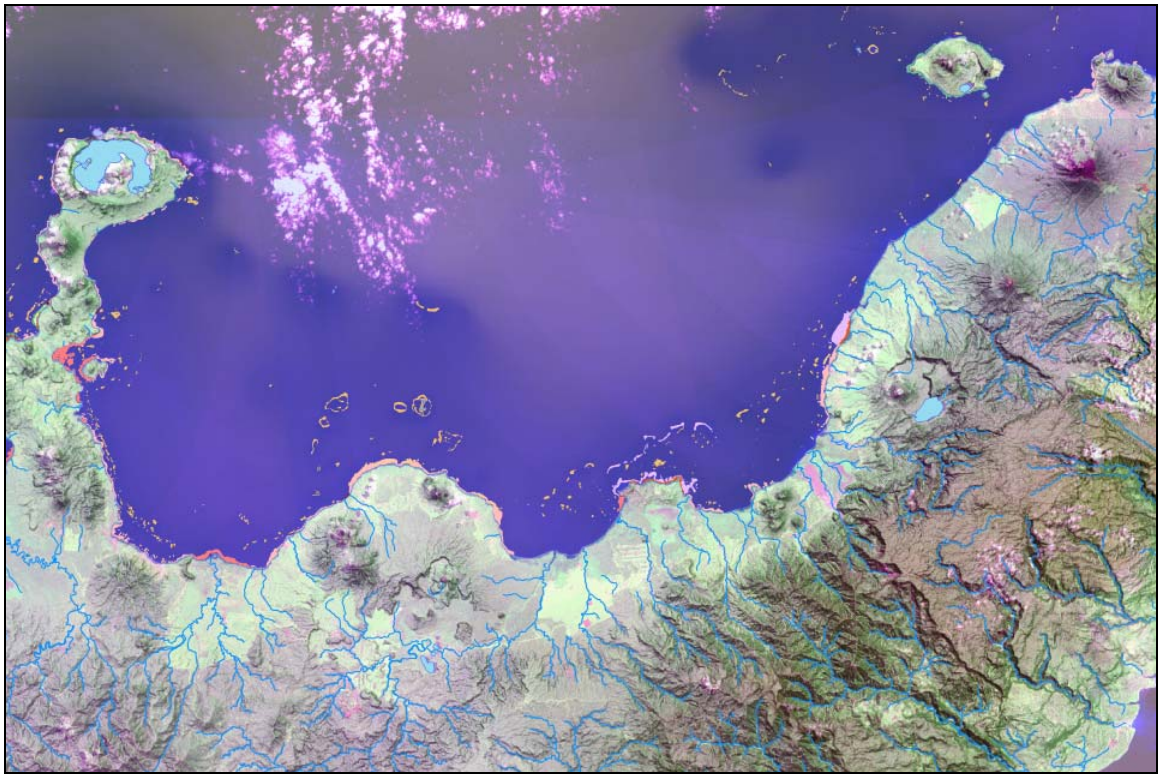
DESIGNING A RESILIENT NETWORK OF MARINE PROTECTED AREAS IN KIMBE BAY, WEST NEW BRITAIN, PAPUA NEW GUINEA



Landsat 6 image of Kimbe Bay (resolution 28m).

Recommendations from the First Scientific Workshop held at the International Marine Projects Activity Centre, Townsville, Australia (February 9-11, 2004)

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

TNC Pacific Island Countries Report No. 11/04

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FORWARD

The Nature Conservancy first became interested in Kimbe Bay, West New Britain as a long term marine conservation project site in 1992, during the early scoping work for the new program in Papua New Guinea. Aside from the spectacular volcanic landscape, the ever-changing moods of the Bay, the magnificence of the coral reefs and abundance of marine life, the decision to invest in Kimbe Bay was influenced by the relative health of these systems and a sense that we could work to abate the immediate threats posed by destructive fishing and land use practices. Much has been accomplished by many people in the intervening decade and TNC and its partners have now built the strong conservation foundation needed to support work towards our long term goal to establish a large-scale, resilient and effectively managed Marine Protected Area network for the Bay, which will help sustain the livelihoods of the communities and people of Kimbe Bay.

Long term engagement with local communities through education and awareness programs has helped to reduce the impact of once widespread destructive fishing practices and resulted in partnerships which are now being translated into community inspired conservation action through the establishment of Locally Managed Marine Areas. Similarly, promising new partnerships are being developed with private enterprise to find solutions to the impact of land based impacts on the Bay's marine diversity. However, in recent years the Bay, like many other coral reef regions in the world, has felt the impact of coral bleaching and global climate change. For our goal to be sustainable we must also address this issue by ensuring we build resilience to global change into the Kimbe Bay network.

This workshop brings together experts to assess our knowledge of the Bay and provide scientific advice for designing the network. It is a vital first step in establishing the network and I thank all those concerned for their enthusiastic participation, willingness to share their knowledge and expertise, and on-going commitment to the protection of Kimbe Bay's unique marine ecosystems.

Peter Thomas
Director
Pacific Island Countries Program
The Nature Conservancy

Kimbe Bay coastline showing nearshore reefs.

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EXECUTIVE SUMMARY

The Nature Conservancy is engaged in establishing a resilient network of Marine Protected Areas in Kimbe Bay, West New Britain Province, Papua New Guinea. This will require strong partnerships with local communities, sustainable industries, scientists, other non-government agencies, and government partners. Preliminary discussions with communities and partners indicate that there is good support for the network.

In February 2004, a workshop was held in Townsville, Australia to provide scientific advice for refining the network design. The workshop focused on:

- Providing important background information on the Conservancy's marine conservation program in PNG, and the proposal to establish a resilient network of MPAs in Kimbe Bay;
- Learning lessons from other locations which have, or are in the process of, designing and implementing MPA networks; and
- Summarizing existing information on the biophysical (biological and physical) and socioeconomic characteristics of the Bay.

This information was then used to define the objectives, conservation targets, and geographic extent of the network, as well as the design principles (both biophysical and socioeconomic) required to achieve network objectives. Key information gaps and research priorities that need to be addressed prior to designing the network were also identified.

The results of this workshop will form the basis for further discussions with local communities and other partners, with a view to establishing a fully functional MPA network by 2008.

Schumann Island, fringing and patch reefs.

BACKGROUND

The Nature Conservancy

The Nature Conservancy's (TNC) mission is to "To preserve the plants, animals and natural communities that represent the diversity of life on earth by protecting the lands and waters they need to survive." To achieve this goal, the Conservancy has developed a strategic, science-based planning process, called Conservation by Design, which helps identify the highest-priority places that, if conserved, will ensure that biodiversity is conserved in the long term.

High priority areas for conservation are identified through Ecoregional Conservation Assessment. Once they have been identified, Conservation Area Planning is used to identify strategies to protect the biodiversity of these areas. In the marine realm, establishing networks of Marine Protected Areas (MPAs)[1] has been identified as an important strategy for protecting marine biodiversity. Once established, these areas will be monitored to ensure that they are achieving their stated objectives. Further information on TNC is available at www.tnc.org

Transforming Coral Reef Conservation

Transforming Coral Reef Conservation is a worldwide program of TNC's Global Marine Initiative, where the Conservancy has joined forces with marine experts to transform coral reef conservation in the 21st century. This program recognizes the serious threat that global change poses to marine ecosystems, and provides advice on how to design large-scale networks of MPAs to ensure that they are resilient in the face of global change by:

- Spreading the risk by protecting representative and replicated areas of major habitat types;
- Safeguarding special and unique sites, particularly those that provide key sources of larvae such as fish spawning aggregation sites and areas that may be naturally more resistant or resilient to coral bleaching;
- Preserving ecological connectivity among coral reefs and related ecosystems due to ocean currents, larval dispersal, and movement of adults (this is important for maintaining natural patterns of connectivity and facilitating recovery of areas affected by major disturbances); and
- Continuing to effectively manage other threats, such as water quality and over-fishing, to ensure that reefs are as healthy and naturally resilient as possible to improve their chances of surviving global change.

[1] Consistent with international usage (Kelleher 1999), MPAs are defined as "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical, and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment." There are many forms of MPAs with many different local names and uses. Most are designed to contain zones with different uses that preserve and enhance recreational, commercial, scientific, cultural and conservation values.

Kimbe Bay: Marine Conservation Platform Site in PNG

One of the primary goals of TNC's marine conservation program in Papua New Guinea (PNG) is to establish resilient networks of MPAs, based on Transforming Coral Reef Conservation principles. This work is focused at two scales:

- Kimbe Bay will be used as a platform site, where these principles will be applied for the first time in PNG; and
- Methods developed in Kimbe Bay will provide the basis for establishing a larger scale resilient network of MPAs in the Bismarck Sea, beginning with other priority areas in the Tigak Islands (near Kavieng, New Ireland Province) and extending later to Manus Province (Fig 1). TNC will also work with conservation partners working elsewhere in the Bismarck Sea, to expand the network beyond these areas.

The Conservancy is also working with local communities to address closely related fisheries issues through the:

- Management of the Live Reef Food Fish Trade (LRFFT),
- Protection of spawning aggregations of species targeted by the LRFFT and of subsistence importance to local communities; and
- Protection of fisheries resources using Locally Managed Marine Areas (LMMAs)[2].

Fig 1. Location of Kimbe Bay, Kavieng, and Manus Island in the Bismarck Sea.

[2] As defined by the Locally Managed Marine Area Network, a LMMA is a delineated marine area, including coral reefs, seagrass beds, mangroves or other associated areas, where special management rules are applied and has significant management input from local stakeholders and interests.

Over the last decade, the Conservancy's marine conservation activities in Kimbe Bay and elsewhere in the Bismarck Sea have focused on:

- Building the capacity of our local partner, Mahonia Na Dari (MND[3]), which has worked with other partners to establish the Kimbe Bay Marine Conservation and Research Center, helped communities create their first LMMAs, and conducted a successful education program focusing on marine conservation and addressing key threats (eg destructive fishing practices).
- Providing technical support for LMMAs by drafting legislation for Local Level Government to assist communities in protecting these areas, and by supporting a scientific monitoring program (by James Cook University) to monitor their success.
- Assessing the biodiversity of Kimbe Bay through a series of Rapid Ecological Assessments. To date, these surveys have focused on coral reefs, mangroves and cetaceans (further studies are required).
- Supporting research into coral reef ecology by partner institutions, particularly James Cook University and University of PNG.
- Participating in ecoregional planning for the Bismarck Solomon Seas Ecoregion (led by World Wildlife Fund), and conducting a more detailed Ecoregional Conservation Assessment for the Bismarck Sea.
- Undertaking Conservation Area Planning for Kimbe Bay to identify conservation targets, their current status and long term viability, threats and sources of threats to these targets, and strategies for addressing these threats.
- Addressing threats to marine ecosystems from land use practices in partnership with industry.
- Working with local dive operators and the PNG Dive Association to establish an environmentally sensitive mooring system in Kimbe Bay and throughout PNG.
- Expanding TNC's conservation activities in the Bismarck Sea with a focus on management of the live reef food fish trade and protecting reef fish spawning aggregations.

The success of these programs has meant that local communities in Kimbe Bay now have a strong desire to engage in marine resource management, particularly with regard to the use of MPAs. This has provided a strong basis for expanding our conservation activities to a larger, more robust scale by designing and implementing a network of MPAs for the entire bay based on the principles of Transforming Coral Reef Conservation. While our work to date has been an important first step in engaging local communities in conservation and building partnerships with sustainable industries, non-government, government, and academic institutions, a larger-scale approach is now required to achieve lasting protection for Kimbe Bay. The goal is to consolidate our learning in Kimbe Bay and create a lasting, well-designed MPA network that produces conservation results, before expanding to other high priority areas in the Bismarck Sea.

The Conservancy is particularly interested in understanding the best way to integrate LMMAs within a larger scale, more comprehensive network of MPAs for the Bay.

[3] The local translation of Mahonia Na Dari is "Guardians of the Sea".

LMMAs are established by local communities to protect their marine resources, and have played an important role in building community support for protecting Kimbe Bay's marine ecosystems. However at present they are unlikely to protect the full range of biodiversity in the Bay because they only represent a small proportion of one of the Bay's many habitat types (inshore reefs), they have not been selected based on scientific principles, and they appear to have been compromised by a lack of strict compliance with fisheries closures. Despite these challenges, preliminary monitoring results suggest that we may be starting to see fisheries benefits of these closures for at least two key species (Jones et al 2004). In the future, LMMAs will continue to play an important role in protecting inshore marine resources for local communities, and in building a more comprehensive network of MPAs for the Bay.

Establishing a Resilient Network of Marine Protected Areas in Kimbe Bay

What is Proposed?
Together with our partners, TNC is designing and implementing a network of MPAs aimed at protecting biodiversity and incorporating the principles of Transforming Coral Reef Conservation. In applying these principles, we recognize that it is essential that the network is relevant and useful to local communities and industries. Our aim is to achieve the biological objectives of the network, while minimizing the cost and maximizing the benefits to local communities and sustainable industries.

It is also important to recognize that the MPA network cannot address all threats to marine ecosystems in the Bay, particularly those originating from outside the MPA boundaries (eg runoff from land use practices). Therefore, it is essential that the network be embedded in a broader management regime to be effective.

The goals of the Kimbe Bay MPA program for the next four years are to design a large-scale, resilient network of MPAs, and to protect at least 20% of the high priority areas for conservation. An additional 30% of these areas will be in the process of being protected.

Why Kimbe Bay?
Conservation activities over the last decade have provided a strong basis for marine conservation in Kimbe Bay (see *Kimbe Bay: A Marine Conservation Platform Site in PNG*). As a result of these activities, there is a good relationship among conservation groups, local communities, scientists and sustainable industry (particularly tourism) in the Bay, which provides substantial support for conservation activities in the area. Local communities also have a positive history of commitment to conservation, a strong desire to engage in marine resource management, and are particularly well disposed towards MPAs based on their experience with LMMAs.

Kimbe Bay is also a good candidate for establishing a MPA network based on several biophysical and socioeconomic characteristics:

Biophysical Characteristics

Kimbe Bay is a spectacular land and seascape on the north coast of the island of West New Britain (WNB) in PNG (Fig 1: 5° 15'S; 150°15'E). The landscape is dominated by numerous volcanic cones, which reach heights of over 2000m in close proximity to shore (Fig 2). Three of the volcanoes are currently active: Mt Pago, Mt Gabuna, and Mt Uluwan.

Kimbe is a large bay (140km x 70km: Fig 3), and a well-defined geographic feature with distinct boundaries: Willaumez Peninsula to the west and Cape Tokoro to the east. Because of the shape of the Bay, it is likely to comprise one or two functional seascapes[4].

The seascape is quite dramatic (Fig 2). Most of the Bay is deep (more than 500m), with a narrow shelf (less than 200m deep) along the coast. On the eastern and outer portions of the Bay, the shelf drops off steeply into very deep water (more than 2000m) very close to shore. The western portion of the Bay is shallower than the eastern side, but still reaches depths in excess of 600m.

Kimbe Bay is also one of the world's most diverse and significant tropical marine environments. The Bay comprises a wide variety of shallow (coral reefs, mangroves, and seagrasses) and deepwater (oceanic waters, seamounts, and possibly deep-sea canyons and hydrothermal vents) marine habitats in very close proximity (Figs 2 & 3). Many of these habitats are of high conservation value.

Rapid Ecological Assessments have described healthy coral reefs with high biodiversity, (Holthus 1994, Beger 2002, Turak & Aitsi 2002), particularly on the eastern and mid to outer portions of the Bay. These reefs are considered part of the global center of marine biodiversity area known as the coral triangle (Fig 4: Green & Mous 2004). Preliminary surveys have also described small, but ecologically significant mangrove forests and extensive seagrass communities in Stettin Bay, with reasonably high biodiversity (Sheaves 2002: further studies are required).

Conservation Area Planning has identified the following habitats and species as having high conservation value in the Bay:

- Offshore reef systems and islands;
- Inshore reef systems (Stettin Bay and Eastern Kimbe Bay);
- Mangrove systems;
- Seagrass systems;
- Estuaries;
- Rare and threatened species; and
- Vulnerable invertebrate species.

[4] Areas within a wider ecoregion within which there is some geographical or ecological distinctiveness, but over a smaller area that maybe more suitable for the application of management measures such as MPA networks (see Green & Mous 2004).

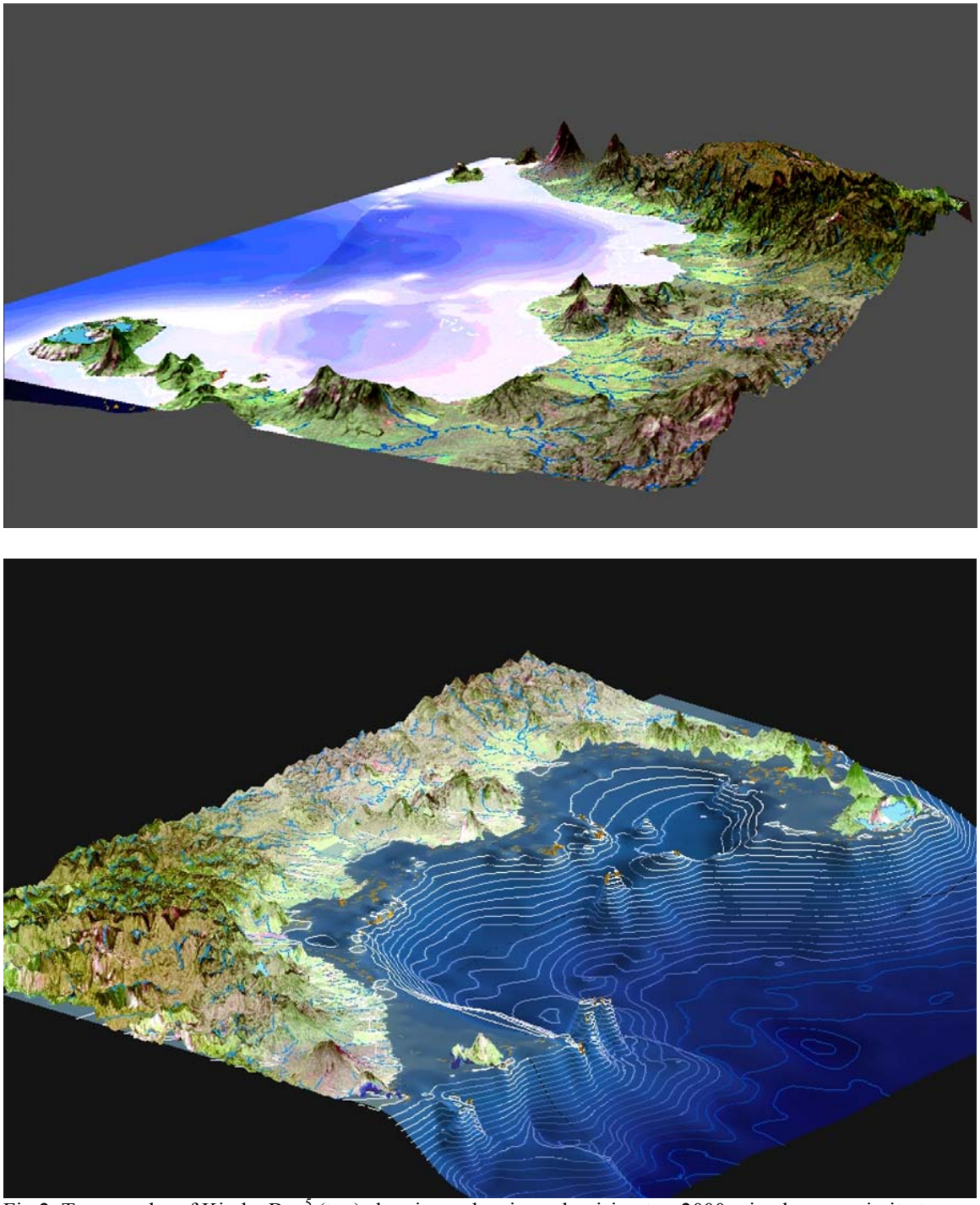

Fig 2. Topography of Kimbe Bay[5] (top) showing volcanic peaks rising to >2000m in close proximity to shore; and bathymetry[6] (bottom) showing the narrow coastal shelf (maximum depth 200m) plunging to deep ocean depths of >2000m.

[5] Based on the Space Shuttle's Radar Topography Mission (90m digital elevation model: NASA 2003).
[6] Interpolated from best available bathymetric data (Navigation Charts and the General Bathymetric Chart of the Oceans) overlaid with IMaRS 2004 geomorphology for the coastline and reefs. Contour intervals are approximately 100m

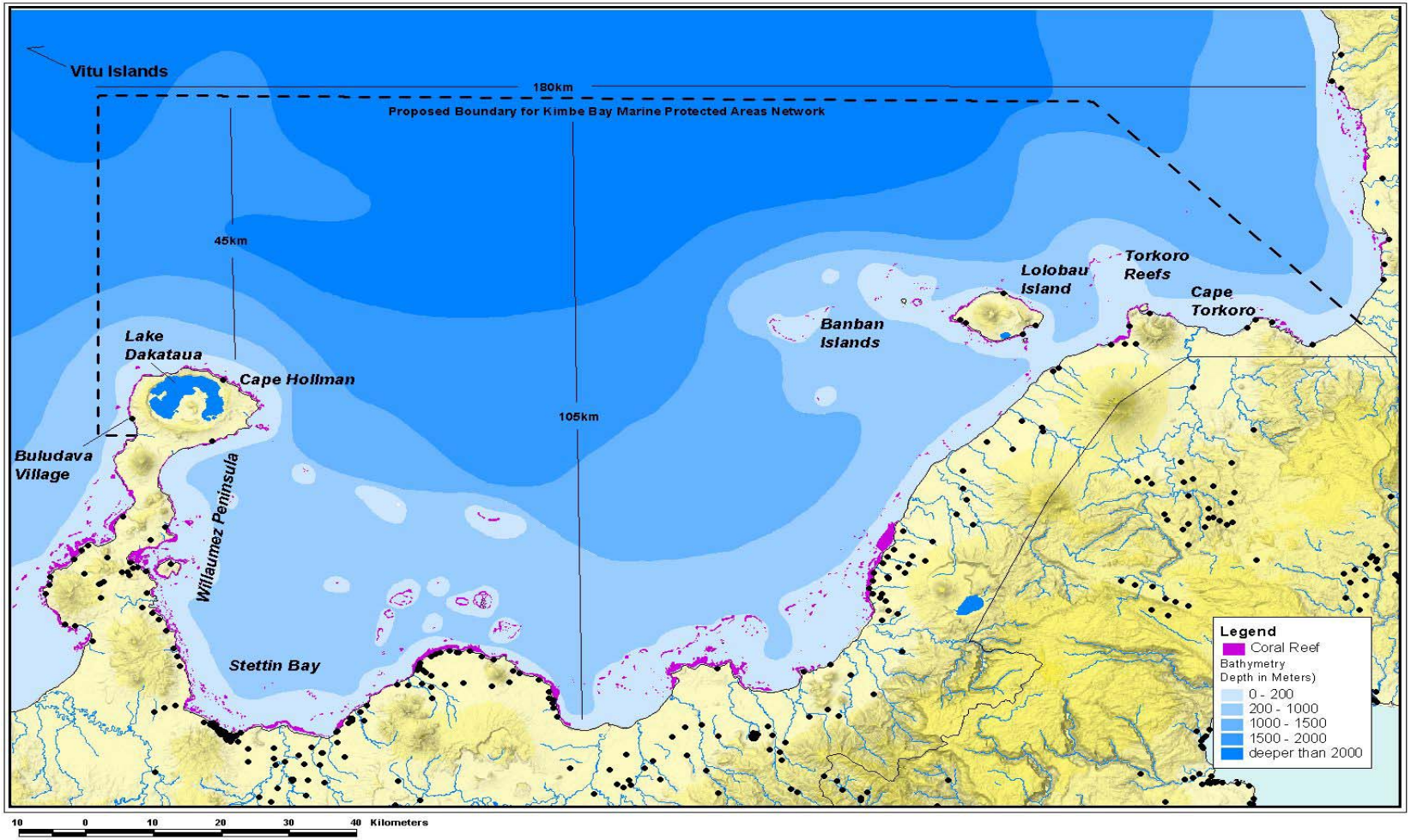

Fig 3. Kimbe Bay showing location of shallow (coral reefs, mangroves and seagrasses) and deepwater habitats in Kimbe Bay (coral reef data acquired from IMaRS 2004), and the proposed boundaries for the MPA Network: the outer boundary is delineated by the dotted line, and the inner boundary is the highest astronomic tide on the coast.

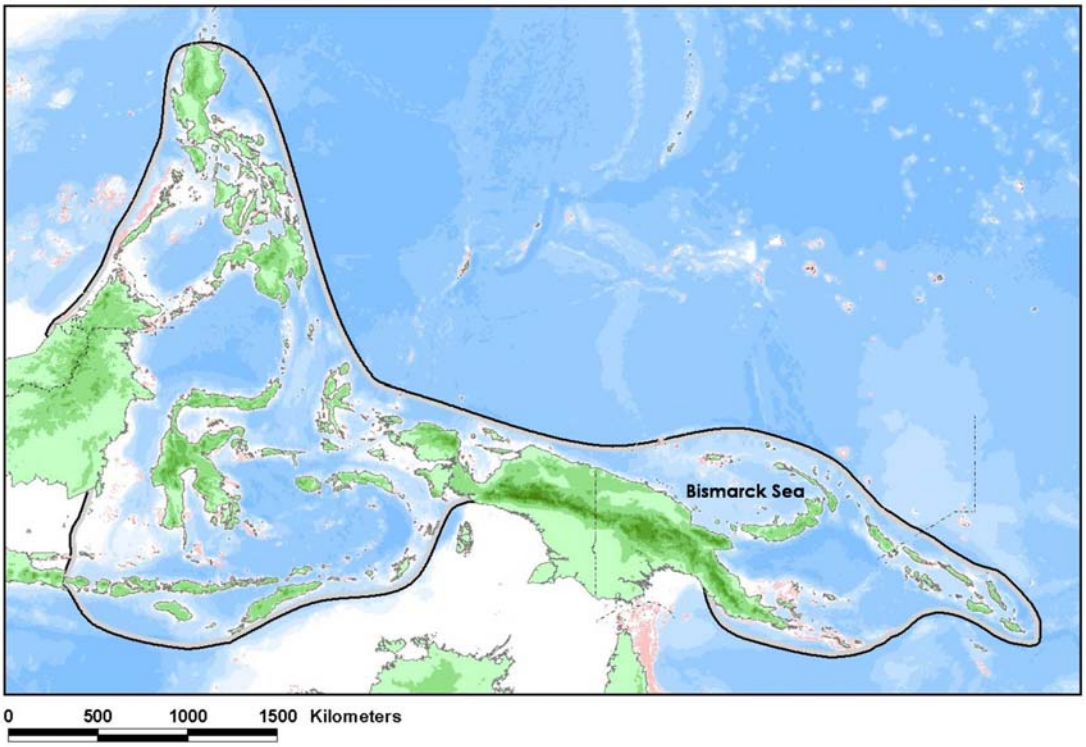

Fig 4. Location of the global center of marine biodiversity, known as the coral triangle (modified from Green & Mous 2004).

Kimbe Bay also supports extensive deepwater habitats including seamounts (Fig 5), which are likely to have high conservation value for pelagic species (whales and fishes) and benthic communities. To date, twelve species of marine mammal (including sperm whales, orcas, spinner dolphins and dugong: Visser 2002a,b, 2003) and other rare and threatened species (including sea turtles and seabirds) have been recorded in the Bay, which suggests that it may provide important habitat for these species. The close proximity of shallow and deepwater habitats provides a unique opportunity to protect a wide range of high diversity marine habitats in one area.

Kimbe Bay is also an integral component of the Bismarck Sea (Fig 1), which is the home of one of the most extensive coral reef systems in PNG. As part of the highest diversity area of coral reefs in the world, known as the Coral Triangle (Fig 4), the Bismarck Sea supports some of world's highest marine biodiversity. It also provides important habitat for the Pacific's largest sperm whale population, important turtle rookeries, and the most productive tuna and bait fisheries in the Western Pacific. In 2003, the East Bismarck Sea was recognized as a globally significant area for pelagic fishes (particularly tuna) and toothed whales (WWF 2003). Kimbe Bay was also recognized as an ecoregionally outstanding area for its well-developed inshore reefs and unique offshore pinnacles rising from deep water; rich coral and fish communities; and frequent whale sightings (WWF 2003). The PNG Conservation Needs Assessment (Swartzendruber 1993) also identified 30 high priority marine areas, half of which are in the Bismarck Sea. One of these, Talasea, is located along both sides of the Willaumez Peninsula (Fig 3), and includes the southwest corner of Kimbe Bay. This area was nominated for reef and soft bottom

marine habitats, and nesting beaches for leatherback turtles. As part of these globally and ecoregionally significant areas, Kimbe Bay is a high priority area for marine conservation and an excellent candidate for a network of MPAs to anchor a wider MPA network in the Bismarck Sea.

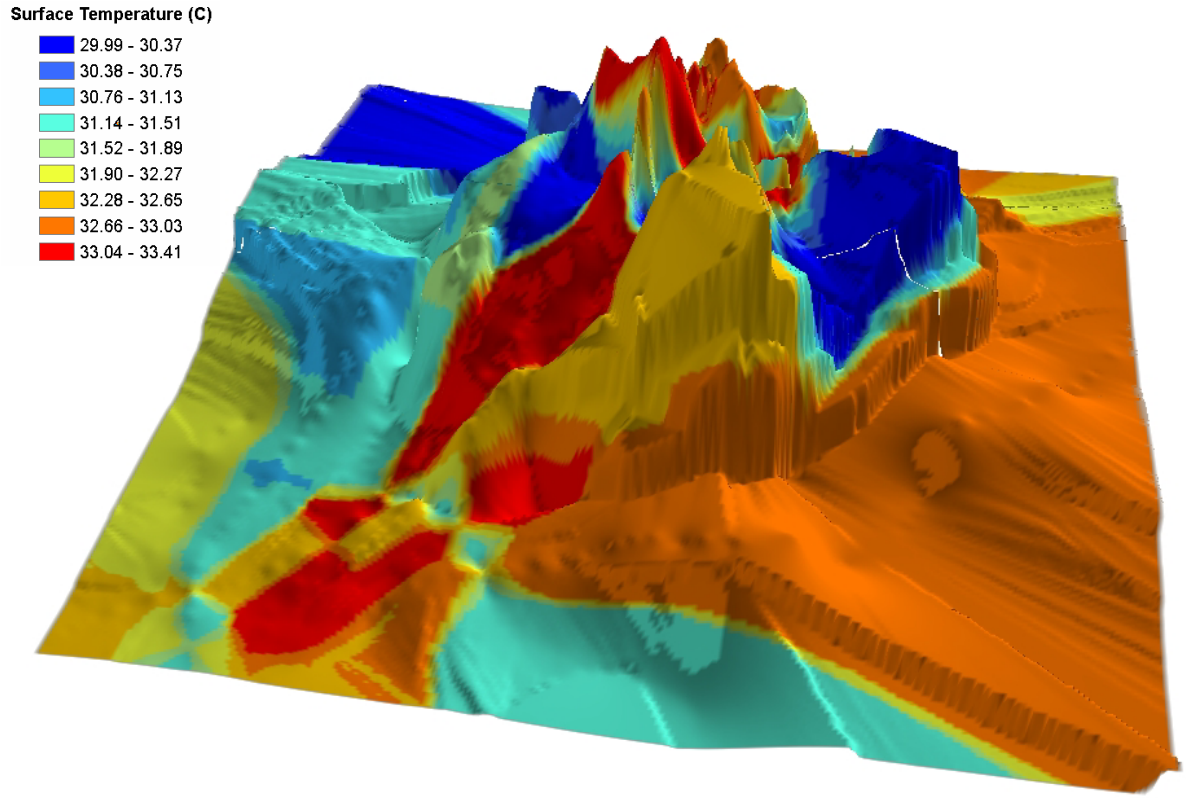

Fig 5. Seamount on the western side of Kimbe Bay, showing the bathymetric and temperature profile developed using the Adaptive Bathymetric System. This seamount rises from a depth of 500m to within 55m of the surface, and is very warm suggesting volcanic activity in the area.

Socioeconomic Characteristics

Kimbe Bay is also a good candidate for a MPA network based on current patterns of marine resource use. Fishing is mostly subsistence or artisanal in nature, and pressure on marine resources is low compared to other areas in the region (Cinner et al 2002). This is because many of the people who live in Kimbe Bay have moved there from PNG's highland provinces, and do not have a strong cultural relationship with the sea or a long tradition of harvesting marine resources. Consequently, most people do not rely heavily on marine resources and have alternative sources of livelihood, particularly from subsistence and cash crop agriculture (Koczberski et al 2001; Cinner et al 2002). However, fishing is an important supplemental component of the livelihood of local communities

Commercial fishing in Kimbe Bay currently focuses on two invertebrate species: beche de mer and trochus. Most of the catch comes from just a few areas of the Bay (particularly around Hoskins and Talasea), and catches have increased rapidly in recent years (National Fisheries Authority unpubl. data). Unfortunately, some of the target species (particularly beche de mer) are particularly vulnerable to overexploitation due to their life history characteristics, and declines in stocks of these species have been noted in some areas. There is also a commercial fishery for sharkfin, but catches recorded to date have been low.

There is no commercial fishery for finfish or lobsters at present, although fishing for these species does occur at the subsistence or artisanal levels. This is fortunate, because stocks of these species are considered low due to the relatively small area of habitat in the Bay. Consequently, it is important that no commercial fisheries for these species become established in the Bay, since these stocks would be vulnerable to overexploitation. This low level of marine resource use provides an excellent opportunity to establish an MPA before fishing pressure becomes a more serious issue in the Bay.

Subsistence fishermen in Kimbe Bay

Nature based tourism is the only non-extractive industry in West New Britain. In Kimbe Bay, most marine tourism activities originate from Walindi Plantation Resort on the western side of the Bay. The resort offers day trips on the southwestern side of the Bay, and operates two liveaboard vessels both inside and outside the Bay. Activities include diving, snorkeling, underwater photography, bird, dolphin and whale watching. All activities are conducted in an environmentally friendly way, and impacts are minimal. For example, the dive boats have a strict "look but don't touch" policy, and moorings have been installed at dive sites to avoid anchor damage.

Tourism activities provide a significant contribution to the economy of Kimbe Bay, which has dramatically increased in the last decade. Most of the related expenditure flows to local businesses, businesses elsewhere in PNG, and local communities. This represents significant income for Kimbe Bay, and many families are supported by tourism. Given the minimal impact of this industry, and its value to local communities and businesses, tourism plays an important role in the development of sustainable industries in the Bay.

Liveaboard dive boat, MV *FeBrina*

Other marine resource use in the Bay includes shipping, which has well defined areas of use (wharfs, pilotage channels, and anchorages). While shipping may pose a threat to marine ecosystems through ship groundings, pollution, and the introduction of invasive species, impacts appear to have been localized to date.

Land use, particularly agriculture and forestry, are major industries in Kimbe Bay (Fig 6). Runoff from these activities appears to be causing significant impacts on nearshore ecosystems in some parts of the Bay (particularly the southwestern corner). Although arising from outside the marine environment, these threats are significant and will be addressed through a separate strategy of collaborative partnership with industry.

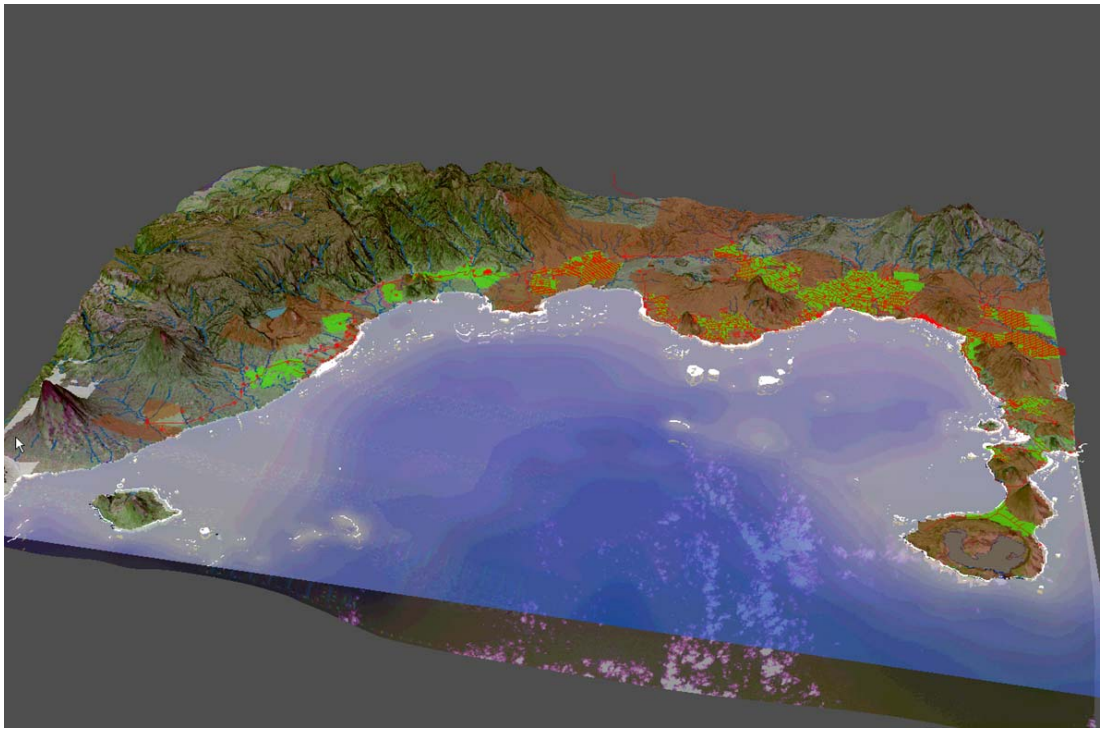

Fig 6. Major areas of land use in Kimbe Bay watershed (red= logging and green=oil palm plantations).

Proposed Process

Designing and implementing a network of MPAs involves a long process with three essential components:

- A sound scientific basis.
- An implementation strategy that may require new legislation and supporting policy, a compliance and enforcement strategy, sustainable financing, and the ability to measure success and allow for adaptive management (if required).
- Strong partnerships with stakeholders, particularly local communities, sustainable industries, scientists, other non-government agencies, and local, provincial and national government.

This is the first time that a process of this nature has been undertaken in Melanesia. Table 1 describes a detailed work plan for each step in the process, with timelines for each step.

Table 1. MPA network work plan and timelines.

	2003	2004	2005	2006	2007	2008
1. Scientific Needs						
1.1 Collate best available information & enter in GIS format	➢	➢				
1.2 Scientific workshop held in Townsville, Australia (Feb 2004) to provide advice on objectives, targets, boundaries, design principles, information gaps & research priorities		➢				
1.3 Address high priority information needs required to design network		➢	➢			
1.4 Use analytical software (MARXAN) to generate design options to achieve objectives				➢		
1.5 Review scientific process and results				➢		
1.6 Design & implement monitoring program to measure success of the MPA network (to be conducted before, during & after implementation)				➢	➢	➢
2. Implementation						
2.1 Develop a strategy for implementing the network (legislation/policy, compliance and enforcement, sustainable financing, measuring success and adaptive management)		➢				
2.2 Draft legislation/policy required to implement network			➢			
2.3 Pass government legislation/policy				➢		
2.4 Implement network (legislation/policy, compliance & enforcement, sustainable financing)					➢	➢
2.5 Monitor Success (see **Scientific Needs**)				➢	➢	➢
2.6 Adaptive management (if required)						➢
3. Stakeholder and Partner Engagement						
3.1 Gain support for MPAs through LMMAs, education & awareness programs	➢					
3.2 Preliminary discussions regarding expanding to broader MPA network for the Bay; gain general support for idea	➢					
3.3 Discussions regarding scientific recommendations for network design (following first scientific network in Feb 2004).		➢				
3.4 Discussions regarding proposal to implement network (once implementation plan has been prepared)		➢				
3.5 In principle agreement with partners to establish network			➢			
3.6 Consider specific design options; discuss preferred option to achieve both biological & socioeconomic objectives				➢		
3.7 Select design that achieves both biological & socioeconomic objectives				➢		
3.8 Education & awareness program	➢	➢	➢	➢	➢	➢

SCIENTIFIC ADVICE FOR NETWORK DESIGN

A scientific workshop was held at the International Marine Project Activities Centre (IMPAC) in Townsville from February 9-11 2004. The primary objective of the workshop was to seek scientific advice to refine the scope of the MPA network in Kimbe Bay, prior to conducting more detailed discussions with partners. Specific aims were to:

- Summarize best available information on the biophysical and socioeconomic characteristics of the Bay;
- Use this information to define the objectives, conservation targets, and the geographic extent of the network, as well as the design principles (both biophysical and socioeconomic) required to achieve network objectives; and
- Identify key information gaps and research priorities that will need to be addressed prior to designing the network.

Workshop participants included[7]:

- TNC staff from PNG, Palau, Australia and Indonesia;
- Conservation partners including Mahonia Na Dari (local conservation non-government organization in Kimbe Bay) and the David and Lucille Packard Foundation;
- Marine scientists with expertise in biological and physical sciences, particularly those who have worked in Kimbe Bay or have experience in similar ecosystems elsewhere in the region (Great Barrier Reef, Palau and Indonesia);
- Socioeconomic scientists with experience working with communities and industry in Kimbe Bay and elsewhere in PNG; and
- Representatives of local communities (TNC staff), industries and government agencies, who could provide socioeconomic information for the Bay.

A full list of participants is attached (see *Attachment 1*).

The following is a summary of the advice received:

Objectives

Workshop participants recommended the following objectives for the MPA network:

1. Conserve marine biodiversity and natural resources of Kimbe Bay in perpetuity; and
2. Address local marine resource management needs.

During the workshop, there was some discussion regarding whether to protect the full range of marine biodiversity in the Bay, or to limit the scope to the shallow water habitats. The participants agreed that it was important to protect the full range of marine biodiversity, by protecting both shallow and deepwater habitats, for the following reasons:

[7] This meeting focused on the scientific aspects of the process only. Consultation with other partners, particularly local communities, is being conducted through a separate process.

- Kimbe Bay provides a unique opportunity to protect both shallow and deepwater habitats in close proximity to each other.
- It is important to recognize functional connectivity among shallow water habitats, and that connectivity among shallow and deepwater habitats is unknown but may also be important.
- Shallow water habitats are known to be important for protecting biodiversity in Kimbe Bay, but very little is known about the deepwater habitats and how important they are. In general, little is known about deepwater benthic habitats (eg seamounts), but what is known from elsewhere suggests that they are very important for protecting biodiversity because they tend to support very specialized species, which have high levels of endemism.
- Protecting deepwater habitats should be relatively easy in Kimbe Bay at the moment (since they are not heavily used), and may be insurance for the future.
- It is important to protect against threats that operate in both shallow and deepwater habitats that may affect biodiversity (eg commercial extractive activities in deepwater eg longlining).

Conservation Targets
Based on the objectives and geographic extent of the network (see below), the participants recommended the following targets for protection in the network:

Habitats:
- Shallow water habitats: coral reefs, mangroves, seagrasses and estuaries.
- Deepwater habitats: epipelagic, mesopelagic, and bathypelagic (which includes seamounts and canyons).
- Islands and associated flora and fauna, particularly uninhabited islands that provide important nesting areas for marine species (sea turtles and seabirds).

Species:
- Rare and threatened species: turtles, seabirds, cetaceans, crocodiles, dugong, sharks and rays.
- Species of very limited distribution (eg some reef fishes, particularly species of the genus *Gobiodon*).
- Commercially important reef species, which may be threatened by overexploitation, including both fish and invertebrates (particularly beche de mer and trochus).
- Large pelagic fish (eg billfish).

Some refinements to these targets will be required over time. Issues that require further discussion include:
- The need to include other important marine habitats that were not identified as conservation targets in this process, particularly deep shelf waters and habitats (inter-reefal areas at depths of 50 to 200m), intertidal and coastal habitats.
- Whether Lake Dakataua on the Willaumez Peninsula (Fig 3) should be included as a target in the MPA network. At present, the lake has not been included since it is unclear how much connectivity exists between the lake and ocean. Since the

lake appears to be primarily freshwater (it is 200ft above sea level), it was considered primarily a freshwater habitat that should not be included in the MPA network. However, the lake is a very important wetland that is a high priority for conservation in Kimbe Bay, which provides important habitat for marine species (nesting seabirds and saltwater crocodiles). Since it was not included in the MPA network, this area has been identified as an area of high conservation value for other conservation work through the Conservation Area Planning process.

Geographic Extent

Several options were considered including:

1. The functional seascape(s) within Kimbe Bay, including offshore islands and seamounts.
2. The functional seascape(s) within Kimbe Bay (including offshore islands and seamounts), and extending north and west to include the Vitu Islands and the west side of the Willaumez Peninsula (Fig 1), which may be part of different functional seascapes.
3. Just the west (Stettin Bay) or east side of the bay.

The participants recommended Option 1 (Fig 3), which appears to be the most biologically and physically discrete unit, with some minor modifications to include some areas of high conservation value just outside the Bay and to address some key socioeconomic factors.

In general terms, the outer boundary was delineated to include what is assumed to be one or two functional seascapes (east and west) in the wider Kimbe Bay area. This boundary was then modified to address some important socioeconomic factors including:

- The eastern boundary (previously Cape Tokoro) was extended a short distance (~20kms) east to coincide with the eastern boundary of WNB Province, and to include the local communities who live in this area.
- The western boundary (previously Cape Hollman) was extended a short distance (~10kms) to the west to include all three villages surrounding Lake Dakataua on Willaumez Peninsula, which form part of the same community. The network was not extended further west or south to include the western side of the Willaumez Peninsula, since this was assumed to be part of a different functional seascape to Kimbe Bay.

A more detailed description of the outer boundary, and the rationale behind it, is as follows: The western boundary of the MPA starts just south of the Buludava Village on the western side of the tip of Willaumez Peninsula. The boundary extends approximately 23kms north of the Peninsula, and then east to include important islands, reefs and seamounts, particularly:

- A seamount (~95m deep) located 18km north of Cape Hollmen;
- Non-reefal communities on the north-east tip of the Willaumez Peninsula;

- Deepwater habitat around Cape Heussner[8];
- Lolobau and Banban Islands;
- Torkoro Reefs northeast of Lolobau Island; and
- Inshore reefs on north-eastern side of the Bay, particularly east of Lolobau Island and in the protected channel surrounding a small island close to Cape Torkoro[9].

The boundary then extends east past the eastern edge of Cape Tokoro to the eastern boundary of WNB Province.

The inner boundary was described as the inland extent of marine habitats (defined as highest astronomic tide), which includes estuaries and inland limit of mangroves (this includes both intertidal and subtidal habitats).

Islands, especially those that are uninhabited, were included in the network because of their importance as nesting habitat for marine species (particularly sea turtles and seabirds).

Network Design Principles

These principles were designed to maximize the biological objectives of the MPA network, while minimizing cost and maximizing benefits to local communities and industries. They recognize that biological diversity in Kimbe Bay can be divided into three broad levels (in descending spatial scales): bioregions[10], ecosystems, and community types. However, each ecosystem and community type is not necessarily represented in each bioregion. Bioregions were selected as the basic unit of biodiversity to use to design the network.

The principles were designed based on the assumption that Kimbe Bay will be a multiple use MPA, where different types of use (fishing, tourism etc) will be permitted in different areas. Since extractive uses (such as fishing) pose one of the greatest threats to marine ecosystems, these principles were designed to identify areas for the highest level of protection, which will be protected from extractive use ("no-take areas").

The principles were drafted using the Great Barrier Reef Marine Park Authority's (GBRMPA) biophysical and socioeconomic operational principles (www.gbrmpa.gov.au) as a starting point, and then modified based on Transforming Coral Reef Conservation principles and expert advice to ensure that they are applicable to Kimbe Bay. These principles were designed to work together as a package (not independent of each other), and should be applied where possible. However, it is recognized that it may not be possible to apply all of the principles all of the time.

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[8] The Willaumez Peninsula is a very prominent feature that juts out into deeper water in the middle of a gyre in the Bismarck Sea. Therefore, it is likely to produce interesting oceanographic features, which may affect the hydrodynamics of Kimbe Bay, and provide important habitat for oceanic species such as cetaceans.

[9] These reefs are considered important because this habitat type has not been seen elsewhere in the eastern side of the bay.

[10] An area that contains relatively homogenous physical and biological characteristics at a chosen scale.

Biophysical

The aim of the biophysical operations principles is to maximize biological objectives by taking into account key biological and physical processes. The following is a summary of these principles:

- Conserve representative examples of each bioregion.
- Include a "sufficient" number and area of each bioregion, and spread them out geographically to reduce the chances that they will all be negatively impacted at the same time. Aim to include at least 3 areas and 20% of the area of each bioregion.
- Take a system wide approach that recognizes patterns of connectivity within and among ecosystems.
- Where possible, include entire biological units (eg whole reefs, seamounts), including a buffer around the core area of interest.
- Where entire biological units cannot be included, chose bigger vs smaller areas.
- Where information is available, include a minimum amount (see above) of each ecosystem and community type within each bioregion (to ensure that all known communities and habitats that exist within bioregions are protected).
- All else being equal, chose representative areas[11] based on knowledge (high biodiversity areas, complementarity) to maximize the number of species protected.
- Include special and unique areas, including:
  - Permanent or transient aggregations of large groupers, humphead maori wrasse, and other key fisheries species (including invertebrates).
  - Areas that may be naturally more resistant or resilient to coral bleaching.
  - Turtle nesting areas (beaches and nearshore resting areas).
  - Cetacean preferred habitats (breeding, resting, feeding areas and migratory corridors).
  - Areas that support high species diversity.
  - Areas that support species with very limited distribution and abundance.
  - Areas that are preferred habitats for vulnerable species (eg sharks, and those on the IUCN red list).
  - Areas that contain a variety of habitat types in close proximity to each other.
- Conserve rare and threatened species: cetaceans, dugong, sea turtles, seabirds, and crocodiles.
- All else being equal, choose sites that are more likely to be resistant or resilient to global environmental change.
- Consider sea and land use, particularly proximity to threats and other protected areas.
- Maximise acquisition and use of environmental information to determine the best configuration, recognizing the importance of connectivity in network design.
- Consider if patterns (distribution and status of community types) are the result of natural processes or human impacts.

[11] An area that is typical of the bioregion within which it is located

Socioeconomic
The aim of these principles is to maximize benefits and minimize costs to local communities and sustainable industries. The following is a summary of these principles. In some situations, specific strategies were identified to implement the principles.

General

- Recognize and respect local resource owners and customary marine tenure systems.
- Understand and incorporate local knowledge and traditional fisheries management and conservation practices.
- Minimize conflicting uses, such as tourism and extractive use.
- Minimize negative impacts on existing livelihood strategies
- Protect areas of cultural importance to traditional owners.
- Consider current and future population trends and changing resource use.
- Ensure the costs and benefits of the network are fairly distributed within and between communities.
- Recognize that local communities are partners in the MPA network and will be involved in all decision making processes.

Fisheries
Work with communities to:

- Ensure MPA supports sustainable subsistence and artisanal[12] fisheries for local communities by recognizing diverse livelihood strategies, and spatial and temporal variations in resource use and value.
- Consider costs and benefits to local communities (and sustainable industries) in management of commercial fisheries.
- Conserve marine resources, which local communities identify as important to their livelihood.
- Conserve marine resources for local communities by prohibiting destructive fishing methods.
- Conserve marine resources for local communities by prohibiting unsustainable commercial fisheries[13], particularly the live reef food fish trade and other fisheries for species particularly vulnerable to overexploitation (sharks, rays, trochus and beche de mer).
- Recognize fisheries benefits of MPAs.

Specific strategies should include:

- Enforcing National Fisheries Act Section 32(1-7) that prohibits the use of fishing with poisons or explosives, and working with local communities through education and awareness programs leading to the eventual prohibition of other destructive fishing methods.
- Prohibiting commercial fisheries for live reef food fish trade under the national management plan.

[12] Catch is sold in markets and stores for local consumption.
[13] Catch is exported out of the local area.

- Conserving spawning aggregations of large commercial fish species, particularly those targeted by the live reef food fish trade.
- Using closures to contribute to the management of commercial fisheries for invertebrates (particularly for trochus and beche de mer).
- Designating special management area under Fisheries Act.
- Developing and implementing a provincial law that caters for fisheries management and conservation.
- Engaging in policy level discussions regarding fisheries policy in PNG, and WNB, which may benefit fisheries management.
- Prohibiting artisanal and commercial fishing for sharks and rays, and fishing or deliberate capture of cetaceans.

Nature Based Tourism

- Use MPAs to provide opportunities for environmentally sound tourism to benefit local communities.
- Promote opportunities for sustainable tourism activities by local communities.
- Ensure that tourism activities are environmentally sustainable.
- Protect high priority tourism sites from conflicting (extractive or destructive) uses.
- Develop and implement best environmental guidelines for diving, snorkeling, visiting islands, and swimming with whales.
- Ensure visiting tourism and recreational vessels are aware of MPA and regulations.
- Implement MPA management charges for the tourism industry to be used to support management of the MPA network.
- Engage in discussions with PNG Tourist Promotion Authority, PNG Dive Association, local dive operators and Provincial Governments to develop a sustainable tourism network in PNG, and WNB (particularly for diving and bird watching).

Shipping

- Accommodate existing shipping infrastructure (wharves, channels) in MPA design (avoid placing highly protected areas in the vicinity of these areas).
- Encourage the development of strategies to reduce the threat to marine resources from shipping related activities (ship groundings, pollution, and invasive species). This will include encouraging the development and implementation of improved navigational aids, incident response strategies, and a strategy for the management of ballast water.

Mining and Drilling

- Protect marine resources from pollution and habitat destruction by prohibiting mining and drilling activities.

Research Priorities
Once the design principles for the MPA network were defined, the group discussed the information required to apply these principles, identified the status of this information (how much was already available) and identified research priorities for the future. It was recognized that while there will never be extensive information available on the biophysical and socioeconomic characteristics of Kimbe Bay, some information was important for designing the network and should be obtained prior to implementing the design (high priority research tasks).

High priority research needs will be addressed over the next two years, prior to designing the network. Low and moderate priority research needs will be addressed as the opportunity arises. The following is a summary of the high priority research needs for designing a network of MPAs in Kimbe Bay. A full list of research priorities can be obtained from agreen@tnc.org.

High priority research will focus on providing a broad understanding of physical processes in the Bay. This information is critical for understanding patterns of connectivity, and assisting with the identification of bioregions and special and unique areas where no biological data is available. This will require:

- Studies of ocean currents and hydrography (temperature, salinity).
- Mapping bathymetry and key features (eg seamounts, deepwater canyons).
- Identifying high productivity areas (ie upwelling areas).
- Understanding weather patterns (wind, rain).

High priority biological research includes:

- Additional marine surveys required to generate a bioregion map for the Bay, focusing on habitats where little or no information is currently available (particularly seagrasses, mangroves and deepwater habitats).
- Identifying special and unique areas for protection, particularly fish spawning aggregation sites and bleaching resistant and resilient sites.
- Understanding the distribution and extent of local human impacts on marine ecosystems, particularly from land use practices.
- Long term monitoring of the status of key resources, and measures of success of MPAs.

High priority socioeconomic research includes:

- Understanding community support, expectations and measures of success for MPAs (based on LMMA experience).
- Understanding more about patterns of resource use and value of marine environment particularly:
- Subsistence and artisanal fishing practices by local communities;
- Resource use and value by commercial fisheries; and
- Hunting for rare, threatened or vulnerable species.
- Understanding local knowledge of the marine environment particularly regarding:

- Distribution and abundance of rare, threatened or vulnerable species (and their critical habitat);
- Physical processes including currents, bathymetry, wave action and location of key physical features;
- Special and unique features;
- Long term trends in status of major habitats;
- Status of commercially important species, which may be threatened by overexploitation; and
- Impacts of local activities and global change on marine ecosystems.

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Subsistence fishermen in Kimbe Bay

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