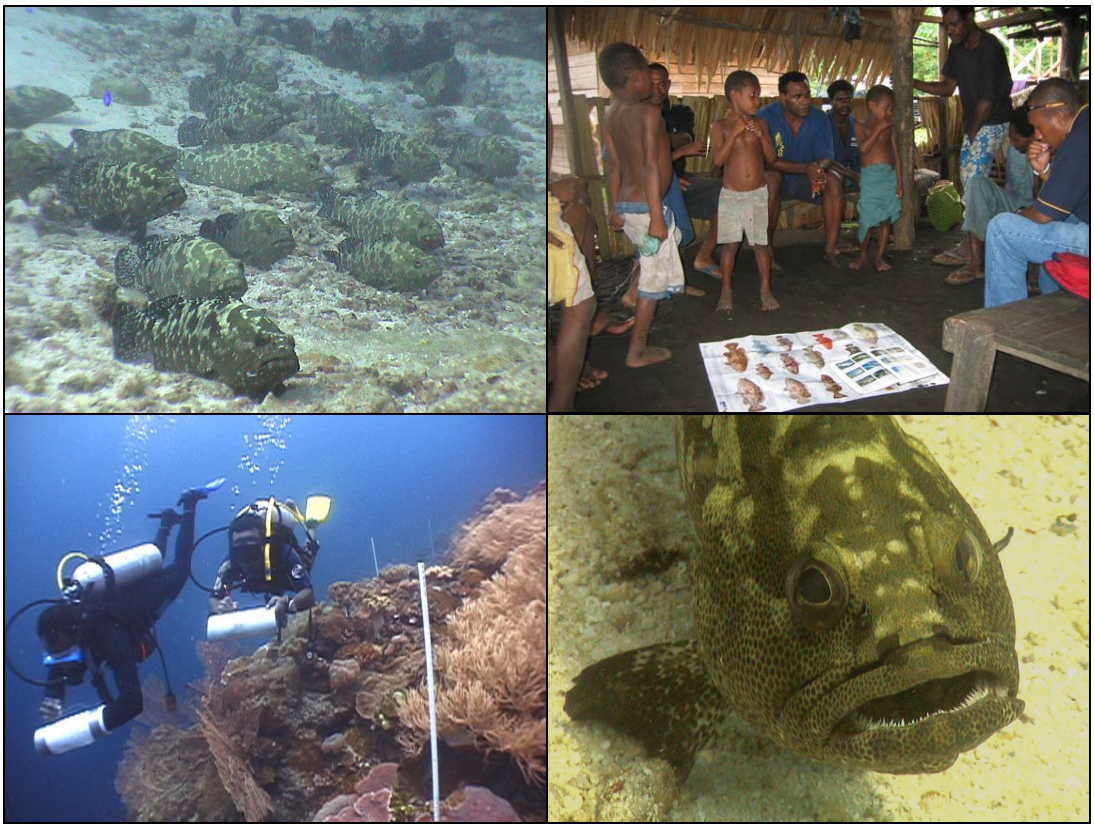
September 2006
TNC Pacific Island Countries
Report No. 3/06

Protecting and Managing Reef Fish Spawning Aggregations in the Pacific

Project Final Report



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Citation:
Smith, A.J. and R.J. Hamilton. 2006. Protecting and Managing Reef Fish Spawning Aggregations in the Pacific: Project Final Report. Report prepared by the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 3/06.

Acknowledgements

We would like to thank the communities, partner agencies, organizations and contractors that have been a part of this project. We are grateful for their continuing support, dedication and the initiative they have shown. In particular we would like to acknowledge Pere community, Manus, PNG, for their commitment to effectively managing their spawning aggregations, and their resolve to continue to do so even when faced with financial opportunities through the Live Reef Food Fish Trade. They were graceful hosts for the Advanced Workshop on Monitoring, and allowed us to present their efforts in the awareness video.

Thank you also goes to The Nature Conservancy's Jean-Louis Ecochard and Shannon Seeto for producing the 3D bathymetric reef maps, and to Dr Peter Mous (TNC Indonesia) for the work he has done on drafting and revising the monitoring manual.

A final thank you goes to all our TNC colleagues in the Pacific Island Countries Program for their involvement, cooperation and support—especially the field teams.

Donors
U. S. Agency for International Development: Financial assistance was provided by the Office of Strategic Planning, Operations and Technical Support, Bureau for Asia and the Near East, U. S. Agency for International Development, under the terms of Award No. LAG-A-00-99-00045-00. The opinions expressed herein are those of the author(s) and do not necessarily reflect the view of the U. S. Agency for International Development.

Oak Foundation.

David and Lucile Packard Foundation.

Report Available From:
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Australia Or via the worldwide web at: www.conserveonline.org

Cover photos: L-R top: *Epinephelus polyphekadion* aggregation Ngerumekaol (Ulong Channel), Palau (A. Smith); Interviewing fishers at Vilavila village, Eastern Kimbe Bay (R. Hamilton);
L-R bottom: Monitoring survey, Pere, Manus, PNG (E. Henningsen/Ion Digital Films); *Epinephelus polyphekadion*, Ngerumekaol, Palau (A. Smith).

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LIST OF ACRONYMS

ADB	Asian Development Bank
CBCA	Community-Based Conservation Area
CBD	Convention on Biological Diversity
CCC	Community Conservation Coordinator
CI	Conservation International
CRRF	Coral Reef Research Foundation
EAPEI	East Asia and Pacific Environmental Initiative
EBM	Ecosystem-Based Management
FSA	Fish Spawning Aggregations
FSM	Federated States of Micronesia
FY	Financial Year
GCP	Global Conservation Program (of USAID)
GPA	Gillett Preston and Associates
GPS	Global Positioning System
IUCN	World Conservation Union
LLCTC	Lauru Land Conference of Tribal Community
LMMA	Locally Managed Marine Area
LRFFT	Live Reef Food Fish Trade
MAR	Meso-American Reef Program, TNC
MOU	Memorandum of Understanding
MPA	Marine Protected Area
NBSAP	National Biodiversity Strategy and Action Plan
NFA	National Fisheries Authority
NFWF	National Fish and Wildlife Foundation
NGO	Non-Governmental Organization
PAN	Protected Area Network (in Palau)
PNG	Papua New Guinea
REA	Rapid Ecological Assessment
RSAMT	Roviana Spawning Aggregations Monitoring Team
RVLRMP	Roviana and Vonavona Lagoons Resource Management Program
SCRFA	Society for the Conservation of Reef Fish Aggregations
SPC	Secretariat of the Pacific Community
TNC	The Nature Conservancy
USAID	United States Agency for International Development
UVC	Underwater Visual Census
WCS	Wildlife Conservation Society
WWF	Worldwide Fund for Nature / World Wildlife Fund

INTRODUCTION

1. PURPOSE OF FINAL PROJECT REPORT

This report summarizes the progress, evolution, results and achievements of this project from FY2003-2006. As most of the results of this project have been documented in the various reports and papers produced throughout the project's life, this report will focus on the current status and elucidating the lessons learned. In addition, we will endeavor to provide candid feedback relating to the various challenges encountered throughout the life of the project, and the adaptive management applied to address them. Many of the activities are on-going, having been successfully incorporated into broader programs to ensure their sustainability.

This report also provides recommendations for the "next steps". The strategies and activities undertaken through this project were never intended to be discrete activities, but rather an on-going and long-term process to effect positive change in destructive fishing and over fishing activities within the Pacific.

This report is also the close-out report for the U. S. Agency for International Development, Office of Strategic Planning, Operations and Technical Support, Bureau for Asia and the Near East, Award No. LAG-A-00-99-00045-00: "Protecting Coral Reefs from Destructive Fishing Practices in the Pacific: Protecting and Managing Reef Fish Spawning Aggregations in the Pacific".

2. BACKGROUND

2.1 Problem – Threat Identification

The goal of this project has been to reduce the degradation of coral reef ecosystems in the Pacific region from destructive fishing practices, and especially the over-exploitation and degradation of reef fish spawning aggregation sites.

Destructive fishing practices that target key species and degrade fragile coral habitats are among the major threats to the viability of coral reef ecosystems. Many reef fishes form aggregations at predictable places and times, frequently for the purpose of spawning. The nature of spawning aggregations makes them extremely vulnerable to elimination by over-fishing. It can take as few as two to three years of intensive fishing on spawning aggregations to eliminate breeding populations of fishes. At the initiation of this project there was little awareness of—or capacity to address—this threat to the marine resources and biodiversity in the Pacific. The spawning aggregation phenomenon has rarely been reflected in fishery management plans or the design of marine protected areas (MPAs).

2.2 Strategies

This project aimed to identify practical ways to improve local resource management and spawning aggregation site protection, increase awareness of these resources' vulnerability to over-exploitation, and enhance capacity to manage reef fish spawning aggregations and MPAs that incorporate these sites.

It had three objectives:

1. To develop and facilitate the application of cost-effective management controls on the exploitation of aggregating reef fish resources;
2. To strengthen the capacity to assess, monitor, and manage aggregating reef fish resources; and
3. To raise the awareness and appreciation among stakeholders of the vulnerability of aggregating reef fish populations and associated ecosystems, the nature and significance of spawning aggregations, and options for improving management.

To achieve this four broad and interrelated strategies have been applied:

1. *Scientific understanding*: Within the context of the project, build our understanding of the phenomenon of spawning aggregations, through targeted research, scientific monitoring, and the documentation and verification of local knowledge.
2. *Capacity building:* Develop the methodologies and undertake the preliminary training to allow our partners—in the community, non-governmental organizations (NGOs) and government sector—to effectively monitor and apply adaptive management on their spawning aggregations.
3. *Awareness raising:* Raise awareness of the importance and vulnerability of reef fish spawning aggregations within the communities and governments in the areas of operations, and to provide advice on management options. Continue to develop and implement the destructive fishing and spawning aggregation awareness materials for use in schools and communities, initiated under the previous project.
4. *Management:* Identify and assess the efficacy of the range of spawning aggregation management options available to governments and communities.

A summary of the USAID work plan objectives and activities for this project are provided in Appendix 2. These activities formed the core of the Pacific reef fish spawning aggregation project. The project site-based activities focused primarily on Melanesia, with some activities also undertaken in Micronesia (Figure 1).

Figure 1: Map of the project countries and sites

This project built on and continued the partnerships and activities carried out under the "Protecting Coral Reefs from Destructive Fishing Practices" project supported by East Asia Pacific Environmental Initiative (EAPEI)-USAID in FY1999-2003.[1] Site and country level activities were focused on Pacific countries in Melanesia and Micronesia where The Nature Conservancy (TNC) is working. We continued to develop close partnerships with other international and local NGOs working at other key sites within the region. In addition, a small number of activities were carried out in collaboration with TNC Indonesia to build on work with spawning aggregations in Komodo National Park, and with TNC's Belize/Meso-American Reef Program (who have an extensive spawning aggregation program). These activities have facilitated the exchange of knowledge and best practices between Indonesia, the Caribbean, and Pacific Island Countries Programs.

In addition, this project is also linked to the TNC-led component of a global initiative to transform coral reef conservation over the next decade that is being developed and implemented in partnership with other international NGOs, research institutions and government agencies. The initiative involves catalyzing a multi-partner effort to improve the scientific basis for coral reef MPA selection, design, and management (including incorporating resilience, representation and replication); building the necessary skills and institutional capacity to manage MPAs effectively; and developing innovative solutions for financing marine conservation action to provide for long-term sustainability. This project continues to provide tangible results and valuable experiences from the Pacific to guide on-going global efforts to effectively protect and sustainably manage key reef fish species that are essential to the integrity of coral reef ecosystems.

2.3 Assumptions and Project Evolution

2.3.1 Definitions

Reef Fish Spawning Aggregations

Reef fish spawning aggregations are groups of conspecific fish gathered specifically for reproductive purposes, and is defined as an increase in fish densities to at least three times the 'normal' density on the site (Domeier and Colin 1997; Colin *et al*. 2003).

Two types of aggregations are distinguished: 'resident' and 'transient'. Resident spawning aggregations consist of individuals from a relatively small area (a few hectares) usually situated within or in proximity to the home ranges of the aggregating fish. Resident spawning aggregations usually (1) occur at a specific time of day over numerous days, (2) last only a few hours or less, (3) occur daily, and (4) can occur year round (Domeier *et al.* 2002). Therefore, the output from a single spawning event of a group of fish forming a resident spawning aggregation usually represents only a small part of the total annual spawning output of these fish.

In contrast to resident aggregations, transient spawning aggregations may consist of fish from a relatively large area (e.g. tens to hundreds of square km) that may travel considerable distances to reach the sites. Transient aggregations typically (1) occur during very specific times of the month, (2) persist for a period of days or, at most, approximately two weeks and (3) do not generally occur year-round (Domeier *et al.* 2002). The spawning output from a single 'transient' aggregation usually represents a substantial portion of the total spawning output of the fish in the aggregation, while the combined aggregations probably represent the complete reproductive output for the population. Reef fishes forming 'transient' spawning aggregations are highly vulnerable to over-fishing since a large portion of the harvestable stock concentrates at predictable sites during predictable periods, facilitating catch rates that are much higher than when the fish are dispersed in their day-to-day habitat (Pet *et al.* 2006).

[1] See the project review document: TNC. 2004. Pacific Live Reef Food Fish Trade (LRFFT) Project: Project Review. Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 3/04

Marine Protected Areas

There is often confusion surrounding the use of the term "Marine Protected Area" (MPA). The Nature Conservancy applies the term in accord with international usage, and as defined by the World Conservation Union (IUCN):

> MPAs are 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 *[including custom[2]]* to protect part or all of the enclosed environment.

Within MPAs some areas may exclude all extractive activities that affect living biological resources. The internationally accepted terms for these "no-take" areas are either "marine reserve" or "nature preserve", and are a sub-set of MPAs. In addition, Locally Managed Marine Areas (LMMA) and Community-Based Conservation Areas (CBCA) are also sub-sets of MPAs. Recognizing these distinctions is important.

2.3.2 Assumptions

- The intention of this project has been to identify, develop and pilot approaches that are appropriate to the sets of circumstances found in the Pacific, and more specifically in Melanesia and Micronesia. At the outset of the project it was assumed that we would need to apply an adaptive approach to implementation. Given the considerable range of partner capabilities, we needed to develop methods and approaches that satisfied a minimum standard, but could be built on where more resources and expertise existed. An example of this was the development of the spawning aggregation monitoring methodology.

- The threats to reef fish spawning aggregations, such as from commercial fisheries (LRFFT and general reef fisheries), can often move at a pace that is much greater than government agencies can deal with. It was therefore assumed that at times the project would need to be both reactive as well as proactive to deal with these on-going threats.

- This project was not intended to be a discrete, one off, but rather an on-going set of activities that would evolve over time and as circumstances changed. As such, the duration of activities was anticipated to be longer than the life of the initial funding grants, and the approaches and methods would need to continue to evolve. This has been the case, and the issue of sustainability is discussed later.

- The term 'reef fish spawning aggregations' covers a broad range of species and situations, as noted in the definition above. To provide focus for this project, we targeted the large commercially important groupers, specifically: the squaretail coralgrouper (*Plectropomus areolatus*), brown-marbled grouper (*Epinephelus fuscoguttatus*) and the camouflage grouper (*Epinephelus polyphekadion*) as the 'flagship' species. These three species often form transient spawning aggregations at overlapping sites and times and are frequently targeted by subsistence, artisanal and commercial fisheries. However, in the documentation of local knowledge of spawning aggregations, some of the scientific studies, and in working with communities, we did not limit ourselves to only working on aggregations of these species. This flexible targeting approach allowed us to be focused, while also being flexible enough to address management and knowledge issues of concern to our partners, especially the communities and local government agencies.

- The scientific community requires aggregations to meet specific criteria for them to be designated as 'spawning aggregations'; they must meet the definition of an aggregation and have spawning verified (Colin *et al* 2003). The Society for the Conservation of Reef Fish Aggregations (SCRFA) have identified direct and indirect spawning signs that can be used to verify spawning. Direct signs

[2] Added here for clarification only. Not in IUCN definition.

provide unequivocal evidence for spawning, indirect signs are other indications of spawning that need to be accompanied by supportive information (Colin *et al* 2003). While we agree with and encourage the need for clear verification of both aggregating and spawning, at times the latter (verification of spawning) is quite problematic to achieve in remote locations. Therefore, during this project we took a precautionary approach and worked with communities on management strategies for their aggregations, even if the full criteria for direct spawning signs were not satisfied. Wherever feasible, all aggregations identified during the local knowledge surveys were verified as actual aggregations, and wherever possible spawning signs were recorded through observations and/or sampling community catches. Given that the focus of this work was the conservation and management of the aggregations that were being targeted by fishers (artisanal or commercial), then we worked to have some form of management applied to those sites, even if the strict designation criteria for spawning aggregations had not been met.

2.3.3 Challenges and Issues

Project Management Issues

The review of the Pacific Live Reef Food Fish Trade Project (TNC 2004) found that the LRFFT Project would have benefited by additional capacity of at least one full time equivalent position. It is clear that this project would also have greatly benefited from an additional full time dedicated position. In the original design of the project there was a dedicated position identified. Unfortunately, in the first year of the project the key in-country staff person dedicated fulltime to the project was promoted to a position where he could only contribute a small portion of his time to this project. Despite an on-going search for a Melanesian candidate to fill the vacancy, we were not able to identify a suitable local candidate for the Melanesia Marine Programs Manager position. We then contracted Dr. Richard Hamilton in December 2003 to move the science and community-based components of the project ahead. Dr. Hamilton's qualifications and experience on the science and conservation of reef fish spawning aggregations, coupled with his fluency in both PNG Tok Pidgin and Solomon Islands Pidjin significantly boosted progress. In August 2005, Dr Hamilton was hired as a Conservancy staff member (Melanesia Marine Scientist) to ensure the continuity and sustainability of the work initiated under this project, and in recognition of the considerable progress and success he has had in working with our in-country teams and the communities. However, the delay in getting a suitable person to work fulltime on the project resulted in the project being extended.

To assist Dr. Hamilton, and to ensure on-going support to the communities involved with the project, we contracted two Community Conservation Coordinators (CCC) in Papua New Guinea—one each in Kavieng (New Ireland Province) and Manus, and recently hired another CCC in Choiseul Province, Solomon Islands. The Manus CCC was initially seconded from the Provincial Fisheries for two years, but recently become a full time TNC staff when his position at the Provincial Fisheries was advertised. The three Community Conservation Coordinators are all from the areas in which we have been working to implement spawning aggregation management. They are the primary contacts and liaisons for TNC within the project communities and provide an on-going presence within the communities (rather than using a fly-in-fly-out approach). They also facilitate community meetings, help deliver awareness materials and programs on spawning aggregations and destructive fishing, lead the monitoring of the sites, present back the monitoring results and assist in discussing and developing the management options with the communities.

The development of education and awareness materials, and their delivery and application, has been a far more time consuming and challenging activity than anticipated. Not having a full time communications or education staff member associated with the project has meant contracting this work out and having science/conservation staff (unfamiliar with media and materials production) manage those contracts and the final products. While the production of these materials has been successfully achieved, and to a high standard, the resources required (time, human and financial) have been much greater than anticipated.

While the majority of contractors produced their reports and products on subject, on time and on budget, some of the key contactors were less prompt with their reports (despite numerous reminders and with-holding of payments). For example, with the awareness materials effectiveness baseline study, the contractor submitted an unacceptable report and required numerous meetings and revisions of the draft report over many months to achieve a marginally acceptable product. These contractual issues delayed the finalization of some of the reports, and the synthesis of the information into this final summary report for the project.

Working Through Partners

To ensure effectiveness and sustainability, for the majority of the activities under this project we placed a very high priority on working in partnership with local communities, government agencies, and other organizations. This necessitated operating at the times and speeds at which these partners operate—often slow, but occasionally surprisingly fast. Community-based work can be especially slow due to the competing calls on community members' time. Similarly partner's priorities are frequently broader than those of this project, and they are required to regularly re-prioritize their time and resources based on immediate needs and urgency, resulting in our need to delay activities. Often times our role has been to encourage, facilitate or catalyze action. Unfortunately this has it limitations. Many of our partners have capacity and resource limitations that are beyond the means and purview of this project to influence. Recognizing these limitations and trying to work around them has been a significant challenge.

Threats

Underscoring this project is the need to deal with the threats to reef fish spawning aggregations. During the life of the project these threats have changed, often quite quickly. In particular, the LRFFT within the region has continued to be a key issue and a challenge to deal with. These operators can change location and set up operations much faster than management agencies can respond. During the project the LRFFT made a slight resurgence in the region, with operations starting again in Palau (although it was shut down within a few months), and more licenses were issued in PNG, including for the sites in Manus. The Manus situation has been reported in Hamilton and Matawai (*In Press*). Dealing with the LRFFT and its management will continue to be a challenge beyond the life of this project.

In relation to threats from fishing, we have had to ensure that our activities do not inadvertently facilitate the exploitation of aggregations. In developing methods and approaches to identify the location of spawning aggregations we have needed to be cautious about what can be made public and what requires a restricted circulation. As a result, a number of the reports produced during this project have been designated as having "restricted access". Reports on local knowledge have been produced in two versions, a restricted one that identifies sites, and an open access version where this information has been removed. In one case, for Choiseul Province, Solomon Islands, the local knowledge report has been restricted at the request of the local partners.

Departure from the Work Plan[3]

- The revision of the draft Field Guide for Monitoring Spawning Aggregations (Rhodes *et al.* 2004) has been put on hold to assess whether or not it is needed, or whether the Monitoring Manual and training video are sufficient. Based on our field teams' feedback a decision will be made in 2007 whether or not to persevere with the Field Guide.
- Agreement that a spawning aggregation-focused Memorandum of Understanding (MOU) between TNC and the Secretariat of the Pacific Community (SPC) was not required; however, the issue would be included in a broader MOU to be developed between the two organizations.
- A number of planned activities that depended on partners were not completed but will still be pursued:

[3] The USAID work plan summary is provided in Appendix 2.

    - SPC's publication of the LRFFT Regional Management Guidelines.
    - Papua New Guinea National Fisheries Authority's (NFA) review and revision of their National LRFFT Management Plan.
    - Solomon Islands adoption and implementation of the National LRFFT Management Plan.
    - The follow-up survey on the effectiveness of the school education and awareness materials.
- Fewer exchanges were undertaken than planned in the original proposal primarily due to a reduced grant award. In addition, there are only limited and small monitoring teams at each site (often only one person is suitably trained, with one dive buddy to accompany them) and with monitoring occurring at the same time at the different sites, they can rarely afford to have one of their team members away, as continuity of observers is also important.
- Shift in the focus of the awareness activities from formal workshops to more informal presentations and discussions with community members. This dictated the development of only a few key awareness materials, such as the spawning aggregation awareness video, and the Melanesian versions of the SCRFA spawning aggregation brochure.
- While the school awareness materials were successfully launched in July 2005, we found out that the Papua New Guinea (PNG) Education Department Curriculum Unit did not ship the materials out to the schools in 2006 as they had agreed. They will not be available to the schools until the 2007 school year. We will continue to work with the Education Department to ensure the materials are shipped and appropriate in-service training provided to the teachers.
- The baseline survey of the awareness materials was delayed and the report, when received, was deemed inadequate and required considerable revision. The follow-up survey will be undertaken mid- to late-2007.

2.4 Financial Support

The funds for this project have come from three primary donors:

- **United States Agency for International Development** (USAID), Office of Strategic Planning, Operations and Technical Support, Bureau for Asia and the Near East, under the terms of Award No. LAG-A-00-99-00045-00: "Protecting Coral Reefs from Destructive Fishing Practices: Protecting and Managing Reef Fish Spawning Aggregations in the Pacific".

  Purpose: To identify practical ways to improve local resource management and spawning aggregation site protection, increase awareness of these resources' vulnerability to over-exploitation, and enhance capacity to manage reef fish spawning aggregations and MPAs that incorporate these sites.

  US$500,000. Funds awarded October 2002. Originally a 2-year grant, but extended until FY 2006. Funds were expended by February 2006.

  Proposal submitted November 2001, as a follow-on to the EAPEI/USAID grant for "Protecting Coral reefs from Destructive Fishing Practices" (which focused on the LRFFT). October 1999 to September 2003.

- **The Oak Foundation** grant #OUSA-02-089 for "Protecting Spawning Aggregations from Destructive Fishing and the Live Reef Food Fish Trade"

  Purpose: To protect spawning aggregations in Melanesia from destructive fishing and the LRFFT through: increasing community awareness about destructive fishing; conducting survey and monitoring training; documenting local knowledge of spawning aggregations and their management; and integrating spawning aggregation management into locally managed marine areas.

  US$80,000 over two years. Awarded in February 2002.

Follow-on grant from Oak Foundation grant for "Controlling the Expansion of the Live Reef Fish Trade". February 2000 to January 2002.

- **The David and Lucile Packard Foundation** grant #2001-19075 to "Protecting Reef Fish Spawning Aggregation Sites".

  Purpose: To develop a practical set of spawning aggregation site identification, survey, and monitoring protocols for the Pacific, and prepare an associated training manual.

  US$44,000 reallocated in 2003 from the original grant: "In Support of a Meeting of Fisheries Experts to Map a Plan of Action for Protecting Spawning Aggregation Sites." June 2001.

Additional support for some of the activities was provided through other site and program funding:

• USAID Global Conservation Program (GCPII): "Support for the Establishment of Effectively Managed Platform Sites as Foundations for Resilient Networks of Functionally-Connected Marine Protected Areas Kimbe Bay, West New Britain Province, Papua New Guinea". Grant # LAG-A-00-99-00045-00	Kimbe Bay/Bismarck Sea MPA Network, Papua New Guinea
• The David and Lucile Packard Foundation: "Creating Resilient Marine Protected Area Networks: Learning by Doing in the Western Pacific" April 2005 – March 2007. Grant Number: 2005-28159 (PNG, FSM & Indonesia)	MPA Networks in PNG, FSM and Indonesia
• The David and Lucile Packard Foundation: "Transforming Coral Reef Conservation in the 21st Century: Palau's Nationwide Network of Marine Protected Areas" 2003 (1 year). Grant # 2002-24086	MPA Network in Palau
• TNC Marine Initiative funding: TCRC One Conservancy internal transfer. 2003/4	MPA Network in Palau
• Barbara Monick: Annual grants to Palau.	Marine program in Palau
• Anonymous donor	Kimbe Bay, Bismarck Sea in PNG

3. SUSTAINABILITY

The intent of the project was to integrate the activities into on-going TNC and partner work plans and activities, rather than sustain the project activities within a separate program.

The two phases of the USAID / EAPEI "Protecting Coral Reefs from Destructive Fishing Practices" project have focused on reducing the degradation of coral reef ecosystems and biodiversity in the Pacific region from the destructive aspects of the live reef fish food trade, especially through over-exploitation, the targeting of spawning aggregation sites.

The key objectives of the first phase focused on making decision-makers and affected communities aware of the potential impacts of the LRFFT if it is not effectively controlled and managed, and to provide the necessary support to develop and implement those management controls.

The overall purpose of the second phase was to develop the necessary tools and approaches through working at selected sites, and then sharing the results and lessons learned with other agencies and organizations working in similar situations.

The momentum developed through the USAID / EAPEI grants will be continued through a new TNC Pacific Island Countries Program fisheries strategy. Through this new strategy we aim to work with partners to ensure that, by 2015, fifty percent of the priority ecoregions' tropical nearshore fisheries in the western Pacific will be managed within an Ecosystem-Based Fisheries Management (EBM) framework, significantly reducing the levels of destructive and over-fishing outside of MPAs. By FY10, the initial policy and legislative frameworks will be in place to enable management of tropical nearshore fisheries within an EBM framework for priority Pacific ecoregions. This new strategy is currently in the conceptual development stage.

Regionally, the protection of reef fish spawning aggregations, as it relates to the Live Reef Food Fish Trade (LRFFT), is primarily being dealt with by the Secretariat of the Pacific Community (SPC). TNC continues to work closely with SPC to ensure that reef fish spawning aggregations are included in their respective fisheries assessment and management programs. One SPC officer has been dedicated to dealing with all LRFFT matters, including the management of spawning aggregations. That position and the related work at SPC is currently funded by the MacArthur Foundation. At the Heads of Fisheries Meeting (August 2004) there was a request made by members to SPC to provide information on the benefits of MPAs with respect to fisheries. At the Heads of Fisheries Meeting (April 2006) there was a request for SPC, together with governments and other regional stakeholders (including NGOs), to assist member countries with the implementation of an ecosystem-based approach to nearshore fisheries management. The Heads of Fisheries urged SPC to produce a briefing paper on the use of Marine Protected Areas for the achievement of fisheries ecosystem-based management goals. The outputs of this project are being fed into that process. Working with SPC on developing and supporting the ecosystem-based management of nearshore fisheries, and helping SPC member countries and territories reach their 2010 implementation target, will be a primary focus of the new fisheries strategy for the TNC Pacific Island Countries Program, and will ensure the continuation of the progress made under both the Live Reef Food Fish Trade project and the Spawning Aggregation Protection and Management Project.

Within the Pacific region the recognition of the need to protect reef fish spawning aggregations is growing. In a recent SPC/WPRFMC/FAO Workshop on Fisheries Legislation and Community-based Fisheries Management (Honolulu, Hawaii, United Sates of America, 4–8 April 2005) it was recommended:

> "3) The management of "live food fish" fisheries was discussed as a major problem in some countries. The destructive nature of fishing on spawning aggregations was a concern to many. It was recommended that a regional approach be taken in resolving the problems faced by countries in the management of their live food fish industries." (Executive Summary pp vi)

In addition, SCRFA continues to be active within the Pacific, and especially in Fiji. They have a general cooperation MOU with SPC.

At the national level, we have progressively integrated the activities of this project into our Melanesia and Micronesia programs as follows:

Palau: The results of the studies documenting and characterizing the reef fish spawning aggregations in Palau (Johannes *et al.* 1999 and Colin 2006) were, in part, incorporated into the development of the design and selection criteria for the Protected Areas Network (PAN), being created under the PAN Act (2003). A design workshop utilizing MARXAN was held in Palau in May 2006. The PAN is the first application of the resilience principles, including, *inter alia*, the protection of spawning aggregations (refugia), connectivity, monitoring and evaluation. Funding for this work has been secured from a number of private donors and foundations. Additional funding is being sought from New Zealand AID. Spawning aggregation monitoring work is continuing to be conducted in Palau by partners (Palau Conservation Society, Koror State, Ngarchelong State, Coral Reef Research Foundation).

Federated States of Micronesia: The FSM has signed a National Implementation Support Partnership Agreement for the Implementation of the Convention on Biological Diversity (CBD) Program of Work on Protected Areas in the Federated States of Micronesia. This MOU is between the government of the FSM, the four state governments, the College of Micronesia–FSM, the Micronesia Conservation Trust, the FSM Visitors Bureau, The Nature Conservancy, Conservation Society of Pohnpei, Kosrae Conservation and Safety Organization and Yap Community Action Program. The parties will implement the National Biodiversity Strategy and Action Plan (NBSAP), including the establishment of MPAs and MPA networks throughout FSM. The protection of reef fish spawning aggregations has been included as one of the targets. TNC's Micronesia Program is focusing on the establishment of the protected areas identified through the NBSAP, and will apply the lessons learned through this project and the PAN work in Palau to the protection of spawning aggregations.

Papua New Guinea: TNC's 'platform' site work in PNG has been focused on Kimbe Bay. The work undertaken nationally under this grant on the LRFFT and protection of spawning aggregations has enabled us to influence fisheries management nationally. TNC has identified the Bismarck Sea as a critical marine area for biodiversity and one in which we are now focusing our efforts to establish MPAs and networks of MPAs. The community-based activities on protecting spawning aggregations have provided practical entry-points to two key areas in the Bismarck Sea—Manus and Kavieng. This expansion has been identified and included in the GCP II funding for Kimbe Bay ($900,000 through 2008). Under the expansion component, the spawning aggregation work will be continued within the context of the wider MPA network(s) design, implementation, and conservation and marine resource management strategies in general. Matching funding has been secured through a gift by an anonymous donor, which will be used to focus on some of the spawning aggregation research needs related to the network design. Additional support will be pursued through the new Pacific Fisheries EBM Strategy.

Some additional joint funding has come from the National Fisheries Authority (NFA) / Asian Development Bank (ADB) funded nearshore fisheries management and development project through co-funding of the spawning aggregation awareness video. We have been working closely with Gillett, Preston & Associates (GPA) and NFA to capitalize on the strong interest shown by them to incorporate the spawning aggregation project results into nearshore fisheries management. TNC and NFA have signed an MOU that includes these components. The ADB sponsored project has funding for at least the next two years.

The TNC Melanesia Program has recently been awarded a National Fish and Wildlife Foundation (NFWF) grant to study "Connectivity between spawning and nursery areas of groupers in Manus, Papua New Guinea". The results of this study will inform regional management strategies and wider MPA network design protocols through a better understanding of connectivity and movement of larvae from spawning aggregation sites to nurseries.

The TNC Melanesia Program, through its expansion of the Kimbe Bay MPA work and the spawning aggregation work undertaken through this project, will continue to seek funding support for its biodiversity conservation work in the Bismarck Sea for at least the next 10 years.

Solomon Islands: The focus of TNC's site-based work in the Solomon Islands has historically been the Arnavon Islands. More recently we have expanded that work to Choiseul Province at the invitation of, and in partnership with the Lauru Land Conference of Tribal Community (LLCTC). Some of our initial work on Choiseul has been through this grant on identifying spawning aggregations for protection and better management, with the community at Chivoko being the first community we are working with. The communities of Voza and Poroporo have also recently established MPAs. At present, we only have funding from the MacArthur and Packard Foundations that includes some support for our spawning aggregation work in Choiseul.

We continue to provide scientific advice and support to our partner, the Roviana and Vonavona Lagoons Resource Management Program (RVLRMP), which has obtained its own funding to continue its monitoring and management of key spawning aggregation sites.

Hiring Dr Hamilton as TNC staff (Melanesia Marine Scientist) has ensured the provision of on-going scientific support that our field team and partners require in Melanesia to continue the spawning aggregation protection and management activities, and their incorporation into broader conservation and marine resources management actions.

OUTCOMES

4. ACHIEVEMENTS

The following summarizes the main achievements for the project:

- Spawning aggregations monitoring methods and protocols for the Indo-Pacific were developed and a manual and associated training video completed and then reviewed by experienced monitoring practitioners during the Advanced Workshop on Monitoring Spawning Aggregations held in Manus (PNG) in June 2005. The manual and training video are being updated annually or on an as needed basis.
- Introductory training workshops on spawning aggregation monitoring were held in Kavieng (PNG; April 2003), Palau (June 2003), Pohnpei (FSM; February 2004), and Gizo (SI; March 2004).
- An Advanced Workshop on Monitoring Spawning Aggregations was held for experienced monitors from Melanesia in Manus (PNG; June 2005).
- Documentation of local knowledge of spawning aggregations and related local management systems for the south coast of Manus, Tigak Islands (Kavieng, PNG), Kimbe Bay (PNG), Roviana Lagoon (Solomon Islands) and Choiseul (Solomon Islands) were completed.
- Two communities in southern Manus, and two communities in Kavieng are monitoring and managing their respective spawning aggregations. In Kavieng another community is managing but not monitoring an aggregation site, and in Manus monitoring is occurring at one site that is not being managed. A community in Choiseul has closed off a significant spawning aggregation site, and will commence monitoring October 2006. Two other communities in Choiseul have established MPAs, and many other communities have requested TNC's assistance in establishing community-based fisheries related MPAs. This resulted from working closely with the main land-owner association in Choiseul. We have continued to advise and work closely with a partner on the monitoring and management of spawning aggregations within the existing community-based MPA program in Roviana Lagoon, as a result two sites are now being monitored and managed.

- Close working relationships maintained and further developed with the PNG National Fisheries Authority concerning the management of the LRFFT and the incorporation of spawning aggregation management into their inshore fisheries management planning and licensing.
- Incorporation of spawning aggregation protection into Palau's Protected Areas Network design and selection criteria.
- Incorporation of spawning aggregations into the MPA network design for the Kimbe Bay Marine Protected Areas Network.
- On-going collaboration and coordination with SPC Marine Resources Division with respect to LRFFT management and the monitoring and management of spawning aggregations.
- A range of destructive fishing, LRFFT, and spawning aggregation awareness materials focused on school children have been launched and distributed.
- A review of the effectiveness of the awareness materials and their use has been initiated in PNG through an independent consultant. The baseline survey has been completed, and the follow-up survey is scheduled for 2007. The baseline survey assessed school children's knowledge of destructive fishing/LRFFT issues in selected primary schools in Port Moresby, Manus, Kavieng, and Kimbe Bay.
- Public awareness presentations, both formal and informal, have been provided by Dr Hamilton and the CCCs to all the communities involved in the local knowledge documentation study and during the subsequent follow-up visits to establish monitoring programs. These presentations resulted in the support and interest by the communities currently protecting and monitoring their spawning aggregation sites.
- Spawning aggregation and destructive fishing awareness videos in English and PNG Pidgin completed and distributed.

5. INDICATORS

The Nature Conservancy identified five outcomes to be attained by the end of this project. A summary of the status is provided beneath each outcome:

1. *At least eight reef fish spawning aggregation sites in Melanesia and Micronesia are being effectively monitored and managed by their respective owners, using the information, methods and management approaches developed and provided through this project*.

    - To date, 15 sites currently meet most of the criteria for this indicator:
        - 2 sites in Manus, PNG (monitored and managed)
        - 1 site in Manus, PNG (monitored but not managed)
        - 2 sites in Kavieng, PNG (monitored and managed)
        - 1 site in Kavieng, PNG (managed, not monitored)
        - 2 sites in Kimbe Bay, PNG (managed, limited monitoring to date).
        - 1 partner site in Roviana Lagoon, Solomon Islands (monitored and managed)
        - 1 partner site in Roviana Lagoon, Solomon Islands (monitored, not managed)
        - 1 partner site in Roviana Lagoon, Solomon Islands (managed, not monitored)
        - 1 site in Choiseul (managed, baseline monitoring conducted, a regular monitoring program is being developed)
        - 2 partner sites in Palau (monitored and managed)
        - 1 partner site in Pohnpei, FSM (monitored and managed)

2. *At least three major regional partners are using the monitoring methods and management guidelines developed through this project*.

    - Three regional partners, WWF (PNG and Solomon Islands), Wildlife Conservation Society (WCS – Kavieng) and Conservation International (CI – Milne Bay), have been trained in the monitoring methods and have indicated they will use them. None are currently monitoring or managing any spawning aggregations in their projects.
    - SPC is aware of the methods, but is not yet in a position to promote them. They are to be feed into the development of approaches for the ecosystem-based management of fisheries.
    - The revised monitoring manual, training video and the management guidelines have been finalized and in the process of being distributed to partners.

3. *Reef fish spawning aggregation management and design criteria developed through this project are being used in the design of two marine protected area networks—one in Kimbe Bay (PNG) and one in Palau*.

    - The information, data and management guidelines developed through this project for the protection of spawning aggregations has been incorporated in the MPA designs for both Palau's Protected Areas Network (design workshop May 2006) and the Kimbe Bay Marine Protected Areas Network (design workshop July 2006). This included incorporating information on: methodologies for identifying and verifying the locations of spawning aggregation sites; monitoring guidelines and management options under various ecological, political, economic and cultural settings; and prioritization of on-going actions.

4. *The community and government partnerships developed through this project at the primary reef fish spawning aggregation sites in Manus and Kavieng will provide the site and community foundations for the expansion of the large-scale, resilient MPA network for the Bismarck Sea and utilizes the MPA network science and design experience from the Kimbe Bay platform site*.

    - The spawning aggregation activities in Manus and Kavieng have provided a solid community foundation for the expansion to a Bismarck Sea MPA network. A Rapid Ecological Assessment (REA) was undertaken in both the Kavieng and Manus areas in August/September 2006. The results of the REA will help guide further activities in those areas.
    - The partnership with Pere community in Manus has proven to be exceptional. They have maintained their closure over their spawning aggregations despite considerable pressure from a LRFFT operator, and have set aside additional protected areas and applied other management controls on fishing.

5. *The PNG National Fisheries Authority and the Solomon Islands Department of Fisheries and Marine Resources have effective Live Reef Fish Management Plans in place and nearshore fisheries management policies that include the protection of reef fish spawning aggregation sites*.

    - PNG's NFA has a National LRFFT Management Plan that is being used to manage their LRFFT licensing. Under this licensing agreement there are specific conditions to protect spawning aggregation sites. This project has, and will continue, to provide input to the management process, and the revision of the National Management Plan and licensing conditions.
    - The Solomon Islands Department of Fisheries and Marine Resources have a draft National LRFFT Management Plan, but have not yet adopted or implemented it. At present there are no LRFFT operations within the Solomon Islands. We will continue to encourage the government to adopt the management plan prior to any new LRFFT operations emerging.

6. STRATEGIES

6.1 Science and Monitoring

Monitoring

The purpose of monitoring is to collect the biological information necessary to make informed management decisions on the best ways to manage spawning aggregations sites. The two specific objectives are to firstly, quantitatively determine the seasonality with which aggregations of *P. areolatus*, *E. fuscoguttatus* and *E. polyphekadion* form in each region, and secondly, collect baseline data on the relative densities and abundances of each of these three species at the sites that are being monitored. Over time, the effectiveness of management decisions, or the removal of management, can be determined.

Development of the Monitoring Methods

One of the greatest challenges of this project has been obtaining agreement on what protocols and methods should be used to monitor spawning aggregations in the western Pacific, especially given that the target audience is in-country practitioners rather than scientists. Most commonly, spawning aggregation monitoring methodologies have been based on the assumption that trained scientists will be conducting the monitoring. However, in the Pacific, and especially in Melanesia, this assumption is not always valid.

To address the needs of local practitioners, the Conservancy has endeavored to make the monitoring methodologies as practical as possible, while maintaining scientific rigor, and ensuring they are related to management questions. Our goal was to develop a monitoring protocol that can be undertaken by in-country fisheries officers, conservationists, and trained community members, with results that can be interpreted and used by managers to obtain a basic understanding of what is happening to a specific aggregation in relation to their management actions.

The evolution of the methodologies has been based on reviews by both external and internal TNC scientists, feedback from participants at the monitoring training workshops, and feedback from the field sites. The methods continue to be regularly assessed and modified, both at the protocol level and for the unique circumstances at the sites.

The results that have been obtained from the monitoring being conducted in Melanesia (see later Site Activities section), demonstrates that the methods are both practical and still scientifically rigorous. As with all methods available to date, there is still the need for a scientist to assist with analyzing and interpreting the results.

The Conservancy's approach has resulted in some criticism from other scientists, in particular from the Society for the Conservation of Reef Fish Aggregations (SCRFA), who have tended to focus more on the scientific assessments and monitoring for publication rather than applied management. We have engaged in an ongoing dialogue with SCRFA on methodologies. In 2003 SCRFA released their own manual (Colin *et al*. 2003), which reviews the various reef fish spawning aggregation methods for scientific purposes. This is a very useful and complementary document to our manual, and one that we provide to all our workshop participants.

Even within the Conservancy, we continue to have debates over questions such as whether or not to include visual length-frequency estimation, as well as other issues. This lively debate on methodologies, both within and outside the Conservancy, has been exciting and is helping considerably in refining the methodologies and the training.

In the manual and training workshops, we always recommend that managers consult qualified scientists whenever possible to build on the basic methods and data and to gain a more detailed understanding of what is occurring at spawning aggregation sites.

GPS Density Survey Methodology

The spawning aggregation study in Palau (Colin 2006) helped Dr Patrick Colin of the Coral Reef Research Foundation to further develop his new "GPS density survey" methodology for surveying spawning aggregations. This methodology uses a Global Positioning System (GPS) to log the observer's position so that fish counts can be more accurately mapped and is outlined in Colin *et al*. (2005 – Conference PowerPoint Presentation) and Colin (2006):

> "The observer, swims a series of transects across the area of an aggregation while towing a small float with a position logging GPS receiver. The observer counts and records the number of individuals of selected species each minute within a chosen distance (usually 10 m either side) of the swim track. After return to shore the GPS data are downloaded, the distance during each minute (during which fish counts were made) determined and the area surveyed calculated from the swath width (Figure 2). This provides the area surveyed each minute (a rectangle), the numbers of fishes within that area and the location of the area on the reef. From these data, the density of fishes can be plotted for any given survey and an estimate of the total numbers of fishes in the aggregation **(**Figure 3). Since the data are quantitative, within certain limits, surveys from different days, months and years can be compared and with some confidence, it can be said whether numbers of fish are changing and if aggregations are of the same spatial extent and location." Colin (2006: 3-4)

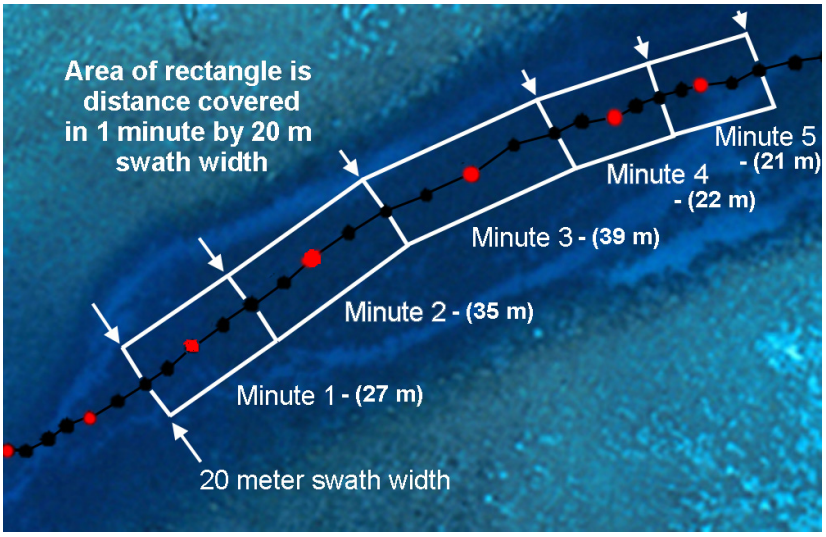

Figure 2: Typical GPS Density Survey swim track with one-minute rectangles (white lines) delineated. Area of rectangles is determined by distance surveyed each minute by swath width, while the numbers of fishes are counted during each minute to calculate density. (Colin 2006)

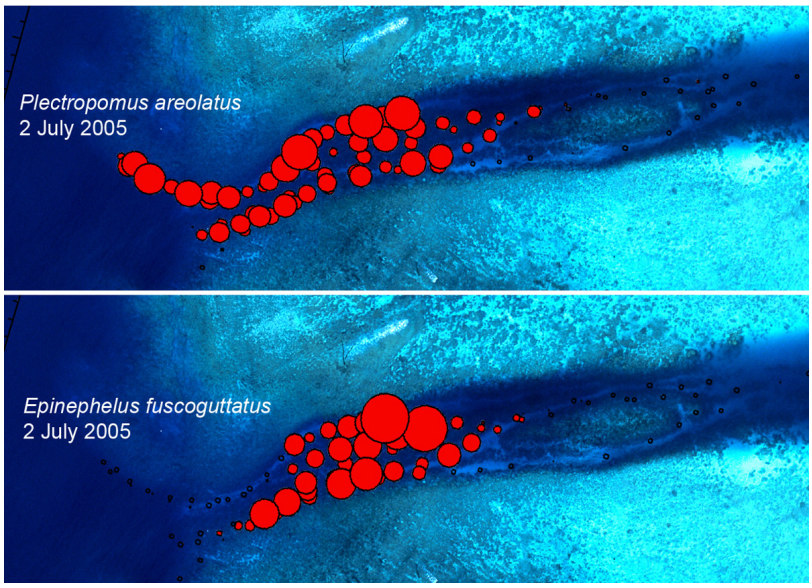

Figure 3: Typical GPS density bubble plot for two species of groupers on the same day at the Ulong Channel aggregation site. *Plectropomus areolatus* in shown in the upper panel while *Epinephelus fuscoguttatus* is in the lower panel. The difference in their respective distributions, as determined by the GPS Density Survey method, is evident. (Colin 2006)

While this GPS density survey methodology does show promise, as it is described in the report and the Power Point, it still requires more development before we can recommend it over permanent, marked, belt transects (as we are using in Melanesia), especially in community settings. There is still the same need to use trained and skilled observers with a high capability to identify species, count effectively (especially where there are high numbers, bad conditions, etc.) and therefore has the same problems of observer error and data verification as transect methods. Also, the density method only estimates the swath width, whereas the belt transects have the width marked. Estimating transect widths has been a major criticism of UVC methodologies, and one we removed by marking the transects. In addition, there is still considerable work required to resolve some data analysis issues and how to interpret the results for management. This method relies more heavily on computers and mapping programs which may restrict its utility for some areas. However, with further development this method does show good promise for certain situations.

Monitoring Manual

The first version of the monitoring and training manual developed for this project was based on a training manual developed in TNC's Indonesia Marine Program, and was used for the first training workshop in Kavieng, PNG:

> Rhodes, Kevin L. 2003. Spawning Aggregation Monitoring Training Workshop Manual. Version 1 (April 2003). Pacific Island Countries Coastal Marine Program, The Nature Conservancy. 33 p.

Based on feedback from reviewers and the workshop participants, a revised manual was developed with TNC Indonesia Marine Program and used in the Palau monitoring workshop:

> Rhodes, K., A. Muljadi, P. Mous and J. Pet. 2003. Introduction to Monitoring and Management of Spawning Aggregations and Aggregation Sites for Three Indo-Pacific Grouper Species (*Epinephelus fuscoguttatus*, *Epinephelus polyphekadion*, *Plectropomus areolatus*): A Manual for Field Practioners. June 2003. The Nature Conservancy. 65 p.

Again, based on feedback from participants, and our field staff, this manual was revised to fit the practical realities of working in the Pacific. This resulted in the TNC Indonesia Marine Program having one manual and the TNC Pacific Island Countries Coastal Marine Program a slightly different one. While focused on different species, the TNC Caribbean Program had a third spawning aggregation manual. Within TNC this caused difficulties, and so it was agreed that the Pacific and Indonesian programs would work with the TNC Marine Initiative to develop a single Indo-Pacific spawning aggregation manual. This manual is now in use in all our Asia-Pacific programs:

> Pet J.S., Mous P.J., Rhodes K. and Green A. 2006. Introduction to monitoring of spawning aggregations of three grouper species from the Indo-Pacific. A manual for field practitioners. Version 2.0 (January 2006). Publication from The Nature Conservancy Coral Triangle Center, Sanur, Bali, Indonesia. 98 p.

The original version of this spawning aggregation monitoring manual was reviewed by the participants of the Advanced Monitoring Workshop in Manus (June 2005). During the workshop the participants—all of whom were experienced spawning aggregation monitors—provided feedback on the manual. One of the manual's authors (from the TNC Indonesia Program) attended the workshop, and incorporated much of the feedback into the revised manual (Version 2). The manual is now regularly updated at least every 12 to 18 months, or as circumstances require.

The draft Spawning Aggregation Monitoring Field Guide was also reviewed by the participants at the advanced workshop. While it was considered a possible useful addition for in-country practioners who need a "how-to" guide to undertake basic monitoring, it was decided to put the revision of the draft Field Guide on hold to assess whether or not it is needed. A decision will be made in the coming year whether or not to persevere with the Field Guide.

> Rhodes, K.L., R.J. Hamilton and A.J. Smith. 2004. Field Guide for Monitoring Spawning Aggregations of Three Indo-Pacific Grouper Species (*Epinephelus polyphekadion* – camouflage grouper; *Epinephelus fuscoguttatus* – brown-marbled grouper; *Plectropomus areolatus* – squaretail coralgrouper). Draft Version 1.0. Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 6/04

Monitoring Database

The work on completing the revisions to the spawning aggregation database that was developed by the TNC Caribbean Program was put on hold due to the departure of their project manager. The Pacific Island Countries Coastal Marine Program collaborated with the Meso-American Reef Program (MAR), to finalize the database during this reporting period, to allow the key Indo-Pacific species to be incorporated into the database last year. While the database is now apparently functional and able to receive monitoring data for Indo-Pacific species, it has only been tested with Pohnpei site data. The database includes length, abundance, species, locale, transect number, monitoring agency, and is able to deal with individual or multiple transects. The database is in Microsoft Access format, but is not yet accessible online (TNC MAR Program is working on making the database accessible online). We were to have received the CD with the database this year from the Meso-American Program, however, there are apparently still some issues that need resolving before we can get it and test it further by entering the Melanesian monitoring data. While the data from the Caribbean will be maintained in a separate database to the Pacific data, the common structure of the database will allow better tropics-wide analyses of spawning aggregation issues.

Site Identification Methods Review

Dr Rhodes completed two reports on assessing and documenting the remote image/promontory spawning aggregation site identification methodology. This work was jointly funded with the TNC Meso-American Reef Program. The reports are:

Rhodes, K.L. 2005. Summary Report on the Utility of Locating Tropical Reef Spawning Aggregations Using Combined Technical and Non-Technical Methodologies. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 4/05. (RESTRICTED CIRCULATION)

Rhodes, K.L. 2005. A Guide for locating Coral Reef Fish Spawning Aggregation Sites. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 5/05. (RESTRICTED CIRCULATION)

Both of these reports provide information that could be used to facilitate the exploitation of as yet unidentified reef fish spawning aggregations. Therefore, they have been restricted to a limited internal TNC distribution list.

The methodology review reports on four regional surveys investigating spawning aggregation locations using a variety of methods that included fisher interviews, nautical charts, aerial photography and satellite imagery. From these combined surveys, a total of 71 potential spawning aggregation sites were identified for field assessment. Of those sites, 29 sites were investigated in the Caribbean and 31 in the Pacific. For Caribbean sites, a total of 25 sites were identified directly through underwater observation or indirectly (fisher catch of gravid females) (= 86.2%). In the Pacific, using the same techniques, 36 potential spawning aggregation sites were identified. Of those, 31 sites were investigated and only three sites were confirmed to be active spawning aggregations (= 9.7%).

For Belize, 24 sites were predicted and 20 were assessed through underwater survey. Of those 20, 17 were identified as having spawning aggregations (= 85.0%). In the Caymans, 11 sites were predicted from satellite imagery and, of those, five sites were known to fishers as spawning grounds. Two of the remaining six sites were not investigated. Of the remaining four, three were found to have active spawning aggregations and only one was inactive. Therefore, the overall predictive rate was 81.8%.

A total of 15 sites were chosen for spawning aggregation site assessment in Pohnpei through a combination of fisher interviews, nautical charts, aerial photography and satellite imagery. Of those, investigators already knew one site as a multi-species spawning aggregation site. Five sites were not investigated in 2005. From the remaining sites, 12 dives were performed over two months to locate an additional two spawning aggregation sites that appeared multi-species in nature. Therefore, the overall success rate was approximately 30%. In Papua New Guinea, 21 sites were identified from satellite imagery to conduct field assessment of spawning activity. No fisher interviews, nautical charts or aerial photography was used in the initial site selection process. Of these 21 sites, none were shown to have spawning aggregations, although some sites nearby were active. The overall predictive rate for Papua New Guinea was 0%.

Based on these results, it would appear that the success rate using the satellite imagery without local fisher interviews is so low that it is not worth pursuing within the Pacific as a viable independent identification method.

The Guide for Locating Coral Reef Fish Spawning Aggregation Sites summarizes the suite of methods available for identifying potential reef fish spawning aggregation sites. All sites identified must be verified by field observations before they can be classified as spawning aggregations. Given the sensitivity of this information, this report has restricted access status.

Local Knowledge surveys

At the commencement of this Project it was recognized that in Papua New Guinea and the Solomon Islands[4] there were several basic information gaps that needed to be addressed if TNC was to meet its objectives. Firstly, the locations and biological parameters of spawning aggregation sites in target areas in Melanesia needed to be identified, and secondly, the destructive fishing pressures on spawning aggregations and the impacts of these practices needed to be understood. In most regions in Melanesia there are no scientific data on spawning aggregations, yet ethnographic surveys that have utilized local fishers' knowledge have often proven to be a cost effective and successful way of documenting baseline information on reef fish spawning aggregation sites (e.g. Johannes 1989; Johannes and Kile 2001; Hamilton 2003). Recognizing this we conducted local knowledge surveys in Manus Province and Kavieng, New Ireland Province, Papua New Guinea in 2004. In the same year local knowledge surveys were also conducted in Roviana Lagoon, Western Province and Choiseul Province, Solomon Islands. A further local knowledge survey was conducted in Kimbe Bay, West New Britain Province, Papua New Guinea in 2005. The aim of the TNC local knowledge surveys were to quickly amass as much information as possible on reef fish spawning aggregations and any related local management strategies, in each region of interest. It was envisaged that documented local knowledge on aggregation parameters (such as specific locations, species composition and aggregation status) could provide a guide that could be used to tailor future research, conservation and management efforts.

In each region that local knowledge surveys were conducted we attempted to cover as wide a geographical area as possible, focusing our efforts on communities that were known to be heavily dependent on marine resources. The authors' knowledge of a region, word of mouth and any available unpublished or published literature were used to determine where we based the majority of our efforts. In each region visited, local knowledge surveys lasted between one and two weeks. Upon arriving in a community we would ask to speak to the community leaders, then we would explain who we were working for and what our agenda was. Typically the community leaders would then call a group of available expert fishers together under a tree or by the beach. We would then introduce ourselves and give an introductory talk on the life cycle of aggregating fishes, outlining among other things, aggregating behavior, spawning, the pelagic larvae stages of fish and sex reversal. We would then point out that while biologists knew a lot about fish biology, we knew nothing about where or when spawning aggregations occurred on reefs in the region we were in, which is why we wanted to ask local fishers for their help. We ended by clearly stating that the information we were collecting was part of a preliminary assessment of spawning aggregations that TNC was making in their region, and specific details on locations of sites and other sensitive local knowledge would remain confidential.

These introductory talks frequently generated a great deal of interest, and served as a very effective way of initiating conversations on reef fish aggregation sites. Fishers often enthusiastically shared their own observations and asked numerous questions on spawning aggregations. Reef fish guide books and posters showing the main target species of the LRFFT were used as visual aids so that fishers could show us what species aggregated on their reefs. Importantly, these introductory talks also served as a quick way of assessing the level of local knowledge on spawning aggregations in the area visited. Individuals or groups of knowledgeable fishers who were willing to be interviewed in detail were asked a wide range of questions on reef fish aggregations that occurred within their fishing grounds. The questions laid out in the Society for the Conservation of Reef Fish Aggregations (SCRFA) questionnaire (http://www.scrfa.org/scrfa/studying/introduction.htm) formed the template

[4] At the same time that TNC was initiating the Melanesia local knowledge surveys, The Society for the Conservation of Reef Fish Aggregations (SCRFA) began to conduct local knowledge surveys to identify reef fish spawning aggregations in Palau and FSM. Because of this TNC decided to focus all of its efforts on Melanesia, with a view to an open exchange of aggregation data with SCRFA. While TNC has provided SCRFA with restricted access reports from Melanesia for incorporation into their database, to date SCRFA has not provided TNC with site specific information from their Palau and FSM surveys for use in conservation activities. A SCRFA public access report for FSM is available on the SCRFA web site (www.scrfa.org).

for the questions covered. Interviews were conducted in PNG Tok Pidgin or Solomon Pidjin, languages that one of the authors [RH] is fluent in.

Temperature loggers

Changing water temperatures have been linked to the onset and cessation of spawning aggregations in both Australia and the Caribbean (Samoilys, 1997; Heymen *et al*., 2005), and it was of interest to see if spawning seasons at monitored sites in Melanesia correspond to annual temperature fluctuations. Accordingly, in July 2004 temperature loggers were placed at the five monitored sites in Manus and Kavieng and at one monitored site in Roviana Lagoon, Solomon Islands. These temperature loggers are routinely checked by monitors, and they are all still actively logging daily temperatures. They will be retrieved and the data downloaded in early 2007 before the battery life of these loggers expires.

6.2 Capacity Building

Introductory Spawning Aggregation Monitoring Training Workshops

Four training workshops were held to introduce participants to spawning aggregation monitoring methods. These workshops were held in Kavieng, PNG (April 2003), Koror, Palau (June 2003), Pohnpei, FSM (January-February 2004), and Gizo, Solomon Islands (March 2004). Reports are available for each workshop:

> Rhodes, K.L. 2003. Kavieng Spawning Aggregation Monitoring Training Workshop Report, Kavieng, New Ireland, Papua New Guinea, 22-30 April 2003. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 3/03
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> Rhodes, K.L. 2003. Palau Spawning Aggregation Monitoring Training Workshop Report, Koror, Republic of Palau, 18-30 June 2003. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 4/03
>
> Rhodes, K.L. 2004. FSM Spawning Aggregation Monitoring Training Workshop Report, Black Coral Island, Pohnpei, Federated States of Micronesia, 31 January – 6 February, 2004. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 1/04
>
> Rhodes, K.L. 2004. Solomon Islands Spawning Aggregation Monitoring Training Workshop Report, Gizo, Western Province, Solomon Islands, 13-21 March 2004. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 2/04

These monitoring training programs introduced basic data-gathering techniques to practitioners for managing spawning aggregations, including species identification, the determination of reproductive season, identification of spawning aggregation sites, site mapping and area determination, species aggregation behavior, species abundance and fish length estimation and data collection, processing and analysis. The workshops focused primarily on the use of underwater visual census techniques and were designed to accommodate local resource managers interested in establishing long-term monitoring programs for management and conservation purposes.

The PNG workshop included three women and had participants from:

- TNC-Papua New Guinea (3)
- Mahonia Na Dari (PNG NGO Kimbe Bay) (1)
- National Fisheries Authority (NFA) (1)
- Ailan Awareness (Kavieng NGO) (2)
- The University of Papua New Guinea (UPNG) (1)

- World Wide Fund for Nature (WWF PNG Madang) (1)
- World Wide Fund for Nature (WWF Solomon Islands Gizo) (1)
- Wildlife Conservation Society (WCS Fiji) (1)
- Conservation International (CI Milne Bay) (1)
- Packard Foundation (PNG Officer) (1)
- Department of Environmental Conservation (DEC) (1)
- James Cook University / Mahonia Na Dari (researcher in residence) (1)

The Palau workshop included one woman and had participants from national and state government agencies and local NGOs:

- Palau Conservation Society (2)
- Bureau of Marine Resources (2)
- Palau International Coral Reef Center (4)
- Koror State Rangers (3)
- Helen Reef Resource Management Program (3)

The Pohnpei, FSM workshop included three women and had participants from national and state government agencies and local NGOs:

- Conservation Society of Pohnpei (6)
- Kosrae State Department of Agriculture, Land and Fisheries (2)
- Chuuk State Department of Marine Resources (1)
- Chuuk Guide and Assist Through Awareness (NGO) (1)
- Yap State Department of Resource and Development (2)
- Pohnpei State Department of Land and Natural Resources (2)
- US Department of Interior (1)

The Gizo, Solomon Islands workshop was held in partnership with WWF (Solomon Islands). It involved participants (one woman) from government agencies, NGOs, communities, and private dive operators.

- Roviana and Vonavona Marine Resource Management and Development Program (5)
- Arnavon Marine Conservation Area (AMCA) (3)
- Solomon Islands Department of Fisheries & Marine Resources (2)
- Uepi Island Resort (2)
- International Waters Project – Solomon Islands (1)
- Dive Gizo (2)
- Worldwide Fund for Nature (Solomon Islands) (3)
- The Nature Conservancy – Solomon Islands and Marine Initiative (3)

Manus Advanced Workshop on Spawning Aggregation Monitoring

The Advanced Workshop on Spawning Aggregation Monitoring was held in Manus in June 2005, and brought together the most experienced monitors within Melanesia. The goal of the workshop was to bring together experienced monitoring practitioners in order to collectively review the effectiveness of the monitoring methods utilized to date, evaluate the usefulness of the monitoring manual in a Melanesian setting and discuss lessons learned. In addition to having these participants critique the existing methods and materials, they also participated in upgrading their skills in length-frequency estimation, mapping aggregations, setting transects, data processing skills and interpretation of data for management.

The details of the workshop have been included in the report:

> Hamilton, R.J., P. Mous and A. Smith. 2005. Advanced Workshop on Monitoring Reef Fish Spawning Aggregations Report, Pere, Manus Province, Papua New Guinea, 2-11 June 2005.

Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 6/05

There were 15 participants at this workshop, including two women. They were from universities, national fisheries departments and non-government organizations (NGOs). The workshop trainers and dive safety officer were from TNC Melanesia (2), TNC Indonesia (1), TNC Pacific (1) programs. The majority of participants were from Papuan New Guinea and the Solomon Islands:

- Conservation International – Milne Bay (1)
- PNG National Fisheries Authority (1)
- Roviana Spawning Aggregation Monitoring Team, Solomon Islands (2)
- The Nature Conservancy Melanesia Program (4 staff; 2 monitoring contractors)
- Wildlife Conservation Society – Kavieng (1)
- University of Papua New Guinea (1)

Exchanges Between Sites

The original project proposal included a number of international exchanges, not only within the Pacific, but also between the Pacific, Indonesia and the Caribbean. However, as the awarded grant was less than requested, these international exchanges were significantly reduced. The exchanges that were undertaken focused on bringing participants to the introductory monitoring workshops.

The Kavieng, PNG workshop included two international exchanges to help spread the standardization of methods:

- Wildlife Conservation Society (WCS) in Fiji requested that one of their female staff participate in the workshop as WCS Fiji was about to investigate the protection of reef fish spawning aggregations in that country.
- World Wide Fund for Nature (WWF) in Gizo, Solomon Islands requested that their reef fish spawning aggregation officer participate to learn the latest monitoring methods.

For the Advanced Monitoring Workshop in Pere, Manus, PNG, we invited experienced spawning aggregation site monitors from around Melanesia. The participants were all involved with monitoring at their own sites, and were able to not only dive the Manus sites and assist with the monitoring there, but also participated in discussions with the Pere community leaders and fishers on how the community is managing their spawning aggregation sites. It also enabled the community members to ask questions of the participants to find out how other places in Melanesia are handling the issue of spawning aggregation monitoring and management. These exchanges included:

- Warren Kama and Michael Giningele from the Roviana Spawning Aggregation Monitoring Team (RSAMT), Solomon Islands.
- Tapas Potuku (Kavieng CCC) and Lawrence Litau (Kavieng monitoring team).
- Noel Wangunu (CI Milne Bay, PNG).
- The TNC Kimbe Bay team (Joe Aitsi, Annisah Sapul, Shannon Seeto).
- Dr Peter Mous (TNC Indonesia) was able to both contribute the Indonesian experience to the workshop, as well as gain significantly from the Melanesian participants' experiences.

One key issue that became apparent with trying to arrange exchanges, was the fact that many of the sites' spawning seasons overlapped. As there are only a limited number of trained surveyors at each site, going on an exchange meant that no monitoring data could be collected for the time they were absent. Until the numbers of well trained surveyors increases, this will remain a problem. Despite this, the feedback on the exchanges was extremely positive, and wherever feasible they should be encouraged.

At the Advanced Workshop a discussion was held on cross-support between monitoring teams, and their availability to contribute to national and/or regional monitoring teams. The key points from this discussion were:

- Participants were keen to be able to assist other programs with establishing monitoring programs.
- A number of practical issues were raised:
    - If possible, such assistance should be written into the monitors' annual work plans, however, if that isn't possible around 4-6 weeks notice will be needed for logistics and to obtain supervisor's approval (approval in principle would already have been obtained; this approval would be for the specific case and time).
    - Monitoring within the Melanesia region tends to be at the same time (prior to the new moon and in every month of the year). For members of a team to participate elsewhere, there needs to be back-up monitors to continue the monitoring.
    - Participants agreed that a maximum time away should be limited to two weeks.
    - Travel costs should be paid by the requesting agency; and the issue of personnel costs should be on a case-by-case basis.
- A range of areas of support were identified and discussed. It was agreed that it would help to have some basic guidelines developed for providing assistance and identifying the pool of people with the appropriate skills. Areas of support identified included:
    - Site identification and verification: This requires time for interviews prior to field verification of sites just prior to the new moon.
    - Establishing monitoring teams and training new monitors in counts and/or size estimation.
    - Site mapping and establishing transects
    - Assisting short-handed teams with undertaking counts or size estimations.
    - Assisting with training workshops as a trainer or resource person.
    - Awareness raising linked to monitoring.
- The participants agreed to initially assist each other within countries first. TNC has provided the names and experience summaries to SPC for their use as needed.

Monitoring teams: The following eleven surveyors are at a suitable standard to be able to assist with establishing new spawning aggregation monitoring programs and to assist with training people at monitoring workshops: Michael Giningele (RSAMT Roviana Lagoon), Warren Kama (RSAMT Roviana Lagoon), Daniel Afzal (formally WCS Kavieng), Manuai Matawai (TNC CCC Manus), Tapas Potuku (TNC CCC Kavieng), Noel Wangunu (CI Milne Bay), Joseph Aitsi (TNC Kimbe), Annisah Sapul (TNC Kimbe Bay), Shannon Seeto (TNC Kimbe Bay), Leban Gisawa (NFA Port Moresby), and Alec Hughes (formally WWF – SI).

6.3 Awareness

Destructive Fishing Awareness Materials

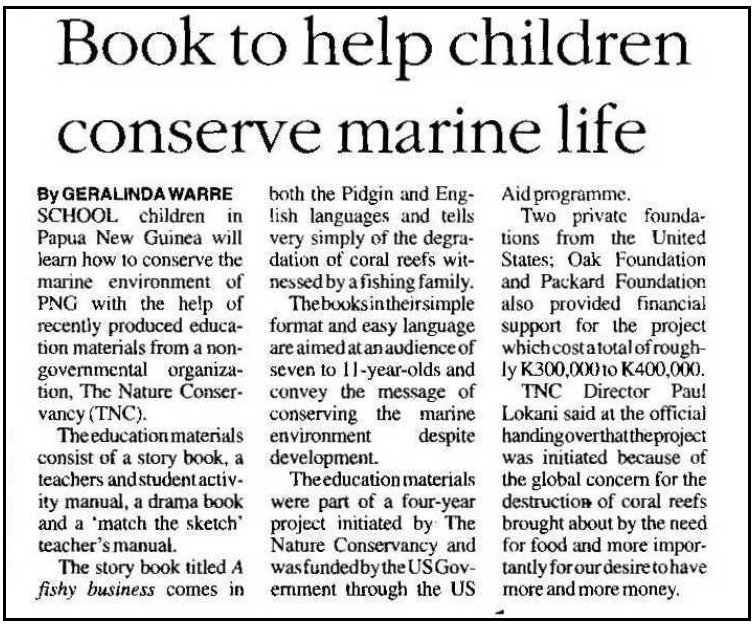
Under the previous grant a range of school focused educational materials were developed, but not fully completed and launched. This project finalized those materials and launched them. Those awareness materials included:

- Storybook "A Fishy Business"
- Teachers and Students Activity Manual for "A Fishy Business"
- Puppet and Drama story
- Match the Sketch Teaching Materials
- Match the Sketch Teaching Manual
- Booklet – What you need to know about Live Reef Food Fish Trade

The environment education materials have been delivered to the Materials Section of the Curriculum Unit, PNG Department of Education, from where they were to be dispatched in late 2005 to schools in the country for use at the primary level.

These materials were officially launched on July 25 2005 and handed over to the Education Department by The Nature Conservancy. The launch was held at the Holiday Inn and was witnessed by 30 guests, including the US Deputy Ambassador and the Member for Parliament and former Environment and Conservation Minister. The Member for Parliament received the materials from TNC Melanesia Director Paul Lokani, as the Education Minister was unable to attend due to an illness. Other guests were from the Education Department, the Department of Environment and Conservation, international and national NGO partners and the media. About sixty school children from the Coronation Primary School in the National Capital District participated in the event and sang the country's national anthem.

National television station EMTV ran a news item on the evening news on July 25 while the National newspaper, one of the two dailies, had a small article on July 26 (Figure 4) The host of a children's program on the EMTV, was also present and took some footage which she used in one of her programs.



Book to help children conserve marine life

By GERALINDA WARRE

SCHOOL children in Papua New Guinea will learn how to conserve the marine environment of PNG with the help of recently produced education materials from a non-governmental organization, The Nature Conservancy (TNC).

The education materials consist of a story book, a teachers and student activity manual, a drama book and a 'match the sketch' teacher's manual.

The story book titled *A fishy business* comes in both the Pidgin and English languages and tells very simply of the degradation of coral reefs witnessed by a fishing family.

The books in their simple format and easy language are aimed at an audience of seven to 11-year-olds and convey the message of conserving the marine environment despite development.

The education materials were part of a four-year project initiated by The Nature Conservancy and was funded by the US Government through the US Aid programme.

Two private foundations from the United States; Oak Foundation and Packard Foundation also provided financial support for the project which cost a total of roughly K300,000 to K400,000.

TNC Director Paul Lokani said at the official handing over that the project was initiated because of the global concern for the destruction of coral reefs brought about by the need for food and more importantly for our desire to have more and more money.

Figure 4: The National newspaper article 26 July 2005

At the recommendation of the Curriculum Unit and Anthrosearch PNG, we will assist a Curriculum Unit staff person to visit the selected schools to ensure that the teachers are familiar with delivering the materials and the associated messages through in-service training. This will also provide the opportunity to help the teachers familiarize themselves with the teacher handbook produced specifically for these materials.

Unfortunately, while the school awareness materials were successfully launched and handed over in July 2005, we found out that the Education Department did not ship the materials out to the schools in time for 2006 as they had agreed. They will not be available to the schools until the 2007 school year. We will continue to work with the Education Department to ensure the materials are shipped and appropriate in-service training provided to the teachers.

Awareness Effectiveness Evaluation

In discussions with USAID staff, we agreed that there was a need to undertake an assessment of the effectiveness of the destructive fishing awareness materials. We agree that this was a significant

oversight in the previous grant and that it would be very beneficial to have the review completed so that it could guide future awareness materials. We worked to have the effectiveness study undertaken by an outside institution with experience in both undertaking such reviews and in PNG culture. A review of the effectiveness of the destructive fisheries awareness materials was planned for FY05. The review was to have two phases:

- Undertake a baseline survey of selected partners; and
- A follow-up survey at least six months after the launch of the materials.

A number of factors contributed to the delay of both the baseline survey and the launch of the materials:

- The original organization that was to undertake the review, withdrew due to receiving a large project from an international donor government. This required identifying a suitable alternative contractor within PNG (our preference was to use local consultants).
- The contracted company, Anthrosearch (PNG), was to have undertaken the field work for the baseline study between October and December 2004. They completed the surveys in three of the four sites (Kimbe Bay, Manus, and Port Moresby) before the end of the school year in December 2004, but were not able to complete the final site (Kavieng) until February 2005.
- The first report submitted was deemed insufficient for our purposes and a long process of multiple revisions of the report was undertaken to ensure all the terms of reference were adequately addressed. The final baseline report, along with all the raw survey data, was received in September 2005, although there remain some issues.
- The production and launch of the materials were delayed in part due to the need to have the baseline survey completed before launching the materials, and also due to a delay in having one final product re-printed (the initial print run was missing two pages).
- We needed to re-establish the partnership with the Education Department's Curriculum Unit. The staff we had originally worked with had moved on, and there were new staff and a new Education Secretary. We needed to satisfy the new head of the Curriculum Unit on the content, sustainability, criteria, and delivery of the materials. These issues were resolved and by mid-2005 we had the full support of the Education Department.
- As noted above, the materials were launched in July 2005, handed over to the Education Department, but were not shipped out by them to the schools for use in 2006 school year.

The follow-up effectiveness survey will be undertaken in 2007 after the materials have been in use for at least six months. Closer to the time we will search for an appropriate independent contractor to complete the review.

Spawning Aggregation Awareness

In the original proposal and work plans we had intended conducting community workshops each year to raise awareness about the vulnerability of aggregating reef fish and the options for management. However, we found it more effective and appropriate to incorporate the awareness raising activities into the community meetings, undertaken during the monitoring work and the studies to document local knowledge. This has allowed us to transfer the information concerning spawning aggregation sites within a contextual framework. The awareness information is being used to educate communities about taking ownership of resource management in order to sustain the resource and the communities' way of life, the short-term and long-term effects of destructive fishing, and the critical role of spawning aggregations in the life cycle of threatened fisheries and the need to protect them.

A summary of the formal community awareness raising presentations that were provided to Melanesian communities by the authors is provided in Appendix 3. Appendix 3 also lists some of the talks pertaining to the Melanesian spawning aggregation work that were given to provincial government, provincial radio, universities and at international conferences. In Kavieng and Manus the Community Conservation Coordinators, Tapas Potuku and Manuai Matawai, work very closely with

local communities, and over the past two years they have built strong relationships and a high level of trust with the communities TNC is assisting to monitor and manage their spawning sites. Their constant presence and involvement with these communities has been critical to the conservation success we are beginning to see at the majority of these sites. Both of the CCCs are continually providing both formal and informal awareness and advice on marine management and conservation issues to communities, local level governments, provincial governments and local radio stations.

Based on feedback from the local knowledge surveys, our CCCs in Manus and Kavieng, and other sources, we have found a need for a video/DVD that explains the importance of reef fish spawning aggregations to fisheries health and food security, the basic biology and ecology (life history) of the key aggregating species, and the important role spawning aggregations play in ensuring a sustainable coastal fishery. Most of the communities we are working with have access to video/DVD players (even remote villages tend to have a small generator to watch videos/DVDs). Most people respond positively to visual media such as videos.

We have worked with the NFA/GPA Coastal Fisheries Management and Development project to produce three awareness videos on spawning aggregations. We worked with an experienced documentary film maker, Jordan Plotsky (Firelight Films), who was willing to work on producing the videos for essentially expenses only, in return for being able to produce his own short video ("Titans of the Coral Sea") for a documentary film course. We decided to focus the awareness videos around the situation in Pere community, Manus, PNG, to ensure that the circumstances portrayed are real and relevant. The videos are:

- "Bung Karim Bilong ol Bikmaus" (Spawning Aggregations in Papua New Guinea) – English narration. (20 mins). Provides information on what spawning aggregations are, their importance to fisheries, threats and management issues. It also incorporates how Pere community in Manus, PNG, has managed their aggregations and dealt with the LRFFT.
- "Bung Karim Bilong ol Bikmaus" (Spawning Aggregations in Papua New Guinea) – PNG Pidgin narration. (20 mins). Same as the previous video, only with PNG Pidgin narration.
- "Titans of the Coral Sea" (18 mins) – A general documentary which tells the story of how Pere community in Manus has dealt with the challenges of utilizing and managing their marine resources. This video was well received by communities around Manus during recent awareness talks by Dr. Hamilton. It is also now being used in the anthropology course at the University of California–Berkley, and was selected for the Documentary New Zealand Film Fest. The rights to this film belong to Jordan Plotsky (Firelight Films), however, TNC has permission to use the video for non-profit purposes.

We collaborated with the Society for the Conservation of Reef Fish Aggregations (SCRFA) to produce Melanesian versions of the SCRFA Spawning Aggregation awareness brochures. The two new versions include images from Melanesia and slightly modified text. TNC covered the costs of translation, printing and shipping, SCRFA provided the original brochure and completed the layout changes. The Melanesian versions have been shipped to both PNG and the Solomon Islands for use in community meetings. The two new versions are:

- Spawning Aggregations of Reef Fishes. SCRFA Awareness brochure. Melanesian version in English.
- Bung Karim Bilung ol Rip Pis. SCRFA Awareness brochure. Melanesian version in PNG Pidgin.

SPC Information Bulletins

The Conservancy has found the SPC Information Bulletins an effective way to disseminate information throughout the region. The SPC Live Reef Fish Bulletin has been SPC's most popular one. The editing of the SPC Live Reef Fish Bulletin was funded under the previous USAID grant. Initial discussions were held with SPC and SCRFA on the possibility of producing an SPC Information Bulletin on reef fish spawning aggregations, however, it was agreed that the SPC LRF

Information Bulletin, the SPC Traditional Marine Resource Management and Knowledge Bulletin, and the SCRFA Newsletter, were sufficient at this time to provide information and messages concerning spawning aggregations.

This project has continued to publish in the SPC bulletins. The following articles have been written as a direct result of this project:

> Hamilton, R.J. 2005. Indigenous Ecological Knowledge (IEK) of the aggregating and nocturnal spawning behaviour of the longfin emperor *Lethrinus erythropterus*. *SPC Traditional Marine Resource Management and Knowledge Bulletin* 18: 9-17.

This article uses local knowledge and scientific observations to provide the first published account of the aggregating and nocturnal spawning behavior of the Longfin emperor *Lethrinus erythropterus.* Research done under this grant has shown that at many locations in Melanesia the Longfin emperor aggregates at overlapping sites and times as *P. areolatus*, *E. fuscoguttatus* and *E. polyphekadion*.

> Hamilton, R.J., M. Matawai, T. Potuku, W. Kama, P. Lahui, J. Warku and A. Smith. 2005. Applying local knowledge and science to the management of Grouper Aggregation Sites (GAS) in Melanesia. *SPC Live Reef Fish Information Bulletin* 14:7-19.

This paper draws together general findings of the local knowledge surveys conducted in Manus, New Ireland, Kimbe Bay and Roviana Lagoon. It provides an overview of the methodology used, trends in aggregation fisheries in Melanesia and the main biological points of interest that came out of these surveys. It ends by introducing the scientific monitoring programs that developed at some aggregation sites following the local knowledge surveys.

> Hamilton, R.J. and M. Matawai (*In Press*) Live reef food fish trade causes rapid declines in abundance of squaretail coralgrouper (*Plectropomus areolatus*) at a spawning aggregation site in Manus, Papua New Guinea. *SPC Live Reef Fish Information Bulletin*.

This paper presents evidence from Manus, PNG, that quantitatively demonstrates the negative impact of the LRFFT on a squaretail coralgrouper (*Plectropomus areolatus*) spawning aggregation site.

The following two brief notes provided information on the activities of this project.

> Smith, A. 2003. Live reef food fish trade – Pacific awareness materials project. *SPC Live Reef Fish Information Bulletin* 11:43-44.

> Smith, A. 2003. Protecting and managing reef fish spawning aggregations in the Pacific. *SPC Live Reef Fish Information Bulletin* 11:54-55.

A further SPC article is planned on outlining management options for spawning aggregation sites in the Pacific.

Other Publications and Presentations

Dr. Hamilton attended the 7th Indo-Pacific Fish Conference in Taiwan in May 2005 and presented the paper in the Conservation of Reef Fishes Session:

> Hamilton, R.J., and A.J. Smith. 2005. Supporting community-based inshore fisheries management in Melanesia to achieve conservation goals. Paper presented at the 7th Indo Pacific Reef Fish Conference. 16-21 May 2005, Taipei, Taiwan.

A written version of this presentation was submitted after the conference. The paper overviews TNC's progress and some of the lessons learned while working with coastal communities to conserve spawning aggregation sites in Melanesia.

At the same conference Dr. Patrick Colin, Coral Reef Research Foundation, presented the new survey methodology developed, in part, through the Palau spawning aggregation study.

> Colin, P.L., T.J. Donaldson and L.E. Martin. 2005. GPS Density Surveys: A New Method for Quantitatively Assessing Reef Fish Spawning Aggregations (and other populations of reef fishes). Paper presented at the 7th Indo Pacific Reef Fish Conference. 16-21 May 2005, Taipei, Taiwan.

The following article is a brief report on the spawning aggregation monitoring efforts in Roviana Lagoon. It provides an overview of how monitoring commenced and TNC's role in initiating these monitoring programs. It also describes the other partners that have become involved with funding ongoing monitoring efforts in Roviana Lagoon.

> Hamilton, R.J. & W. Kama (*In Press*). Community based monitoring of grouper spawning aggregation sites in Roviana Lagoon. *CRNN Status of Coral Reef in the World 2004 Report.*

The following invited presentations were made to the US Coral Reef Task Force Meeting in Palau in November 2005:

> Yeeting, B. and A.J. Smith. 2005. Live Reef Fish Trades in the Pacific: Impacts, Issues and Needs. Presentation to the US Coral Reef Task Force Meeting, 5 November 2005, Koror, Palau

> Colin, P. 2005. Spawning Aggregations of Reef fishes: Myths, Methods and MPAs. Presentation to the US Coral Reef Task Force Meeting, 7 November 2005, Koror, Palau

The following paper will be presented by Dr Hamilton at the Conservation Science in Practice Conference in November, in Tuscon, Arizona, USA:

> Hamilton, R., T. Potuku and M. Matawai. 2006. Conserving spawning aggregations of grouper (Serranidae) in Melanesia. Conservation Science in Practice Conference, 27-30 November 2006, Tuscon, Arizona, USA

Peer Reviewed Publications in Preparation

A number of peer reviewed papers and book chapters will be produced as a result of this project:

- Dr. Patrick Colin will be publishing the results of the Palau spawning aggregation study.
- Dr. Richard Hamilton and Dr. Yvonne Sadovy are currently writing a chapter for a book on spawning aggregations. The working chapter title is: The use of traditional knowledge in the conservation and management of reef fish spawning aggregations. The book is being edited by Dr. Yvonne Sadovy and Dr. Patrick Colin, and is to be published by Springer.
- Dr. Richard Hamilton and several colleagues are in the process of completing a journal article on the Roviana spawning aggregation monitoring work that has occurred over the past two years.
- Dr Richard Hamilton and colleagues will be publishing several other papers on the results of the monitoring work in Papua New Guinea in the future.

6.4 Management

Regional Management

Secretariat of the Pacific Community

The Conservancy has a positive relationship with SPC based on the LRFFT activities under the previous TNC-SPC Memorandum of Understanding (MOU). Initially we believed it would be useful to have a new MOU focused on the spawning aggregation work. However, after discussions with SPC, it was agreed that there was not a need for a formal MOU targeted just on the issue of reef fish spawning aggregation protection and management. It was felt that the relationship between TNC and SPC was strong enough that a formal agreement was not required for the two organizations to effectively work, cooperate and collaborate on issues related to reef fish spawning aggregations.

In recent discussions with the Director of the SPC Marine Resources Division, we have agreed that it would be beneficial to pursue a MOU that covers a broader range of issues for collaboration and coordination. To have the most regional impact, focusing an MOU around developing and supporting the ecosystem-based management of nearshore fisheries in the Pacific (as discussed earlier) would be the most productive approach. This would include, amongst other things spawning aggregation protection and management, marine protected areas, nearshore fisheries management (including the LRFFT).

LRFFT Management Guidelines

The final draft of the regional LRFFT management guidelines was submitted to SPC in 2004. Unfortunately they have not yet completed their internal review and finalization of the guidelines due to staff work loads. While TNC does not have any control over SPC's finalization of the guidelines, we will continue to encourage them to complete the guidelines, and if requested, assist them in doing so.

Review of Spawning Aggregation Management Options

A review of reef fish spawning aggregation management options was commissioned. This review considered all tropical reef fish spawning aggregations, not just Indo-Pacific species.

> Rhodes, K.L. and K. Warren-Rhodes. 2005. Management Options for Fish Spawning Aggregations of Tropical Reef Fishes: A Perspective. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 7/05

The review focused on:

- Providing a characterization of spawning aggregations;
- Giving an overview of the dominant threats to spawning aggregations;
- Reviewing potential options for spawning aggregations management and the underlying biological concerns and scientific backing for their use;
- Presenting examples where tropical spawning aggregations management options have been adopted, and;
- Evaluating the realistic potential of success or failure of these options for spawning aggregations conservation.

The review argues the need to integrate biological concerns within the political, cultural and socioeconomic frameworks within which spawning aggregations management actions occur. Although the report's analyses are applicable to a variety of locales globally, the case studies focus on the western Pacific and Caribbean. The rationale for choosing these locales related to the significant biodiversity contained within spawning aggregations in these areas, the relative magnitude of pressures being exerted on those resources, the existence of promising implementation experiences

with spawning aggregations management, and an immediate need and expressed desire by local governments and communities for improved spawning aggregations management.

The consultants' found that:

> "…while a myriad of management options for fish spawning aggregations (FSA) exist, few have actually been applied, particularly in a manner that eliminates the potential for FSA loss or decline. These management options are generally the same as those utilized in other stages of a fish's adult life history, e.g. area and temporal restrictions, size limits, quotas, etc. Of the few FSA that are actively managed, success in implementation and enforcement has varied due to the complex cultural and economic conditions characteristic of many tropical developing island nations, the extensive geographic distribution of FSA and an incomplete understanding of species' life history and spawning dynamics. Given the significant variations in implementation context, there is not likely to ever be a 'one size fits all' conservation strategy … that tropical marine resource managers can use to provide the necessary level of protection to FSA. Instead, effective management of coral reef FSA will require careful consideration of local circumstances and flexibility in implementation, and likely involve shared management responsibilities between communities, governments and non-government organizations...
>
> Regardless of the management option(s) chosen, all generally require, at a minimum, information on species-specific seasonal reproductive activity, adequate monitoring and strong, incorruptible enforcement and prosecution. As is the case in Western settings, a political willingness to back management, that at first may be unpopular with the local electorate, is the first key to success ... Once that aspect is achieved, all other steps toward providing effective management become easier. Much of the biological information needed for adopting effective management policy can be gathered by trained local marine resource staff or non-governmental agencies.
>
> Based on our review, we recognize that the most effective option to achieve adequate FSA protection is through the total elimination of fishing on reproductively active fishes, specifically FSA and the (reproductive) migratory pathways that individuals use to reach these sites. We make this contention in light of the overwhelming evidence that exists on failed management policy and implementation toward effective FSA protection, the difficulties associated with aligning political, cultural and economic circumstances for effective FSA management, and the innumerable cases of past FSA loss and population-level damage associated with most levels of FSA fishing worldwide—even with certain types of management in place. We are not aware of any recorded FSA that is fished and unmanaged; yet maintaining or increasing its abundance. Finally, we assert that full FSA protection should not be delayed in lieu of data demonstrating negative fishing effects, since all known current accounts of FSA fishing appear to be unsustainable." (Extracted from Executive Summary)

National Management

PNG National Fisheries Authority

The National Fisheries Authority has been supportive of this project throughout. Their staff have participated in the two workshops held in PNG, and they contributed to the production of the awareness video. The adoption of relevant guidelines for managing spawning aggregations at a national level moved forward in 2005 when Leban Gisawa, Manager for Inshore Fisheries at NFA, attended the Advanced Workshop for Monitoring Spawning Aggregations in Manus. Towards the end of this workshop participants developed a list of management recommendations for protecting spawning aggregations in PNG against LRFFT activities. One of the key recommendations was to place a monthly lunar ban on all LRFFT operations, whereby LRFFT fisheries could not operate in the week leading up to and including the new moon, or for the three days after the new moon. The monthly lunar ban seemed to be a plausible management option, especially as NFA is working toward providing 100 percent observer coverage on all LRFFT vessels. The recommendation was based on the information that has emerged from the both local knowledge and monitoring surveys in Melanesia to date:

- The Kavieng monitoring data has shown the months of the year in which peak aggregations form can vary on very small spatial scales. Consequently, developing closed seasons (even at a provincial level) will require a large amount of monitoring data from multiple sites. This data is currently unavailable for the majority of sites where the LRFFT operates in PNG.[5]

- Annual seasonality varies markedly in Melanesia, however, local knowledge and monitoring results have shown that the lunar periodicity with which aggregations form and subsequently disperse are very set. Large aggregations of grouper build up in the week prior to the new moon, and disperse on or several days after the new moon.

- One of the key target species, *P. areolatus*, aggregates on a monthly basis, and is thus vulnerable to over fishing from the LRFFT in all months of the year. A closed season would do little to protect spawning stocks of this species.

In August 2005 Leban Gisawa put in a submission to the NFA Board recommending a year round 10-day lunar ban on LRFFT activities in PNG. However these new conditions have yet to be passed by the NFA Board, as the NFA Board is yet to review the LRFFT Management Plan and standard licensing agreements. Prior to that review, Dr Hamilton is prepared to provide a presentation to the NFA staff and Board that outlines the biological justification for the recommended lunar closures, highlights alternative management options for spawning aggregations, and identified the current scientific information gaps. NFA has asked TNC to assist them in developing protocols for collecting fisheries data from the LRFFT, with the intention of utilizing this data to inform management of this fishery. Dr Hamilton has worked with Leban Gisawa to develop standardized forms that NFA LRFFT observers can use to document catch rates, mortality, and age-based demographic parameters of target species.

Solomon Islands

The adoption of the Solomon Islands National LRFFT Management Plan is dependent on the Minister for Fisheries re-establishing the Fisheries Advisory Council. To date this has still not occurred, and is beyond our control. We will continue to encourage the Minister and the Department of Fisheries and Marine Resources to establish the Council. This Council is also needed to review and approve the recently completed beche-de-mer management plan, and so we remain optimistic that progress will be made in the not too distant future. In the meantime, there are no LRFFT operations within the Solomon Islands, although there continue to be expressions of interest.

Republic of Palau

The Republic of Palau has some of the most effective government and community level management strategies in place to protect reef fish spawning aggregations. These include: a seasonal ban on catching or possessing the five main species of grouper from April 1 to July 31 every year; size limits and export bans on humphead wrasses; a number of traditional seasonal closures (*bul*) on fishing at spawning aggregations; the complete closure all year to fishing at a number of key spawning aggregation sites; and a high level of awareness of the value of spawning aggregations for food security and for alternative sources of income such as tourist diving. However, even with these controls and level of awareness, one state, with community support, decided to allow LRFFT operators into their waters in November 2004. The local fishers were offered very high prices for the fish, but as with many cases where the LRFFT operates, it quickly became evident to the community fishers that they were not going to get high prices and that the company mostly used foreign fishers (brought in to "train" local fishers). The community quickly turned against the operation and the holding pen nets

[5] Note however than in cases where seasonality is known, we recommend that seasonal bans should be put in place without delay. For example, in Manus, a ban on LRFFT activities should be put in place between March – August each year. This suggestion was put to NFA staff and Provincial Government of Manus in August 2006.

were slashed on at least one occasion. The community asked the national government to investigate the operation, and the carrier vessel was seized due to a number of fisheries law violations. This has been a classic case of the community being misled, resulting in social conflicts arising due to the operation. After the community tensions with the operator developed, TNC was able to provide packets of LRFFT awareness materials to both the government agencies and the community concerned to ensure they could make informed decisions.

There is currently a draft Bill that proposes to extend the grouper closed season by one month, as all the recent studies have shown the spawning aggregations for *Epinephelus polyphekadion* and *E. fuscoguttatus* extend beyond the current July 31 end of the closed season.

Palau is currently establishing a nationwide Protected Areas Network (PAN). A law was passed in November 2003 that created a national framework to provide assistance to the states to protect areas of significant biodiversity, important habitats, and other valuable resources that are essential to the future stability and health of Palau. The network has the dual purposes of protecting Palau's unique marine and terrestrial biodiversity, and supporting the states and communities to effectively manage their natural resources. The protection of spawning aggregation sites within the MPA network is one of the priorities of the network. The initial network design and selection criteria include reef fish spawning aggregations sites as critical habitats.

Federated States of Micronesia

Action is being taken at the State level to include reef fish spawning aggregations in MPAs. The recent National Biodiversity Strategy and Action Plan (NBSAP) included existing knowledge of spawning aggregations as one of the targets to identify areas of biological significance with in FSM. The national process was built on separate state Biodiversity Strategy and Action Plans, which is the level at which the management of reef resources occurs. Pohnpei State is currently taking the lead on protecting spawning aggregations through a combination of state law and LMMAs.

Community Management

Manus, Papua New Guinea

Four Titan communities along the south coast of Manus placed a variety of harvesting restrictions on three large monitored spawning aggregation sites in 2004. While two aggregations remain managed and one is now fully closed to all forms of fishing, a third site was opened to the LRFFT in July 2005, with detrimental consequences for the aggregation (Hamilton and Matawai, *In Press*). An overview of the development of the LRFFT in Manus and the response of communities to the LRFFT is provided in section 7.2.1. of this report. A recognition of the limitations of respect for customary law have resulted in community leaders asking TNC for advice on how to have community management plans recognized under formal government structures such as through local level governments. TNC is working to facilitate legal advice and training through a partner PNG legal NGO, CELCOR.

Kavieng, Papua New Guinea

Two communities in Kavieng placed closures (*tambu*) on their aggregation sites in early 2004, thereby preventing all forms of fishing at these aggregation sites at all times of the year. Both of these sites have been monitored over the past two years, with monitoring showing that at one site where local community management is strong, fish numbers appear to be improving. Conversely, at the other site that has weaker community management, numbers appear to have deceased since monitoring was initiated. At one location the regular presence of TNC field staff at the monitored spawning aggregation sites and the ongoing community awareness work of TNC field staff are beginning to have positive flow on affects. For example, in April 2005, one of the communities that TNC is working with decided to ban all forms of fishing at another large grouper spawning aggregation that falls within their customary marine tenure boundaries. The community that placed this *tambu* on their aggregation site is actively enforcing this recent ban, and immediately after putting this *tambu* in place they

informed nearby communities who historically targeted this spawning aggregation site that there would be serious consequences if they were found poaching at this recently closed site.

The pressures to fish these sites for artisanal and commercial purposes are still very real. Over the past year local community leaders have reported to the Kavieng TNC CCC several accounts of poaching by reef owners. On one occasion in May 2005 traditional reef owners from Dyual came to the Kavieng TNC CCC to let him know that the LRFFT operation had approached them about allowing operations to recommence at Site 1. The TNC CCC advised the community leaders strongly against it, and as a consequence the community denied the LRFFT operation access to its fishing grounds.

Choiseul, Solomon Islands

A community based MPA was established around a locally well known spawning aggregation site for small *Epinephelus* species in early 2005. This MPA was established in partnership with Chivoko community, the Lauru Land Conference of Tribal Community (LLCTC) and TNC. Baseline surveys of this MPA and another recently established one on the south coast of Choiseul were conducted in November 2005, and the occurrence of large numbers of *E. merra* was confirmed at the Chivoko MPA in June 2006 (See section 7.3.2 this report). Interest in community based MPAs is growing rapidly in Choiseul and many communities have asked TNC to assist them with both awareness campaigns and in the design of their MPAs. TNC's capacity to assist with these requests, while limited, is growing with the establishment of a field office within the LLCTC headquarters in Taro and the recent appointment of a shared Community Conservation Coordinator in August 2005.

Partner Site: Roviana Lagoon, Solomon Islands

Following monitoring and awareness raising activities of RSAMT, RVLRMP and TNC staff, Roviana communities have set aside two spawning aggregation sites as community-based MPAs. The most recent of these being in June 2006. One of these sites is currently monitored while the other is not. See section 7.3.1. in this report for an overview of activities that have occurred in Roviana Lagoon.

Management

The lessons learned from this project concerning management of reef fish spawning aggregations are summarized in Section 8 of this report.

7. SITE ACTIVITIES

7.1 Palau

Overview

The Republic of Palau has recognized the importance of their reef fish spawning aggregations and acted to both study them and protect them. The Johannes, *et al.* (1999) study of three aggregations in Palau was the first detailed study of a transient spawning aggregation in the Indo-Pacific. Even before this study, Palau had imposed management controls, both legislative and through traditional closures (*bul*), from the mid-1990s to protect their aggregations from overfishing. Palau was also one of the earliest to experience the overfishing issues associated with the LRFFT, when fishing occurred in Palau in the mid-1980s (Graham 2001). The most recent attempt at a LRFFT fishery in Palau was in November 2004 (see section 6.4 above).

Palau Spawning Aggregations Study

Dr. Patrick Colin, Coral Reef Research Foundation (CRRF), was contracted to study Palau's reef fish spawning aggregations and factors affecting connectivity of these sites with other reef areas. This information is critical for the design of MPA networks that incorporate reef fish spawning aggregations as targets. The results of this study have been compiled into a report, and a number of scientific publications are in preparation. Many of the activities are on-going through additional funding Dr Colin has raised.

> Colin, P.L. 2006. Study of reef fish spawning aggregations and connectivity on the Palauan reef tract: Final Report and Addendum. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 2/06

The study focused on two basic aspects of reef fish spawning important in any consideration of MPA and network design. Firstly, the documentation of the time and location of spawning aggregations to learn when and where spawning actually occurs and to quantitatively document the numbers of fish in aggregations over time and space for future comparison. Second, oceanographic aspects of spawning aggregation occurrence and dispersal of eggs related to the issue of connectivity of aggregation sites into general ocean and lagoon circulation and eventually recruitment areas. This study has not answered these questions, but does provide new information related to these considerations, and the work is on-going.

The new GPS density survey methodology (see section 6.1 above) was used to map the distribution and densities of the three target species (*Plectropomus areolatus*, *Epinephelus polyphekadion*, and *E. fuscoguttatus*) at Ngerumekaol (Ulong Channel) in Koror State (the location of the training workshop in 2003, and one of the Johannes *et al.* 1999 study sites). Surveys were made at this site for 24 days in 2003, 6 days in 2004 (very poor weather conditions prevailed during this spawning season) and 26 days in 2005. Sample bubble plots of the data are provided below:

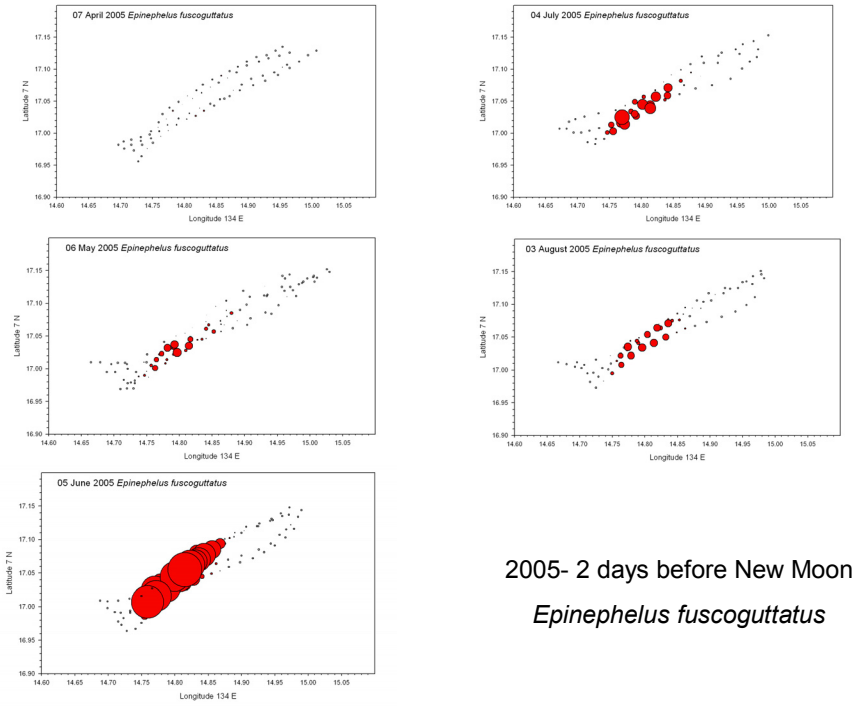


Figure 5: Bubble plots showing distribution and relative abundance of *Epinephelus fuscoguttatus* at Ulong Channel on the same lunar phase during five months of 2005. Refer to Figure 3 for relationship between the plots and location of the channel.

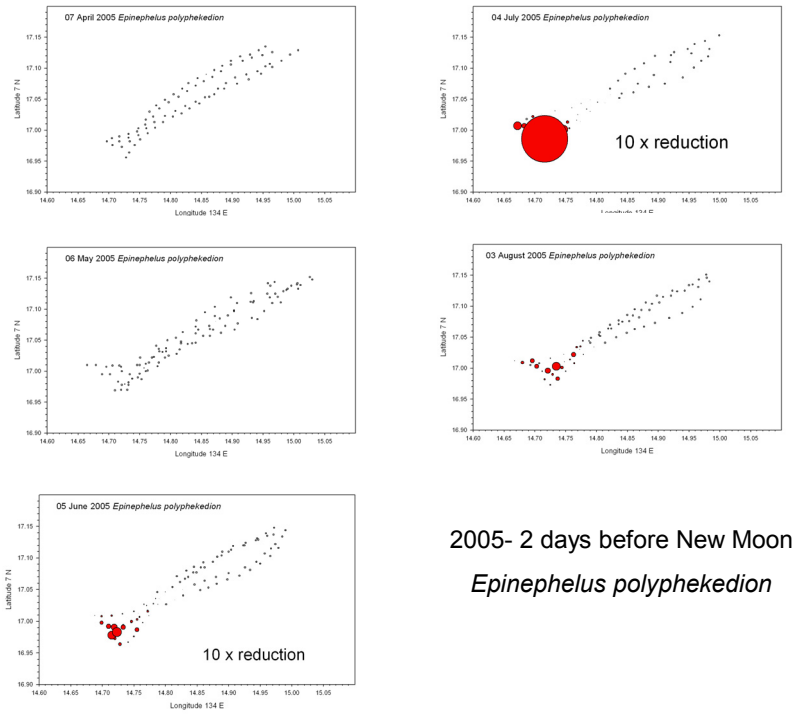


Figure 6: Bubble plots showing distribution and relative abundance of *Epinephelus polyphekadion* at Ulong Channel on the same lunar phase during five months of 2005. Refer to Figure 3 for relationship between the plots and location of the channel.

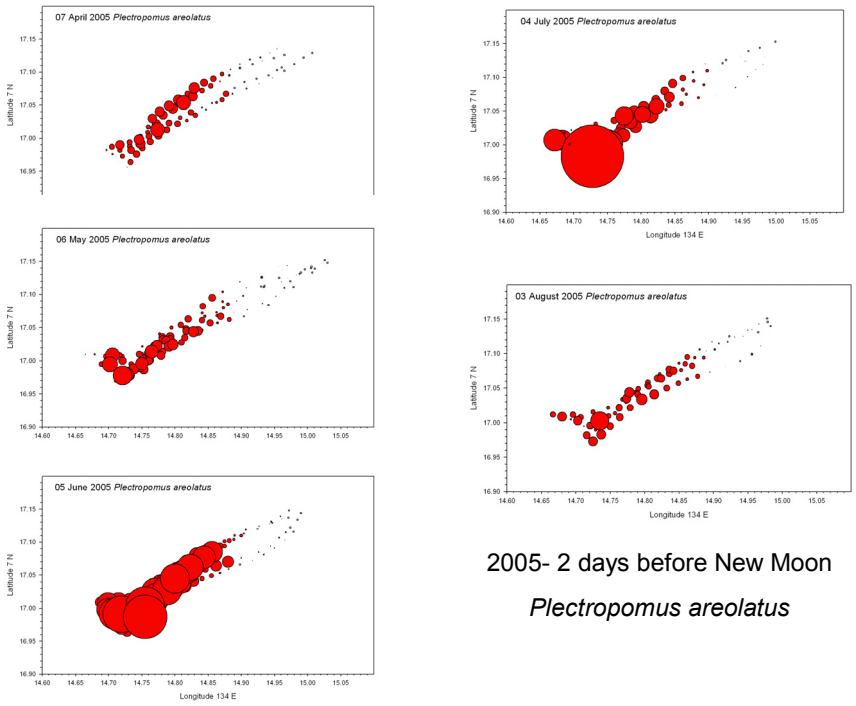


Figure 7: Bubble plots showing distribution and relative abundance of *Plectropomus areolatus* at Ulong Channel on the same lunar phase during five months of 2005. Refer to Figure 3 for relationship between the plots and location of the channel.

For *E. fuscoguttatus* the aggregation season was May to August with a peak in June (Figure 5). For *E. polyphekadion*, few fish were seen during April and May, however very large numbers were present in June and July, with a reduced number in August (Figure 6). In contrast to the previous two species, significant numbers of *P. areolatus* were found from April through August with peak abundance in June and July (Figure 7). It should be noted that *P. areolatus* aggregates each month in Melanesia, and it appears to do so in Palau as well.

Comparison of data between years, when the same lunar phase and lunar month are compared, can help provide some indication as to whether the populations of aggregating fishes are stable, decreasing or increasing. For the lunar phase day in Figure 8, it appears likely there has been an increase in fish numbers at the aggregation sites between 2003 and 2005. However, longer term data will be required to confirm this is an increase and not simply inter-annual variation.

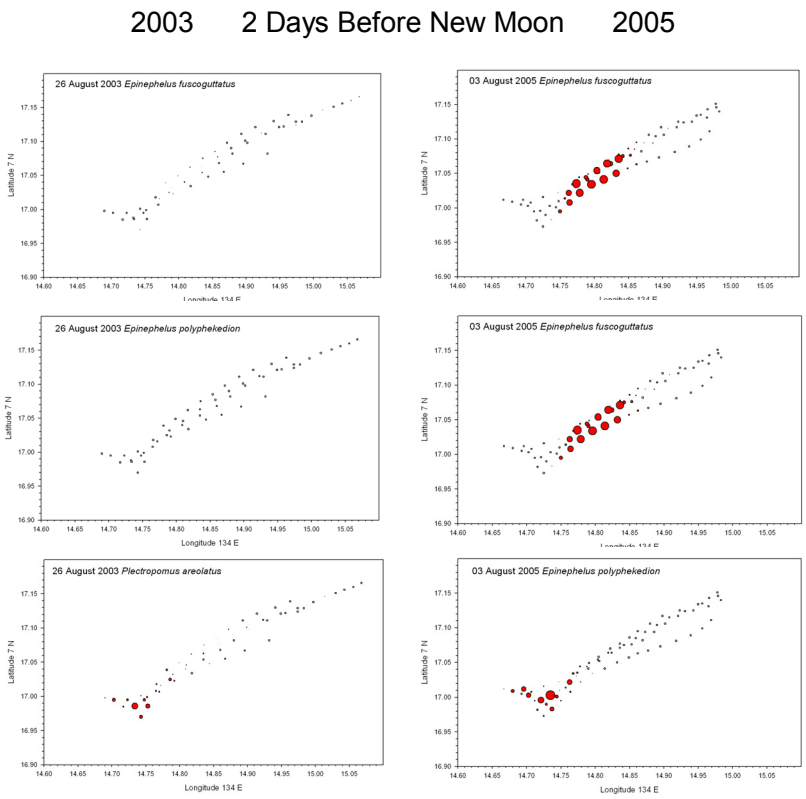


Figure 8: Comparison of distribution and relative numbers of three species of groupers at the Ulong Channel aggregation site between 2003 and 2005 on the same lunar phase (2 days before new moon) in August. Refer to Figure 3 for relationship between the plots and location of the channel.

During this study work was also undertaken to complete bathymetric mapping of five additional aggregation sites, supported monitoring at one additional transient aggregation site (Ebiil Channel), and also at an area of resident aggregations (for the humphead wrasse, *Cheilinus undulatus*). Current meters were deployed at Ulong Channel, and GPS logging drifters were used to track water movements at estimated times of spawning and different tidal phases. The initial results of this work have been included in the report, but further detailed analysis is required, and the final results will be included in the scientific publications in preparation.

While this study has contributed to our knowledge of spawning aggregations in Palau (and in general), it will still require many more years of work to fully understand the issues related to connectivity.

Palau Protected Areas Network

The Palau Protected Areas Network (PAN) legislation was signed into law in late 2003. Since then the Ministry of Resources and Development and its partners (including TNC) have been working on making the PAN operational. Priorities to date have included, *inter alia*:

- Developing operational procedures, rules and regulations for how areas will be included in the PAN, and developing criteria to guide decision-making
- Working on collecting GIS data on biodiversity and resource-use through both science and consultation with the states and communities.

In May 2006, TNC facilitated a network design workshop to:

- Review and refine the available spatial information for the marine and terrestrial resources of Palau;

- Review and agree on an initial set of conservation goals and protected area design principles for use in analysis to help identify areas that could be included in the nationwide network of protected areas in Palau;
- Present and discuss possible uses of MARXAN analysis to help identify areas that could be included in the nationwide network of protected areas in Palau; and
- Identify information gaps and future research and data needs.

Both local knowledge and scientific information on Palau's reef fish spawning aggregations were included in the design analysis as priority targets. The workshop participants determined that Palau's transient spawning aggregations should have a conservation goal of 100 %, that is, all known spawning aggregations should be captured within the marine component of the network. Similarly, all known resident spawning aggregations sites (e.g. for humphead wrasse) should also have a conservation goal of 100%. A number of MAXAN scenarios were run and presented to the participants and to the Congress for discussion. The next phase in the MPA network design will be to undertake finer scale design work at the State level. Of significance, however, is that reef fish spawning aggregations were considered to be critical targets for the network.

7.2 Papua New Guinea

7.2.1 Manus

Overview

The locations, biological parameters and status of more than ten grouper aggregation sites in Manus were documented in several local knowledge and UVC surveys that were commissioned by the Papua New Guinea National Fisheries Authority (NFA), The Nature Conservancy (TNC) and the Society for the Conservation of Reef Fish Aggregations (SCRFA) (Squire 2001; Hamilton 2003; Hamilton *et al*. 2004). Out of all of the known aggregation sites, three sites, Sites 29, 33 and 35, were identified as being of very high conservation priority. These three sites are all located along the south coast of Manus Island. UVC surveys at these sites were first conducted in 2001 (Squire 2001). These sites are the largest of all known grouper spawning aggregation sites in Manus, and they all have a high biodiversity value (Hamilton *et al*. 2005a). The squaretail coralgrouper (*Plectropomus areolatus*), brown-marbled grouper (*Epinephelus fuscoguttatus*) and camouflage grouper (*Epinephelus polyphekadion*) are known to aggregate at these sites at overlapping times and locations. Local fishers report that *P. areolatus* aggregations form at Site 29, 33 and 35 during the third quarter in every month of the year, with a peak season in the months of March, April and May, during which time the abundance of *P. areolatus* at aggregation sites is an order of magnitude higher than in other months of the year.

In early 2004 we held community awareness meetings on the importance of conserving grouper aggregations with the four communities that own the reefs where Sites 29, 33 and 35 are located. All of the communities subsequently expressed an interest in managing their aggregation sites and they requested that TNC provide them with technical assistance in their efforts. By May 2004 all four communities had banned spearfishing at these three grouper aggregation sites in the ten days leading up to and including the new moon in every month of the year. Capturing fish for sale was also banned. Subsistence hook-and-line fishing was, however, allowed at these sites.

In July 2004, after consultations with the relevant communities, permanent belt transects were established at Sites 29, 33 and 35. Two transects were established at each site: a deep transect with a midline at 25 m that samples the high-density *E. fuscoguttatus* and low-density *P. areolatus* aggregations and a shallow transect with a midline at 10 m that samples the high-density *P. areolatus* and low-density *E. fuscoguttatus* aggregations. The permanent belt transects are all a minimum of 100 m long and 10 m wide. Transects were established using the methodology set out in the TNC grouper aggregation monitoring manual (Pet *et al*. 2006). Logistical difficulties prevented monthly monitoring

in much of 2004 and the first half of 2005. Routine monthly monitoring commenced at Sites 29, 33 and 35 in July 2005 and has continued to the present. Monitoring occurs in the three days leading up to the new moon of each month, and involves two SCUBA divers counting all of the *P. areolatus*, *E. fuscoguttatus* and *E. polyphekadion* sighted within the transect boundaries. Each transect is surveyed once per month.

In June 2005 the robustness of community-based management to outside commercial pressures were tested when NFA and the Manus Provincial Government allowed a LRFFT company into the south coast of Manus. The LRFFT company immediately expressed interest in fishing Sites 29, 33 and 35, along with several other known grouper aggregation sites in the area. While the traditional owners of Sites 29 and 33 did not allow the company access to their reefs, the owners of Site 35 did (the fishing was actually undertaken by local fishers, who sold their catch to the LRFFT company).

Site descriptions

Sites 29, 33 and 35 are all located on seaward facing reef promontories (Figure 9 and Figure 10). The aggregations at Site 29 and 33 occur over linear reef distances of approximately 300 and 200 meters respectively. Reefs at Sites 29 and 33 are both steep slopes, leveling out in a sandy bottom at approximately 40m. At Sites 29 and 33 groupers aggregate between depths of 3 – 40 m. The aggregations at Site 35 occur over a linear reef distance of approximately 400 m. The shallower part of the site (2-15 m) is mostly a slope, whereas the deeper part of the reef is mostly a steep wall that drops to a sandy bottom at about 60 m depth. Groupers aggregate between 3 – 50 m. At all three sites the highest densities of groupers occur around the promontories. Currents at both locations can be strong. Historically Site 35 supported the highest abundances and densities of all species of groupers (Squire, 2001; Hamilton *et al*., 2004; Hamilton *et al*., 2005a), but this changed rapidly when this site was opened up to the LRFFT in 2005 (Hamilton and Matawai*, In press*).

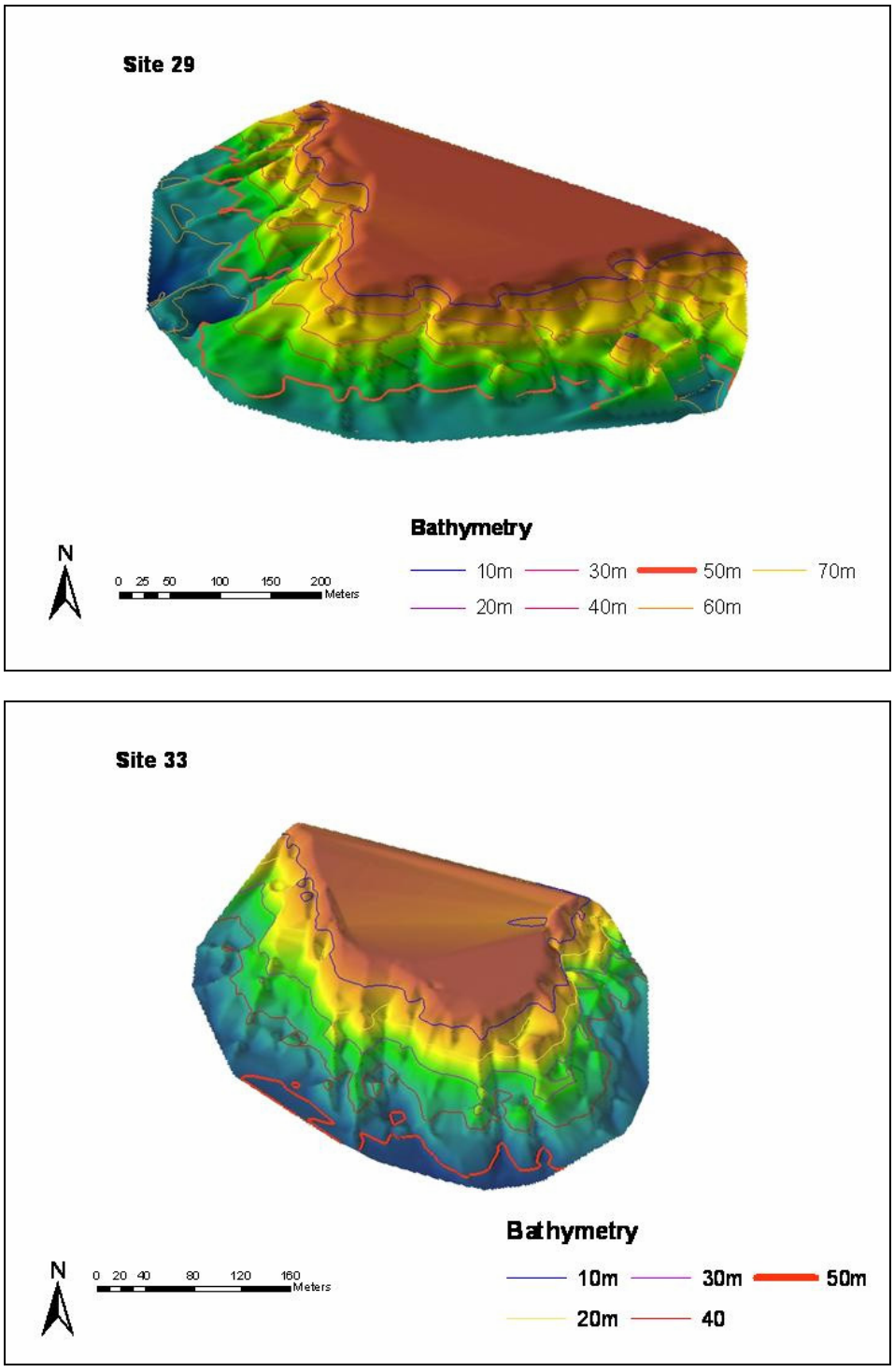


Figure 9: 3D bathymetric reef maps of Site29 and 33. Bathymetric maps were made using the Adaptive Bathymetric System (Ecochard *et al*., 2003).

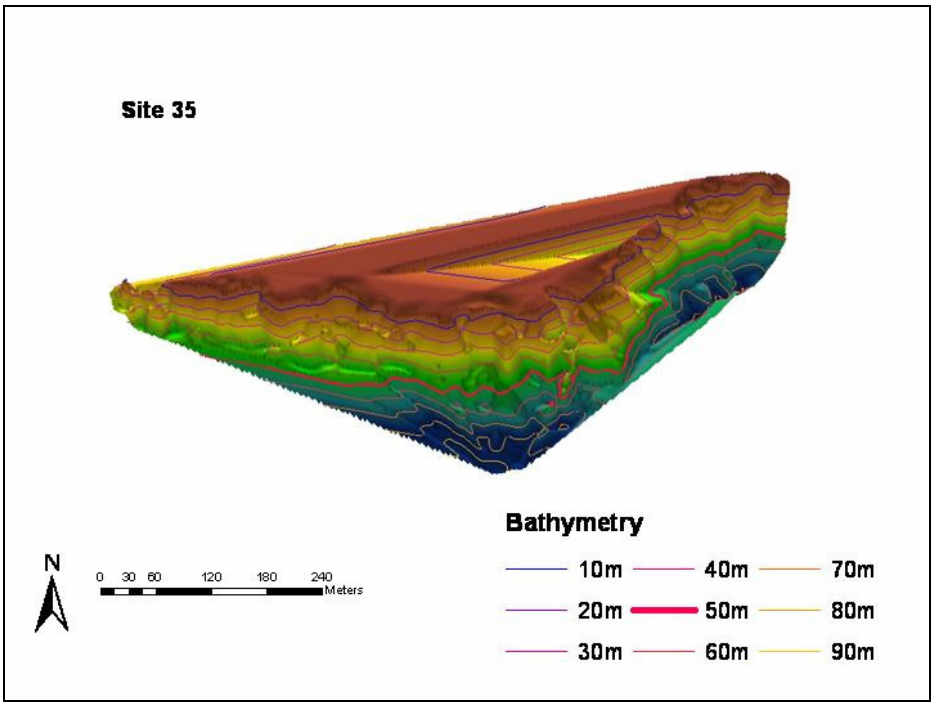


Figure 10: 3D bathymetric reef maps of Site 35. Bathymetric maps were made using the Adaptive Bathymetric System (Ecochard *et al*., 2003).

Results

Plectropomus areolatus

As was predicted by local fishers, UVC surveys show that *P. areolatus* were present at the aggregation sites in virtually every month of the year between July 2005 and July 2006, with a marked peak season at Site 29 and 33 between the months of March and June 2006 (Figure 11). Maximum densities[6] of *P. areolatus* at Site 29 and 33 were two or three times higher than maximum densities recorded in Kavieng or Roviana Lagoon (See section 7.2.2 and 7.3.1 of this report). The UVC data also shows that densities of *P. areolatus* at Site 35 were, contrary to the observations in 2001 and 2003-2005, lower than at the two un-fished sites in 2006, and in 2006 no peak season was detected at Site 35. This finding contrasts dramatically with local knowledge and historical UVC data that show that prior to 2006 the largest *P. areolatus* aggregations formed at Site 35 (Squire 2001; Hamilton 2003; Hamilton *et al*. 2004). Indeed, during the peak season in 2006 *P. areolatus* abundances at Site 35 fell well short of abundances seen at this site during the tail end of the 2005 season. The absence of a detectable peak season at Site 35 in 2006 may also to be indicative of overfishing by the LRFFT (See Hamilton and Matawai, *In press* for further discussion on these results).

[6] For inter site comparison purposes, all fish densities in this report are displayed as number per 500 m.sq. That being the minimum transect size used in any of the monitored sites in Melanesia.

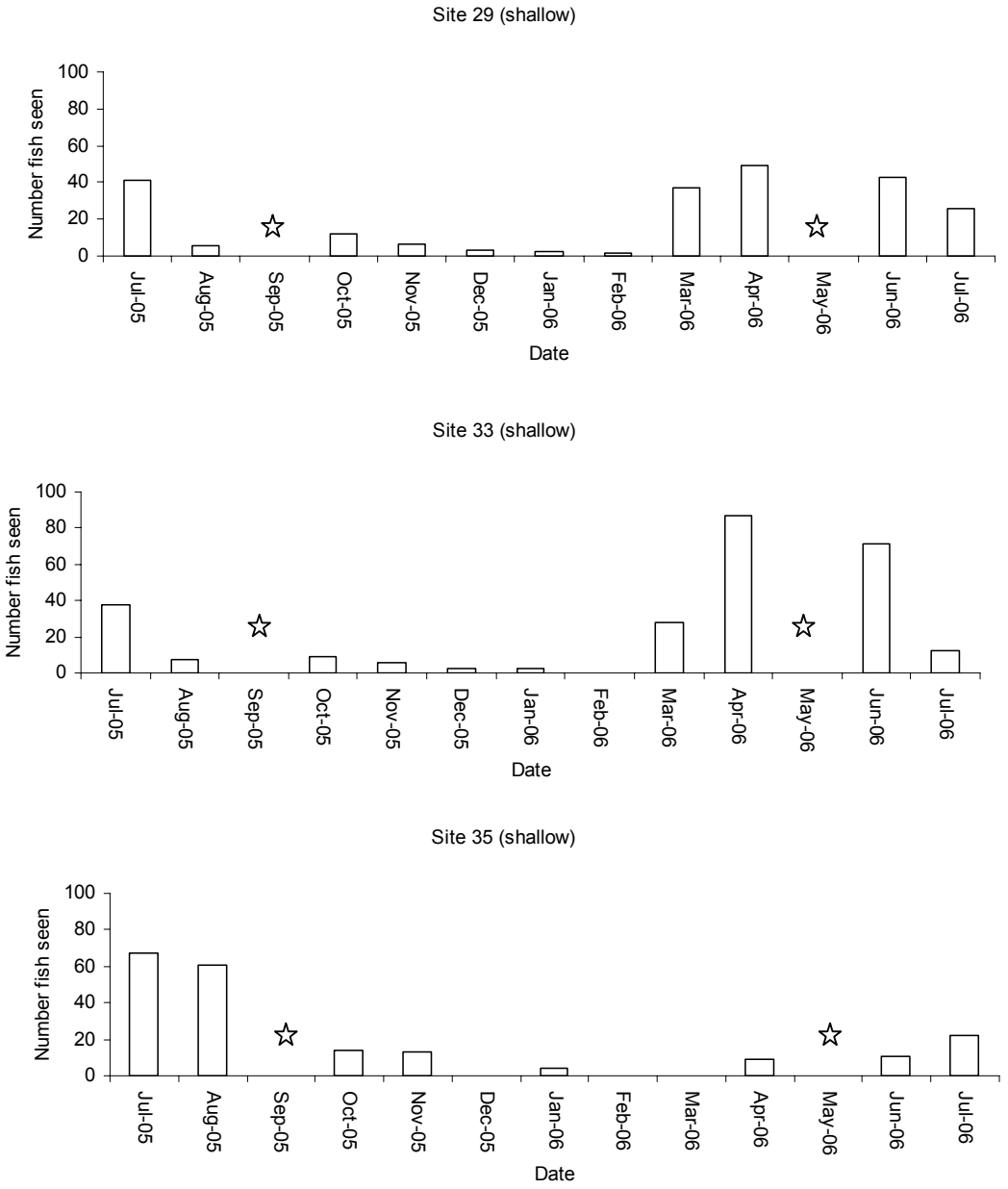


Figure 11: Number of *P. areolatus* sighted on the new moon along shallow water transects at Site 29, 33 and 35. Transect area = 500 m. sq. ☆ indicates that no UVC surveys were conducted in that month.

Epinephelus fuscoguttatus

UVC surveys show that *E. fuscoguttatus* aggregations at all three sites have a definite annual season that appears to be from March to August each year. The largest aggregations seen occurred in June 2005 and 2006, and in April 2006, closely concurring with local knowledge that states that peak aggregations occur between the months of March to June each year. Maximum densities of *E. fuscoguttatus* at Site 29 33 and 35 were four to twelve times higher than maximum densities recorded in Kavieng.

The UVC data also shows that maximum densities of *E. fuscoguttatus* seen at Site 35 in April 2006 were only half the density of *E. fuscoguttatus* sighted in June 2005. This finding may well be a result of this site being targeted by the LRFFT. It is noteworthy that the LRFFT operated at Site 35 between July-December 2005, thereby missing the peak *E. fuscoguttatus* season for 2005. (Figure 12)

Epinephelus polyphekadion

At all three sites *E. polyphekadion* was the least abundant grouper species. June and July were the only months in both years in which low densities of this species were recorded at the majority of surveyed sites (Figure 13).

Species distributions with depth

At all three sites *P. areolatus* and *E. fuscoguttatus* overlap in their spatial distributions, although *P. areolatus* primarily aggregates in the shallower part of these sites (3-15 m depth), whereas *E. fuscoguttatus* and *E. polyphekadion* primarily found in the deeper part (15-40 m depth). The depth distributions of the three species at Site 29 are shown in Figure 14.

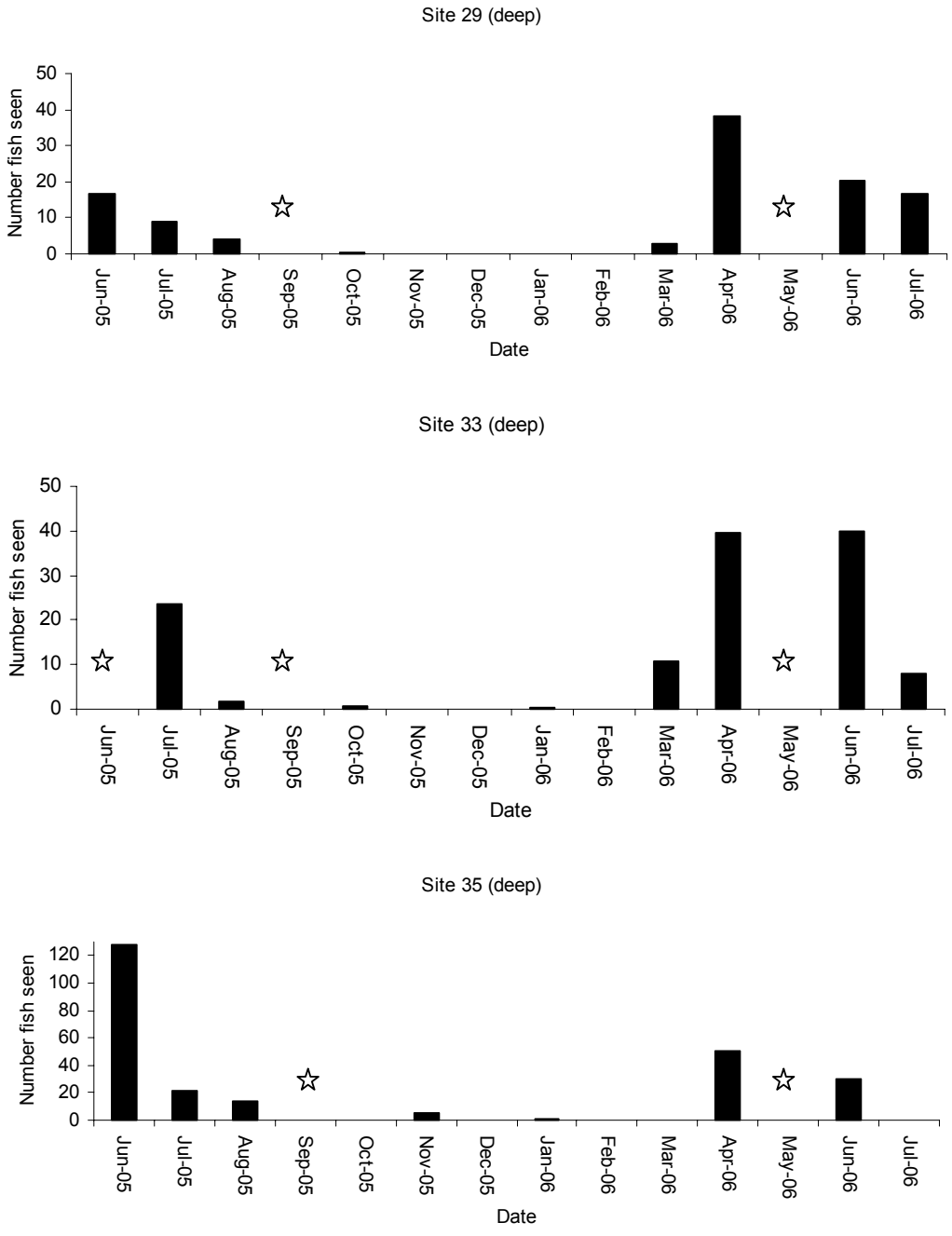


Figure 12: Number of *E. fuscoguttatus* sighted on the new moon along deep water transects at Site 29, 33 and 35. Transect area = 500 m. sq. ☆ indicates that no UVC surveys were conducted in that month.

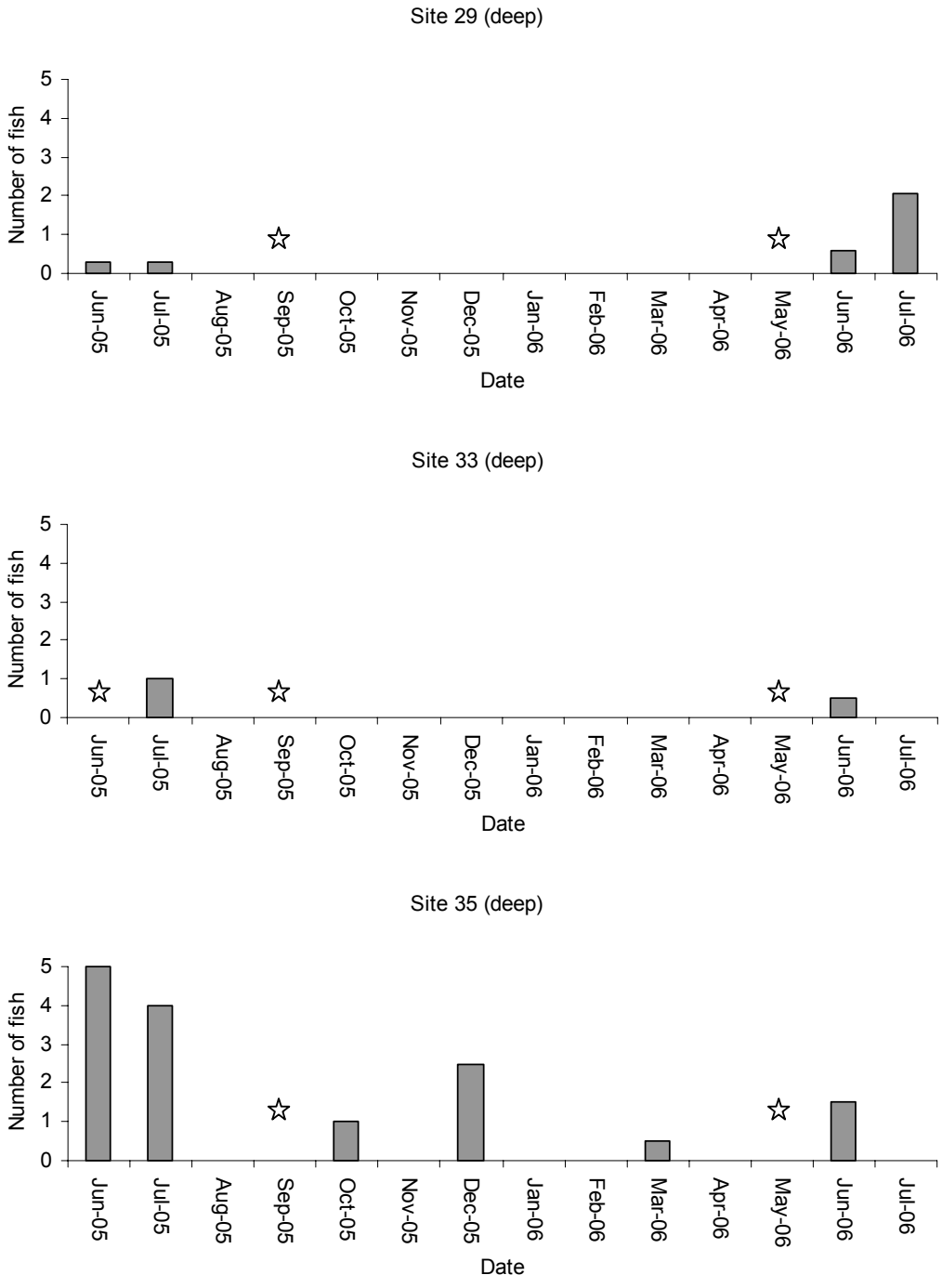


Figure 13: Number of *E. polyphekadion* sighted on the new moon along deep water transects at Site 29, 33 and 35. Transect area = 500 m. sq. ☆ indicates that no UVC surveys were conducted in that month.

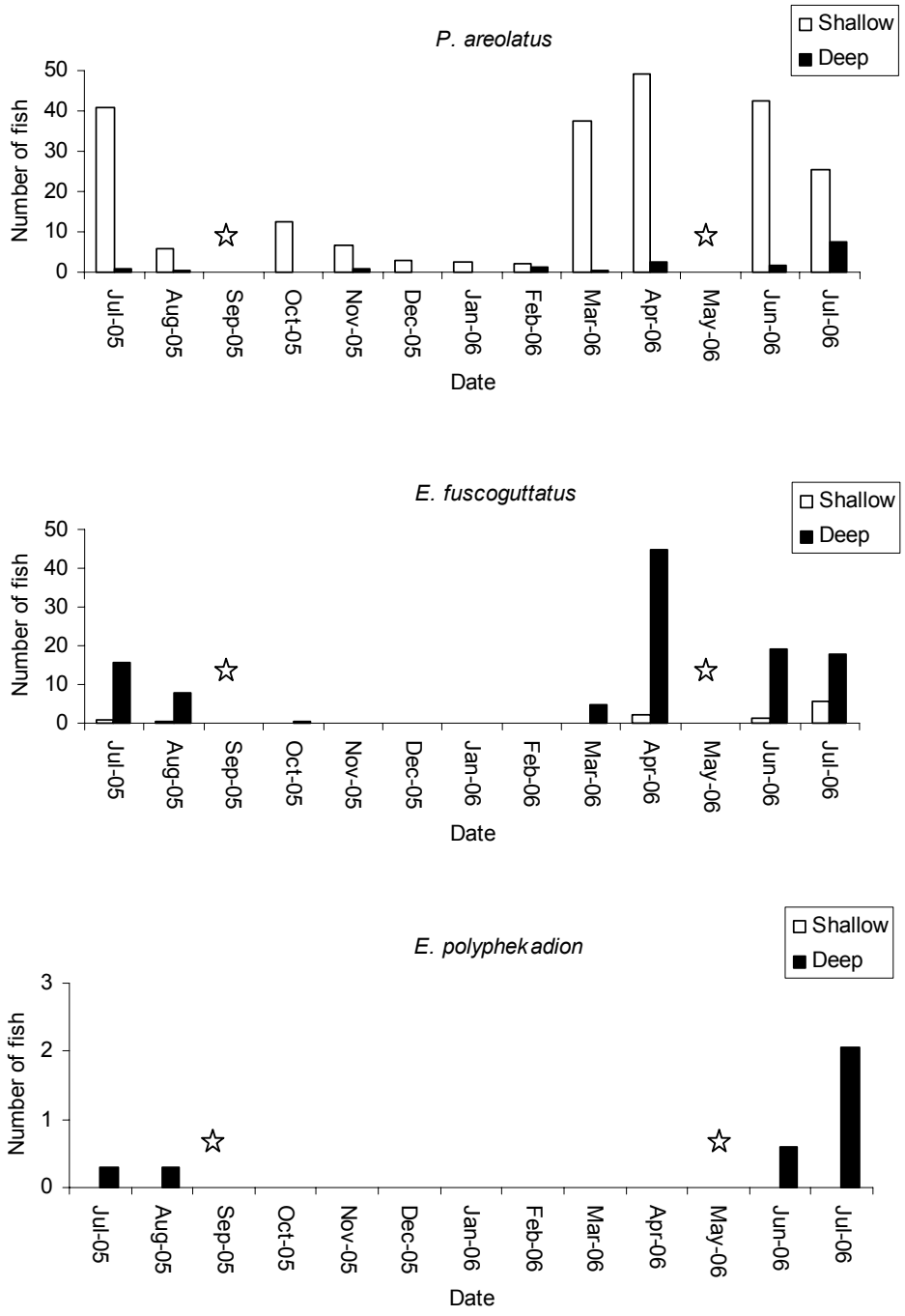


Figure 14: Number of *P. areolatus, E. fuscoguttatus* and *E. polyphekadion* sighted on the new moon along shallow and deep water transects at Site 29. Transect area = 500 m. sq. ☆ indicates that no UVC surveys were conducted in that month.

Further Activities

Routine monitoring at Sites 29, 33 and 35 is ongoing, and in May 2006 monitors also began conducting surveys on the full moon, as monitoring in Indonesia has shown that *P. areolatus* aggregations occasionally occur around the full moons as well as new moons, and this has important implications for management. Available data from full moon monitoring is limited and is yet to be

examined. At this stage TNC has secured funding to continue monitoring for the rest of 2006 and 2007.

Recently TNC also received a grant from the National Fish and Wildlife Foundation (NFWF) to examine the degree of connectivity between the three monitored spawning sites and surrounding nursery areas of groupers in southern Manus. This research will be a joint effort with staff from James Cook University, and will involve tagging gravid females with non-radioactive isotopes of barium. This research will commence in March 2007, will involve working closely with the Titan communities and Manus Provincial Fisheries. It is envisaged that ultimately the research will help us in the development of a network MPAs in Manus Province that include both spawning sites and connected grouper nursery areas.

7.2.2 Kavieng

Overview

In 2003 TNC held a spawning aggregation monitoring workshop in Kavieng (Rhodes, 2003). The practical components of this workshop focused on a multi-species grouper aggregation site, the location of which had been revealed to workshop coordinators by local fishers. In early 2004 27 other potential single and multi-species fish spawning aggregations in the Kavieng region were identified through a local knowledge survey (Hamilton *et al.*, 2004). Many of the identified sites supported aggregations of one or more species of grouper, the most common species being *P. areolatus*, *E. fuscoguttatus* and *E. polyphekadion*. These single and multi-species grouper aggregations were all reported to form in the third lunar quarter and disperse shortly after the new moon, with grouper aggregations said to occur in every month of the year. Many fishers stated that *E. fuscoguttatus* and *E. polyphekadion* had a peak aggregation period that lasted for several months each year, however they were unable to pinpoint the months when these peak aggregations occurred. In the Kavieng region the majority of known grouper aggregation sites have been overfished, with LRFFT activities and night spear-fishing being the two main culprits (Rhodes, 2003; Hamilton *et al*., 2004; 2005b).

Following the 2004 local knowledge survey, underwater visual census (UVC) surveys were conducted around the new moon in January, May and June 2004 at nine of the sites identified as potential grouper aggregation sites. During these UVC surveys observations of multiple indirect spawning signs (i.e. color change, multiple gravid females, chasing, quivering and bite marks) were used to verify that these grouper aggregations had formed for the purpose of spawning. Four of these sites were subsequently independently verified as supporting grouper aggregations. We then used information on customary marine tenure estates and communities' attitudes towards conserving aggregations (Hamilton *et al*., 2004)[7] to identify two multi-species aggregation sites (Site 1 and 10) that we believed could be effectively managed at community level. Community awareness meetings and on-going liaisons between TNC field staff and target communities were then held with the communities that claim ownership over Sites 1 and 10.

Both communities expressed an interest in conserving their spawning aggregations, and following awareness presentations, both communities declared that they would place a *tambu* on their sites, hereby preventing all forms of fishing at their aggregation sites. The communities also requested that TNC assist them in monitoring their spawning aggregations. Subsequently, permanent belt transects were established at Site 1 and 10 in July and August 2004, and routine monitoring of these transects commenced in September 2004. Monitoring at these sites is conducted on SCUBA and involves carrying out monthly UVC surveys along permanent belt transects a day or two prior to the new moon. A minimum of two transects were established at each site: a deep transect with a midline at 25 -30 m that samples the high-density *E. fuscoguttatus* and low-density *P. areolatus* aggregations and a shallow transect with a midline at 10 m that samples the high-density *P. areolatus* and low-density *E. fuscoguttatus* aggregations. The permanent belt transects at Kavieng vary between 50 m to 100 m in

[7] TNC Community Conservation Coordinator, Tapas Potuku, collected ethnographic data for areas of interest throughout 2004.

length, and all transects are 10 m wide. Transects were established using the methodology set out in the TNC FSA monitoring manual (Pet *et al.* 2006).

Site descriptions

Site 1 and 10 are both located on seaward facing reef promontories that descend quickly into deep water (Figure 15). The aggregations at Site 1 and 10 occur over a linear reef distance of approximately 400 and 300 linear meters respectively, and between depth ranges of approximately 4 – 50 m. At Site 1 the highest densities of aggregating groupers occur around the promontory and in the shallow bay to the east of the promontory. At Site 10 highest densities are seen around the promontory. Currents at both locations can be extremely strong.

Results

Monitoring by the TNC Community Conservation Coordinator (CCC) Tapas Potuku and his team has now been conducted around the new moon at both sites over 24 new moons and 23 consecutive months. Results show that aggregations of *Plectropomus areolatus* form throughout the year (Figure 16). At Site 1 for example, *P. areolatus* aggregations were sighted in 19 of the 24 new moon periods surveyed, and in at least one of these months (June 2005) monitoring occurred after the lunar days on which aggregations typically disperse. Marked differences in monthly aggregation trends existed between the two monitored sites that are only separated by tens of kilometers. On several occasions large aggregations of *P. areolatus* occurred at one site but were completely absent from the other site. At both sites *P. areolatus* densities varied on a monthly basis, and there appears to be no clear evidence of a peak annual season for this species at either site.

At Site 1 compliance with local management measures has been strong since it was initiated, and local fishers and monitors both claim that grouper abundances at Site 1 have improved notably since this site was closed in early 2004. On average *P. areolatus* densities in the second half of 2005 and first half of 2006 were much higher than those seen between September 2004 and July 2005. The average density of *P. areolatus* sighted between December 2005 and May 2006 (12.29 +/- SD 2.94 per 500 m.sq.) was more than twice as high as the average density of *P. areolatus* sighted between December 2004 and May 2005 (5.66 +/- SD 2.39 per 500 m.sq).

In contrast, at Site 10, where compliance with local *tambu* on the aggregation site is known to be weaker and poaching occurs, *P. areolatus* densities dropped dramatically in late 2005 and the first half of 2006. Maximum densities seen between September 2005 to July 2006 were three times lower than maximum densities seen in 2004 and the first half of 2005. This apparent recovery of *P. areolatus* at Site 1 and decline of *P. areolatus* at Site 10 may relate to differing levels of fishing pressure on the two aggregating populations, or alternatively, this may represent natural inter annual variability in aggregation densities in response to factors such as differing levels of recruitment success between years. Ongoing monitoring will help to clarify these patterns.

Epinephelus fuscoguttatus shows a strong seasonal pattern in other regions of Melanesia and the Indo-Pacific, and it was expected that *E. fuscoguttatus* aggregations in Kavieng would also show a high degree of seasonality. While this species does show more of a seasonal pattern than *P. areolatus*, this seasonality varied markedly between the two sites. Figure 17 shows the total number of *E. fuscoguttatus* sighted on deep transects at Site 1 and Site 10 between September 2004 – July 2006.

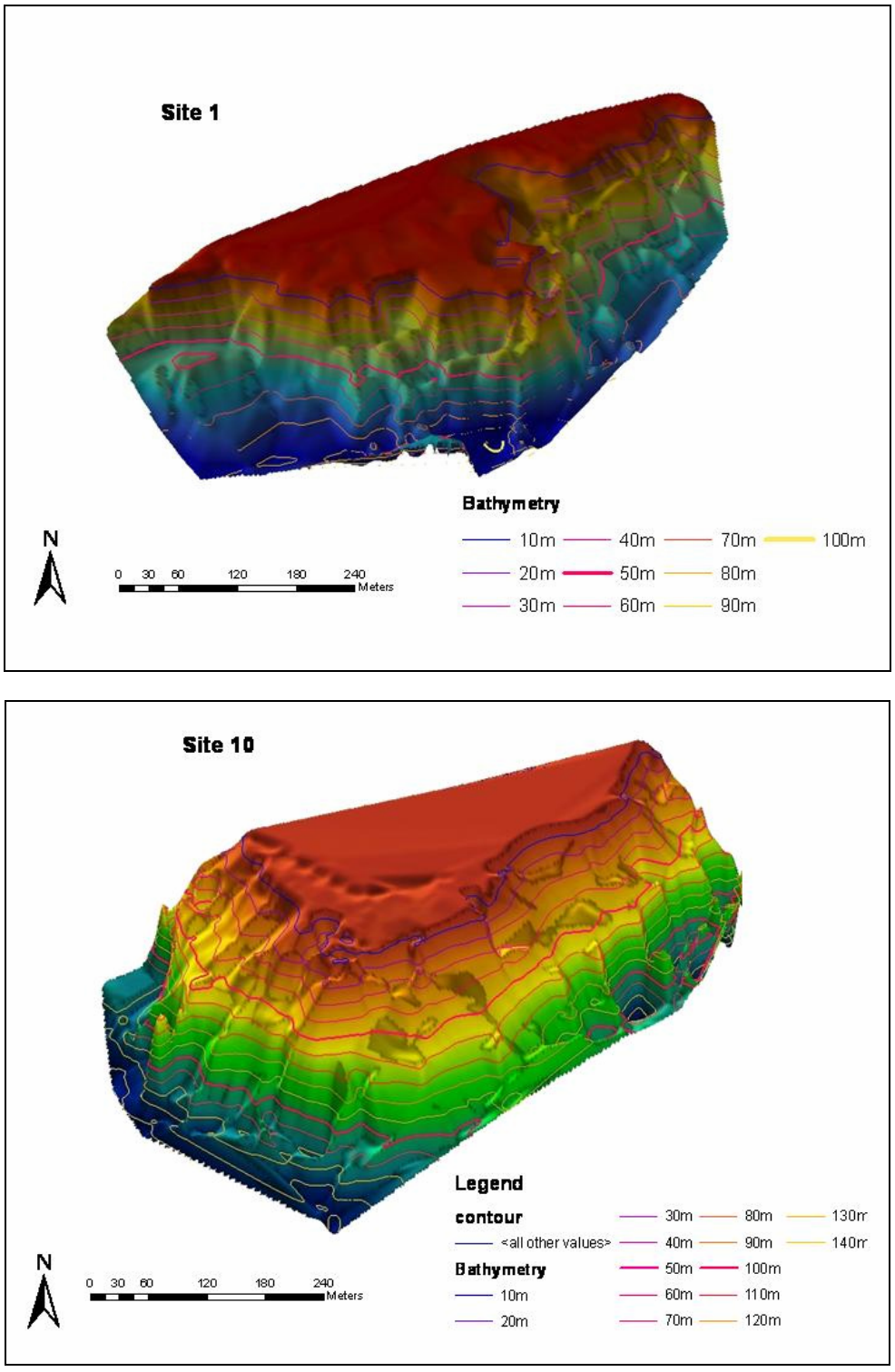


Figure 15: 3D bathymetric reef maps of Site 1 and 10. Bathymetric maps were made using the Adaptive Bathymetric System (Ecochard *et al*., 2003).

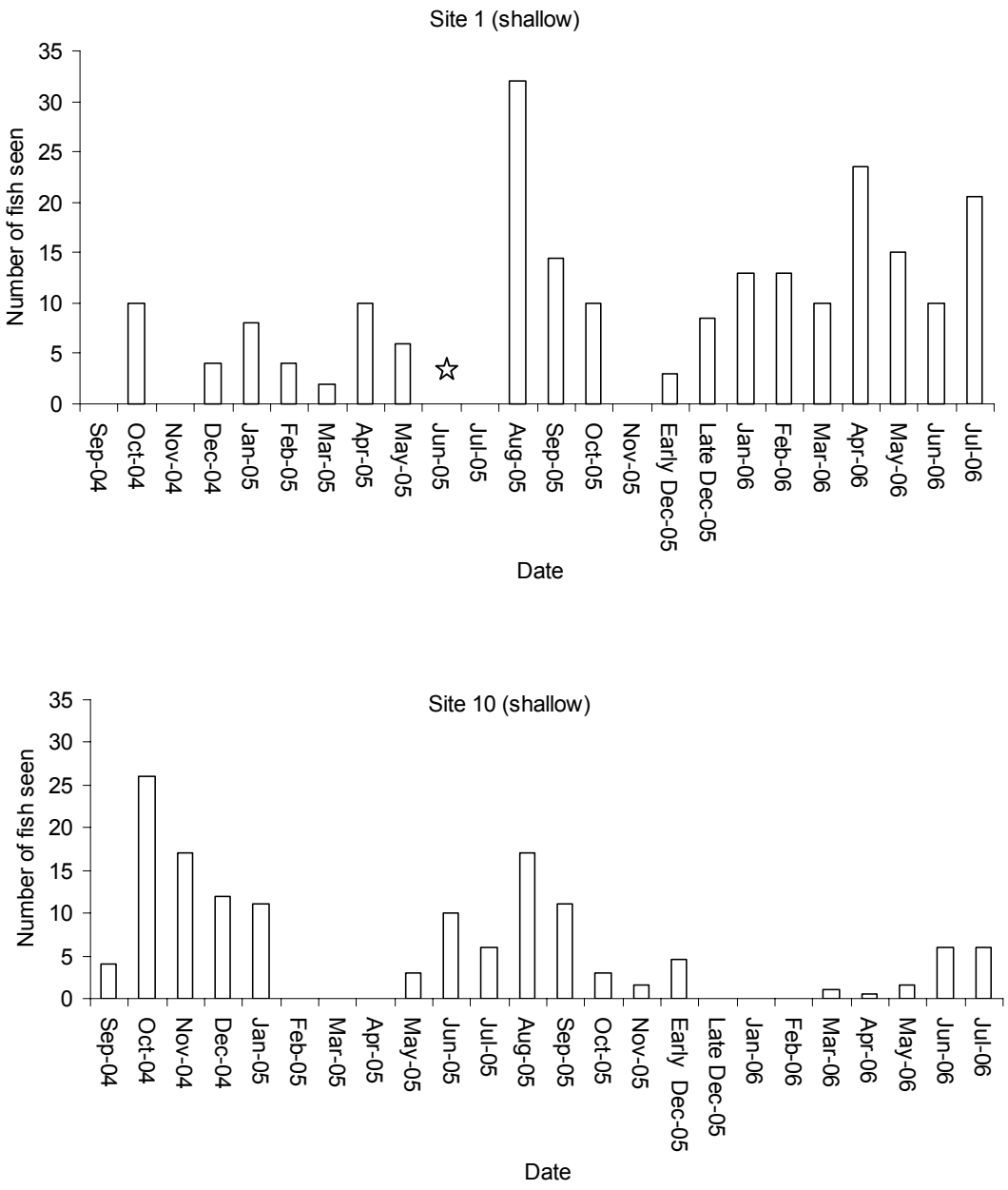


Figure 16: Number of *P. areolatus* sighted on the new moon along shallow water transects at Site and Site 10. Transect area = 500 m. sq. ☆ indicates that monitoring occurred several days after the new moon.

At Site 1 peak aggregations of *E. fuscoguttatus* occur between the months of March to August each year. In 2005 the highest densities of *E. fuscoguttatus* occurred in April, May and August, and in 2006 highest densities were seen in April, May and June 2006. It is noteworthy that reasonable sized aggregations of *E. fuscoguttatus* were also sighted at Site 1 in March 2003 (Rhodes, 2003) and May 2004 (Hamilton *et al*, 2004). At Site 10 the total number of aggregating *E. fuscoguttatus* was much lower, and a deep transect was not placed at this site until January 2005. Consequently, the density counts made along transects at Site 10 were not as insightful. However it is clear that the aggregating period is different to Site 1. In 2004 small aggregations of *E. fuscoguttatus* (30 – 50 in total) formed at this site in September, October, November and December 2004. In 2005 and the first half of 2006 *E. fuscoguttatus* were only sighted on transects between the months of June to November. No *E.*

fuscoguttatus were sighted at Site 10 during the months of April and May in 2005 or 2006, that being the peak aggregation periods for this species at Site 1.

At Site 1 maximum densities of *E. fuscoguttatus* sighted on deep water transect in 2006 were slightly higher than those seen in 2005. In actual fact, the total number of *E. fuscoguttatus* aggregated at Site 1 was much higher in 2006 than in 2005, as many *E. fuscoguttatus* were sighted in shallow water in 2006, something that was not seen in 2005 (Figure 20). At Site 10 *E. fuscoguttatus* abundances remained fairly constant.

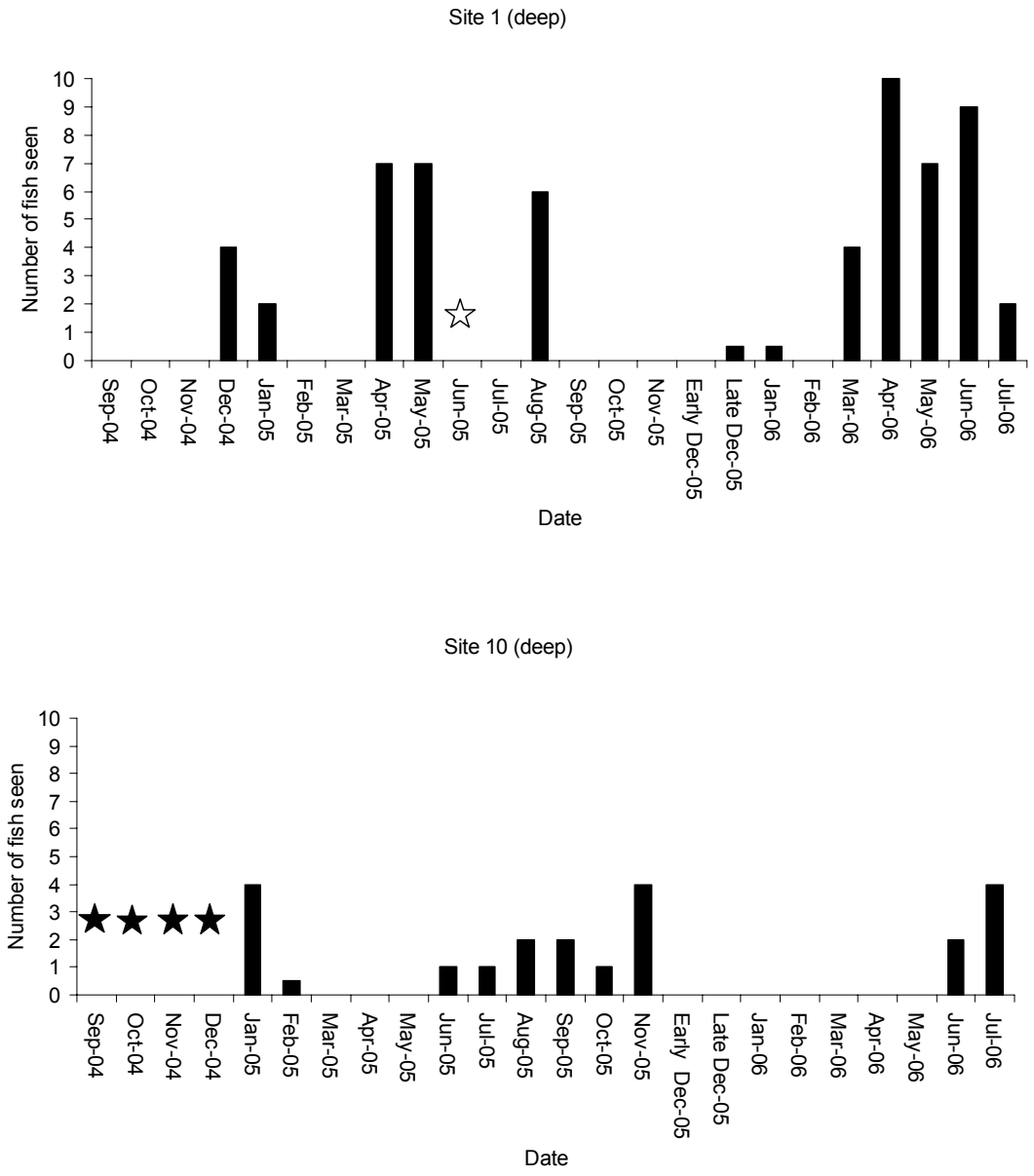


Figure 17: Number of *E. fuscoguttatus* sighted on the new moon along deep water transects at Site 1 and Site 10. Transect area = 500 m. sq. ★ indicates that the deep transect not yet established, but aggregations of *E. fuscoguttatus* were sighted at the site in these months. ☆ indicates that monitoring occurred several days after the new moon.

E. polyphekadion was only ever seen aggregating at Site 1. At Site 1 aggregations of *E. polyphekadion* occurred during the same months as peak aggregations of *E. fuscoguttatus*. Highest densities were seen in August 2005 and in 2006 highest densities were seen in May, June (Figure 18). Densities seen in 2006 were higher than in 2005. In 2006 *E. polyphekadion* also aggregated into shallow water (Figure 19).

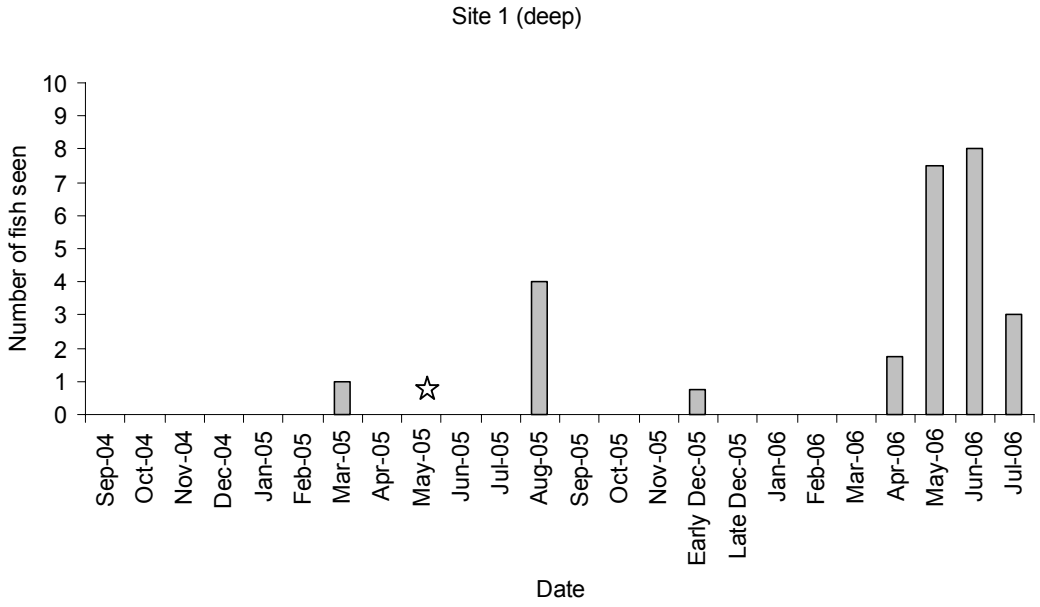


Figure 18: Number of *E. polyphekadion* sighted on the new moon along a deep water transect at Site 1. Transect area = 500 m. sq. ☆ indicates that monitoring occurred several days after the new moon.

The effect of depth on the distribution of the three grouper species is seen in Figure 19 and Figure 20. It is clear that at both sites *P. areolatus* is almost never aggregated below 25 -30m. *E. fuscoguttatus* was aggregated in both shallow and deep water at both sites during different months of the year. *E. polyphekadion* was only sighted in deep water in 2005, but was present in shallow water in high densities in May and June 2006.

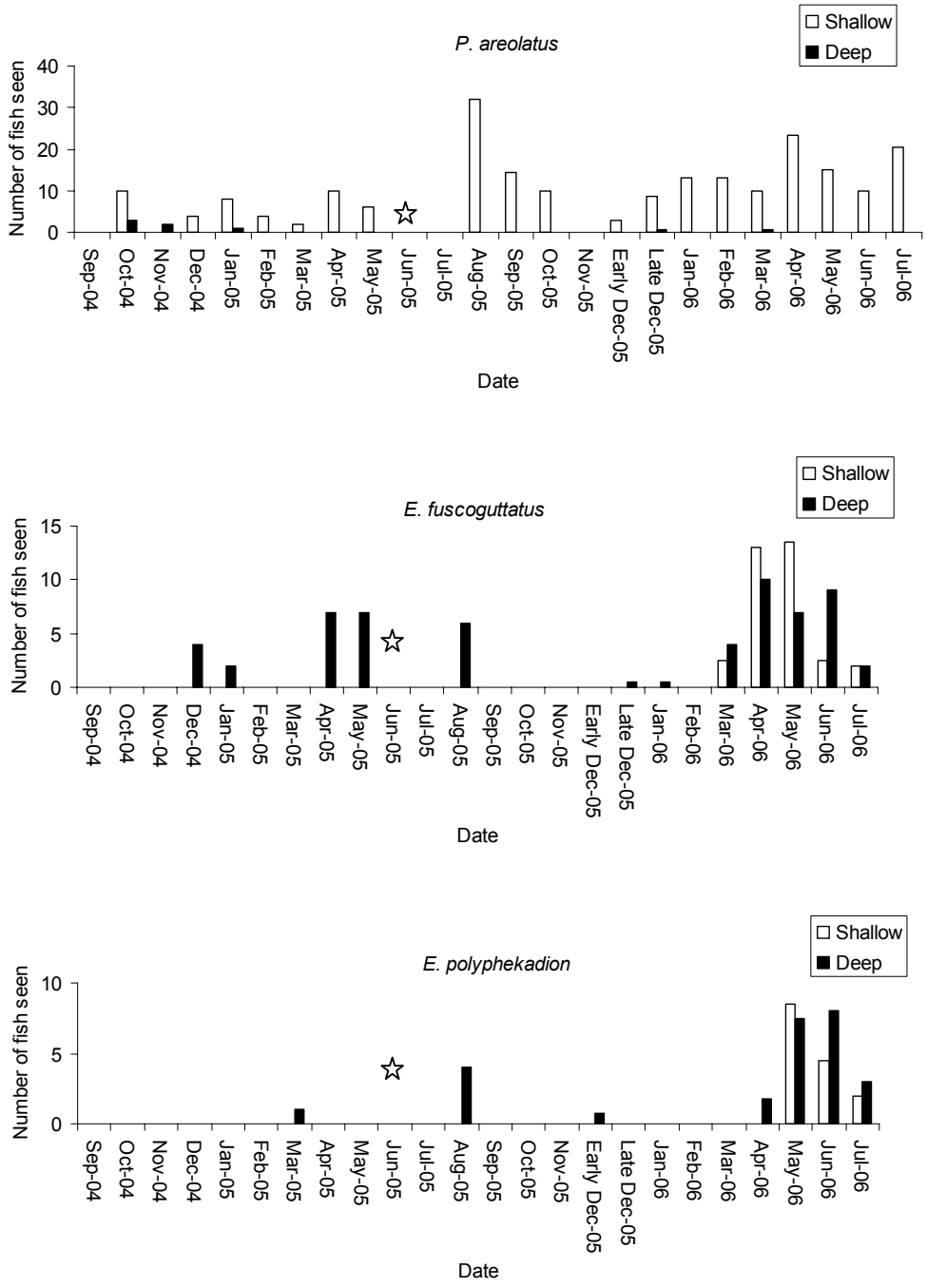


Figure 19: Number of *P. areolatus, E. fuscoguttatus* and *E. polyphekadion* sighted on the new moon along shallow and deep water transects at Site 1. Transect area = 500 m. sq. ☆ indicates that UVC surveys occurred several days after the new moon.

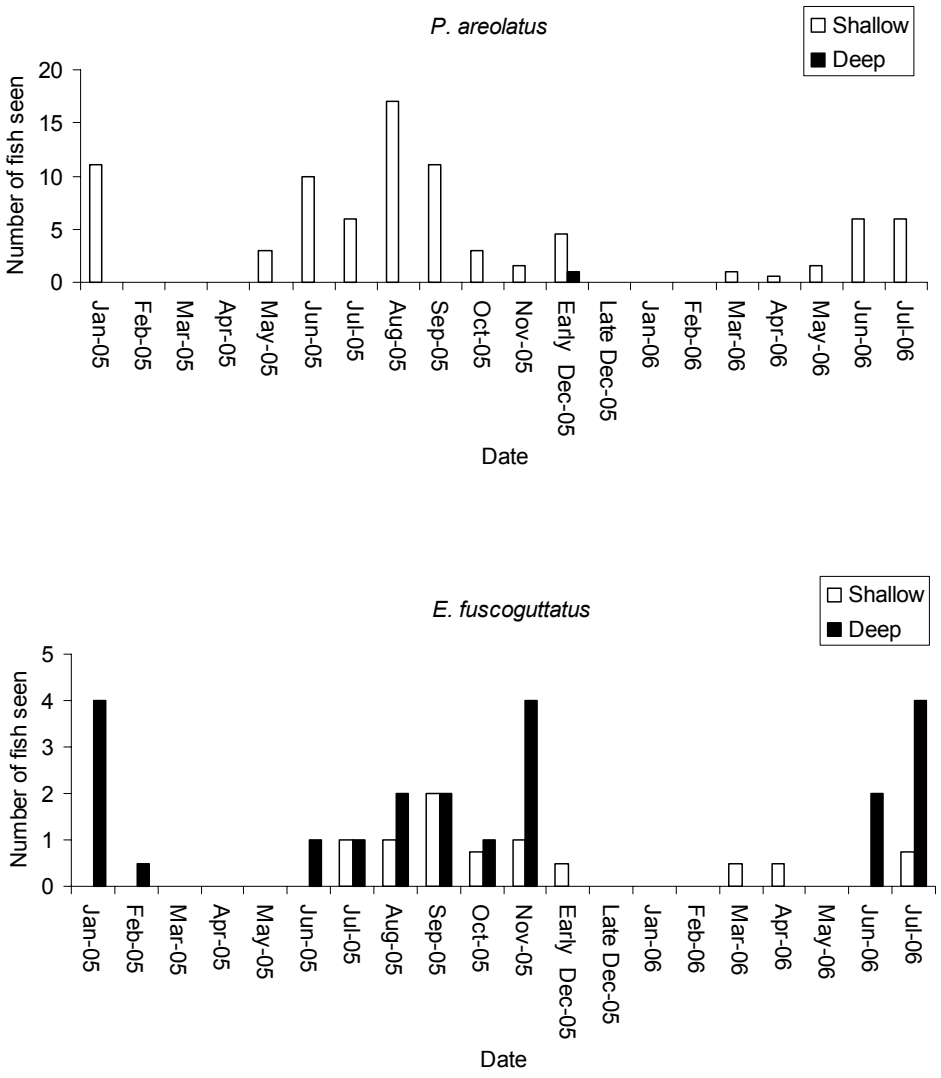


Figure 20: Number of *P. areolatus* and *E. fuscoguttatus* sighted on the new moon along shallow and deep water transects at Site 10. Transect area = 500 m. sq.

Future Activities

Routine monitoring at Sites 1 and 10 is ongoing, and in May 2006 monitors also began conducting surveys on the full moon, as monitoring in Indonesia has shown that *P. areolatus* aggregations occasionally occur around the full moons as well as new moons, and this has important implications for management (Pet *et al*. 2006). Available data from full moon monitoring is limited and is yet to be examined. At this stage TNC has secured funding to continue monitoring for the rest of 2006 and 2007.

7.2.3 Kimbe Bay

Since 2003 TNC has been involved in locating spawning aggregations in Kimbe Bay, using a variety of methods including satellite imagery and local knowledge (Aitsi and Seeto, 2003, Hamilton *et al*., 2005c, Aitsi *et al*, 2006). Local knowledge has proven to be the most effective method for locating spawning aggregations (Rhodes 2005), and to date 14 potential grouper spawning aggregations have been identified, of which seven sites have been independently verified as being grouper aggregation sites. In contrast to Manus and Site 1 at Kavieng, the majority of known and verified aggregations in

Kimbe Bay appear to support relatively low numbers of groupers (typically less than 100 fish), with most aggregations being single species *P. areolatus* aggregations.

Due to the low numbers consistently seen, there has been no attempt to place transects at known grouper aggregation sites, with total counts deemed more appropriate. UVC surveys at known aggregation sites in Kimbe Bay have been sporadic over the past four years due to workloads of TNC staff, and as such monitoring work has focused on verifying the presence of grouper aggregations at potential grouper aggregation sites, in order that these sites could be incorporated into the initial Kimbe Bay MPA network design. This activity has now been carried out successfully, and all known and verified grouper aggregations have been captured in the recently completed Kimbe Bay MPA network design.

In light of the UVC data from Kavieng and Manus and Roviana Lagoon in the Solomon Islands, it is likely that *P. areolatus* form aggregations of variable size throughout much of the year in Kimbe Bay. However (Claydon and McCormick, not dated) have data from grouper aggregations in the Western Kimbe Bay that suggests that *P. areolatus* aggregations predominantly form in the first half of the year, a similar pattern to aggregation trends of this species in southern Manus. We have a poor knowledge of seasonality for *E. fuscoguttatus* or *E. polyphekadion*, as seasonality for this species does not appear to be present in local knowledge bases (Hamilton *et al*., 2005c) and only one small aggregation of *E. fuscoguttatus* (30 fish) has ever been sighted in Kimbe. This aggregation was seen in March 2005, but was not present in April 2006 during a follow up survey.

Future Activities

There is a need to conduct further verification surveys at all potential and verified grouper aggregation sites in Kimbe Bay. Further UVC spawning aggregation surveys have been planned for January – June 2006, the period when we suspect grouper aggregations peak in Kimbe Bay. It is envisaged that these surveys will be carried out over six continuous months, so that the seasonality of *E. fuscoguttatus* can be determined. The hiring of local community members for training and inclusion in the spawning aggregation monitoring has also been identified as a priority for 2007.

7.3 Solomon Islands

7.3.1 Roviana Lagoon

Overview

Between March 2004 and May 2006 TNC and the Roviana and Vonavona Lagoons Resource Management Program (RVLRMP) assisted the Roviana Spawning Aggregations Monitoring Team (RSAMT) in their efforts to conduct monthly monitoring programs at several grouper spawning aggregation sites in Roviana Lagoon (Hamilton and Kama, 2004). RSAMT is made up of traditional reef owners from the Roviana that are qualified SCUBA divers. The Melanesia Marine Scientist, Dr Richard Hamilton, has provided remote and field assistance to RSAMT since it formed, and part of this assistance has included having RSAMT members attended several TNC sponsored spawning aggregation monitoring workshops (Kevin, 2004; Hamilton *et al*., 2005a).

Many known spawning aggregations in Roviana Lagoon have been overfished by LRFFT activities and night time spearfishing, with several aggregations reportedly fished to expatriation (Johannes and Lam, 1999; Hamilton and Kama, 2004; Hamilton *et al*., 2005b). The majority of RSAMTs efforts have focused on Site 1, a multi-species aggregation site that is located a short distance from the nearby town of Munda. The squaretail coralgrouper (*P. areolatus*), brown-marbled grouper (*Epinephelus fuscoguttatus*) and camouflage grouper (*Epinephelus polyphekadion*) are known to aggregate at these sites at overlapping times and locations.

Two transects were established at Site 1. In March 2004 a deep 250 m long transect with a midline at 25 m that samples the high-density *E. fuscoguttatus* and low-density *P. areolatus* aggregations was established, and in January 2005 RSAMT established a 200 m long shallow transect with a midline at 10 m that samples the high-density *P. areolatus* and low-density *E. fuscoguttatus* aggregations. Monitoring occurs a day before or on the new moon of each month, and involves two SCUBA divers counting all of the *P. areolatus*, *E. fuscoguttatus* and *E. polyphekadion* sighted within the transect boundaries.

In June 2006 a meeting was held between the Dundee community[8], TNC staff and RVLRMP staff. During this meeting Dr Richard Hamilton gave a presentation to the Dundee community on the findings made from two years of monitoring, and the implications for management. On the basis of these results and on the strength of awareness raising initiatives that had been carried out here over the past two years by RMSAT, TNC and RVLRMP, the Dundee community voted to turn Site 1 and the surrounding reefs into a MPA. RVLRMP, TNC and RSAMT are currently developing long term monitoring protocols for Site 1 that will involve monitoring around peak aggregation periods.

Site description

Site 1 is located on seaward south facing reef promontory that descends quickly into water depths of greater than 200 m (Figure 21). The walls to the west and east of the promontory slope very steeply, and as such do not provide suitable aggregation habitat. The aggregations at Site 1 occur over a linear reef distance of approximately 400 m, between depth ranges of approximately 3 – 50 m.

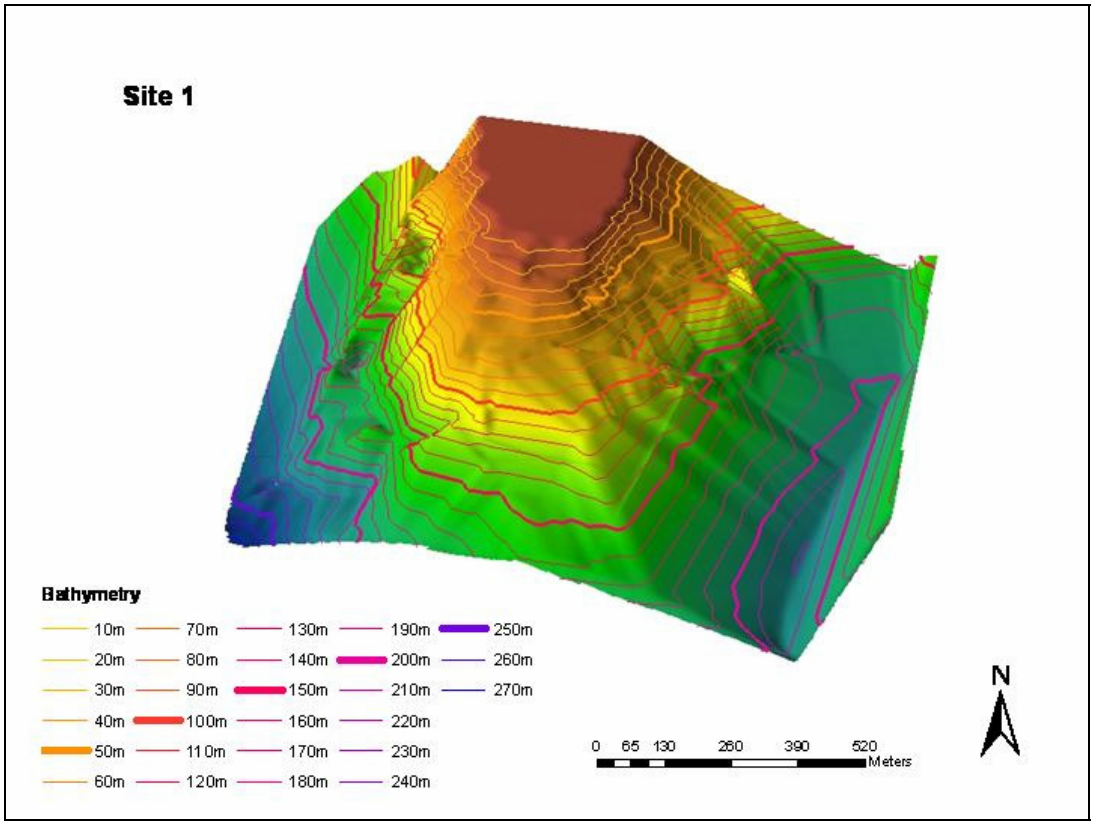


Figure 21: 3D bathymetric reef maps of Site 1, Roviana Lagoon. Bathymetric map was made using the Adaptive Bathymetric System (Ecochard *et al*., 2003).

[8] Dundee is one of several communities that claim ownership over Site 1 (Aswani and Hamilton 2004).

Results

Plectropomus areolatus

UVC surveys show that, as in Kavieng and Manus, at Site 1 *P. areolatus* aggregations of variable size occur in virtually every month of the year (Figure 22). Maximum densities of *P. areolatus* are 35 per 500 m.sq., being very similar to maximum densities seen in shallow water at monitored sites in Kavieng.

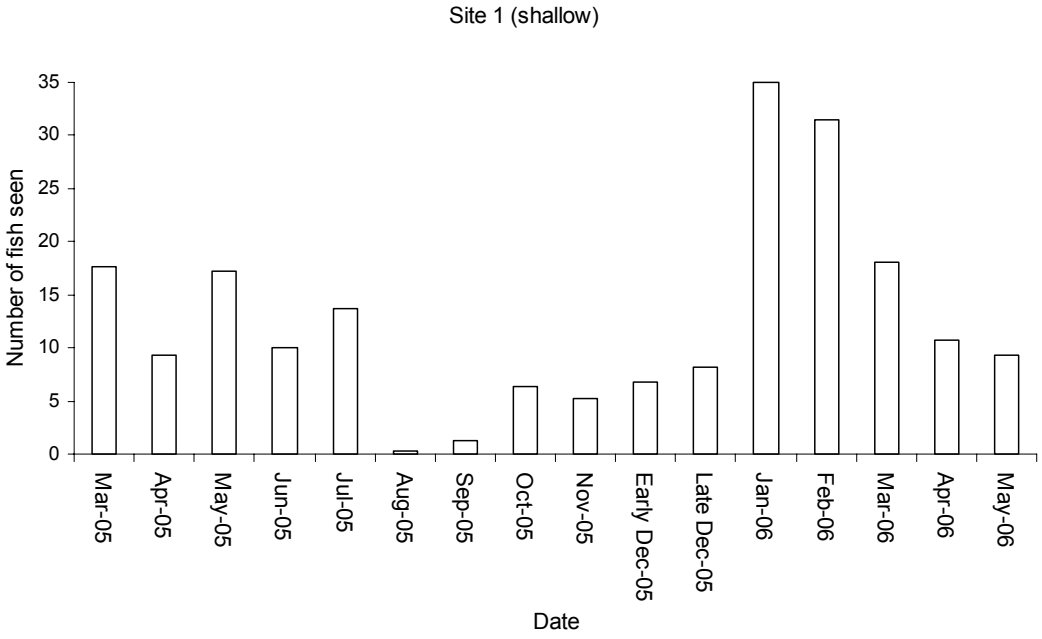


Figure 22: Number of *P. areolatus* sighted on the new moon along shallow water transects at Site 1. Transect area = 500 m. sq.

Epinephelus fuscoguttatus and *E. polyphekadion*

Monitoring results have shown that peak aggregations of both *E. fuscoguttatus* and *E. polyphekadion* aggregate at Site 1 between the months of December to April each year, contrasting with local knowledge that places the spawning season in this region between October to January each year. The full findings of the Roviana monitoring are currently being written up for a scientific publication and as such will not presented here.

Future activities

Two years of monitoring data has now been collected from the major monitored site in Roviana, and the results of this data is currently been written up for scientific publication (Hamilton *et al*., in prep). TNC, RVLRMP and RSAMT are currently developing long term monitoring protocols for Site 1 that will involve monitoring around peak aggregation periods. We are also looking at the possibility of expanding the monitoring work to include additional sites in Roviana Lagoon. The concept of having local enforcement rangers stationed at an island that is nearby to Site 1 during the peak aggregation period is being discussed.

7.3.2 Choiseul Province

One of the sites where TNC is working in Choiseul is on the north coast, where TNC has engaged with the Chivoko community. This community has traditional ownership over a reef passage where *Epinephelus merra, Epinephelus spilotoceps* and *Epinephelus tauvina* are reported to aggregate in the thousands in June and July each year. Aggregations occur on the shallow reef flats on either side of the passage in 1 -2 m of water (Figure 23). In early 2005 the Chivoko community declared this site as a MPA, and in November 2005 baseline surveys were conducted in and around this MPA. Results of the November 2005 survey showed that *E. merra* was the most abundant grouper at this shallow water site during non-aggregation periods, with a mean abundance of 2 per 2500 m.sq.

In June 2006 we visited this site and conducted UVC surveys within the MPA aggregation area. *E. merra* were densely aggregated within the MPA, with a mean density of 38 per 2500 m.sq. That being a 19 fold increase on non aggregating periods. Neither *Epinephelus spilotoceps* nor *Epinephelus tauvina* were sighted in the MPA in June 2006. During the same period 15 *E. merra* were captured with hook and line and their gonads examined. While several females had ripe well developed ovary (Figure 24) and several appeared to have recently spawned, the majority had no obvious gonad development. These preliminary investigations imply that *E. merra* that were aggregated at the site for the purpose of spawning, however, the duration and lunar periodicity of spawning is currently unclear and will require further investigation.

Future activities

We are currently developing community-based monitoring methods for all the MPAs in Choiseul. These monitoring methods will address a range of local marine resource management and conservation issues, including spawning aggregations. Community-based monitoring will fall into two broad categories: Firstly, developing basic and inexpensive methodologies that can be taught to a wide range of people and secondly, building up specialized teams of individuals that conduct rigorous scientific monitoring programs on SCUBA. To this end local participants from Chivoko, Voza and Choiseul Provincial Fisheries were trained in SCUBA diving in late 2005, and these individuals will assist TNC staff in upcoming MPA monitoring activities in October 2006. RSAMT members will also assist in these activities.

Figure 23: The shallow reef area at aggregation site

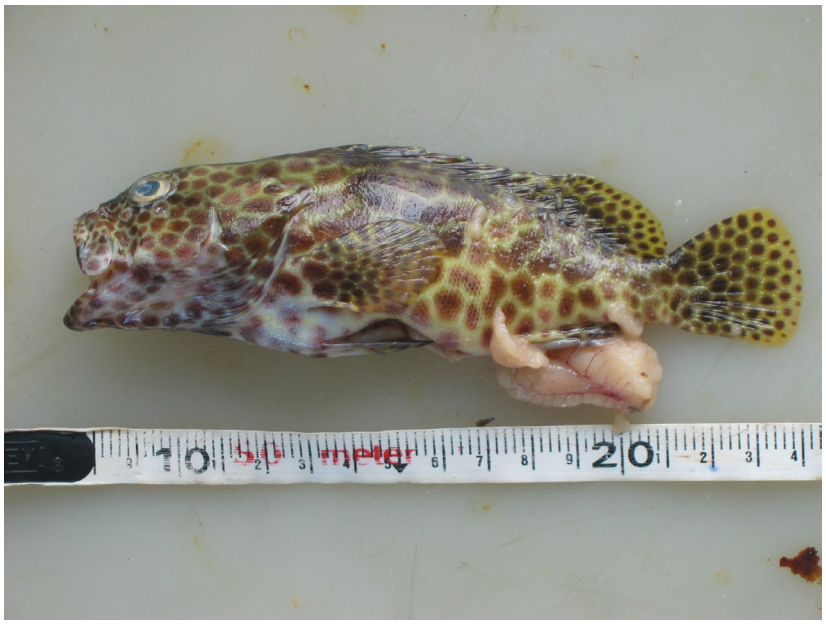


Figure 24: Ripe female *E. merra* that was captured from the aggregation site in June 2006

LESSONS LEARNED AND RECOMMENDATIONS

8. KEY LESSONS LEARNED

Project Management

- This project would have benefited by an additional full time equivalent position. While this was recognized during the project, all efforts to identify and hire a suitably qualified and experienced local candidate to be based in Melanesia failed. There is a very real challenge in both Melanesia and Micronesia to find suitable candidates for the type of work involved—science, resource management, community partnerships. Not because the right people do not exist, but because they are nearly always already employed, and "poaching" such people from your partner agencies or organizations can cause tensions. In the longer term we do need to concentrate on building the pool of qualified and experienced people in both Melanesia and Micronesia.

- The hiring of Community Conservation Coordinators (CCC) in Papua New Guinea and the Solomon Islands has been successful and extremely valuable. The three current Community Conservation Coordinators are all from the areas in which TNC is working to implement spawning aggregation management. They are the primary contacts and liaisons for TNC within the project communities and provide an on-going presence within the communities (rather than using a fly-in-fly-out approach). They also facilitate community meetings, help deliver awareness materials and programs on spawning aggregations and destructive fishing, lead the monitoring of the sites, present back the monitoring results and assist in discussing and developing the management options with the communities.

- There is always a fine line when working in Pacific communities, especially remote ones, between encouraging and facilitating conservation and management action within the community, and building unrealistic expectations. With this project a considerable amount of care was taken to ensure that unrealistic expectations were not raised, especially during the local knowledge surveys, by being open about our agenda and clear about what we could and could not assist communities with. Given our objectives and resources, we focused on a few key communities that wanted to act themselves, and where TNC's role and responsibilities were to support the communities with specific activities they requested. The success of the work in Manus (PNG) and Choiseul (Solomon Islands) has resulted in TNC receiving more requests for assistance to establish MPAs and advise on marine resource management, than we have the capacity to respond to. While it is exciting that so many communities want to be proactive in better managing their nearshore marine resources, it does raise the concern that they may, for example, establish MPAs without clear management objectives, or establish them in the wrong place so that their expectations will not be met and they become disillusioned with MPAs.

- Although educational programs can be a very effective way of raising awareness on the need to conserve spawning aggregations, on their own these programs will often be insufficient to bring about effective management of these resources. This was reflected time and time again in the communities we visited, where, after community meetings, individuals would inform us that while they appreciated and understood our message, what they really required was long term assistance in managing their inshore fisheries resources. Clearly, if the goal of significantly reducing the overfishing and degradation of spawning aggregations in Melanesia and Micronesia is to be achieved, then community based management initiatives must be supported over a long time frame. This is a role that NGOs and Provincial Fisheries departments can and should provide.

- Although many communities may express a desire to manage their aggregations, eroded or disputed customary marine tenure estates means that not all communities are capable of effectively implementing and enforcing community-based management measures. This is a fundamentally important point, for if community-based conservation efforts are to be effective in

Melanesia and Micronesia, then NGOs must tailor their efforts on areas of high biodiversity that are located within customary marine tenure estates that provide a suitable framework for effective community-based management.

- While we recognized that sustainability over the long term would be an issue, the time frames involved for both the management of reef fish spawning aggregations and the science for understanding the aggregation phenomena, will require on-going support for at least a decade, if not longer.

- The identification, assessment and monitoring of reef fish spawning aggregations usually requires the use of small boats and the need to SCUBA dive, often in remote areas. These activities can be both challenging and risky, especially at spawning aggregation sites where heavy seas and strong currents frequently occur. To maximize safety and minimize the risks for both diving and small boat operations it is critical that dive safety and small boat safety policies are established and followed. The monitoring manual (Pet *et al.* 2006) includes basic safety guidelines, however, they are not comprehensive, nor a substitute for a detailed diving and small boat safety plan or program.

- While the number of site exchanges was reduced due to funding limitations, one key issue that became apparent with trying to arrange exchanges, was the fact that many of the sites' spawning seasons overlapped. As there are only a limited number of trained surveyors at each site, going on an exchange meant that no monitoring data could be collected for the time they were absent. Despite this, the feedback we had on the exchanges was extremely positive, and wherever feasible they should be encouraged.

- The number of well trained monitors needs to be increased at each site. If spawning aggregation monitoring programs are to be successfully conducted over meaningful temporal scales then there needs to be a minimum of three certified and trained divers per monitoring team. A team of three monitors could be expected to survey 2-3 sites over a period of 2-3 days.

- Cross-support between monitoring teams, and their availability to contribute to national and/or regional monitoring teams was an outcome for this project. Eleven monitors have been trained and are at a suitable standard to be able to assist with establishing new spawning aggregation monitoring programs and to assist with training people at monitoring workshops.

- The development of education and awareness materials, and their delivery and application, has been a far more time consuming and challenging activity than anticipated. Not having a full time communications or education staff member associated with the project has meant contracting this work out and having science/conservation staff (unfamiliar with media and materials production) manage those contracts and the final products. While the production of these materials has been successfully achieved, and to a high standard, the resources required (time, human and financial) have been much greater than anticipated. Any future projects involving education and awareness materials needs to include appropriately skilled staff to manage these activities.

- A number of factors can influence progress: Working in partnership with local communities, government agencies, and other organizations necessitates operating at the times and speeds at which these partners operate, often disrupting annual work plan timetables; The threats to reef fish spawning aggregations can change, often very quickly, and at speeds greater than management agencies can respond; Fully satisfying the criteria for designating an aggregation as a "spawning aggregation" can sometimes be challenging. All these factors, and more, requires the application of both a precautionary approach, for example working on management options for aggregations they may not yet be confirmed as spawning aggregations, and adaptive project management. Flexibility is key to these sorts of projects.

Science and Monitoring

- At multi–species grouper aggregation sites in Melanesia the most abundant groupers are *P. areolatus*, *E. fuscoguttatus* and *E. polyphekadion* respectively. This contrasts with Palau and FSM where *E. polyphekadion* is often the most abundant species.

- Annual seasonality varies markedly in Melanesia, however, local knowledge and monitoring results have shown that the lunar periodicity with which aggregations form and subsequently disperse are very set. Large aggregations of grouper build up in the week prior to the new moon, and disperse around the new moon. In Micronesia, the aggregations in Palau also form just prior to the new moon, however, in Pohnpei the aggregations form prior to the full moon. Caution needs to be applied to extrapolating lunar periodicity between regions. Similarly it is also dangerous to extrapolate annual seasonality based on knowledge from one area to other nearby areas, as the Kavieng monitoring data has shown.

- In Melanesia and Palau (Micronesia) aggregations typically peak around the new moon, however the lunar day on which aggregations peak and subsequently disperse at any given site can vary by several days between months. Because of this, monitoring conducted on the new moon may occur after aggregations have peaked and subsequently dispersed (Authors, unpublished data, Hamilton *et al*., 2005b). For this reason, it is strongly recommended that baseline monitoring in Melanesia and Palau is conducted 2-3 days prior to the new moon. This is especially important if logistics and finances limit monitoring of sites to once per month.

- In Melanesia multi-species aggregation site are often large (20,000 -30,000 m^2) with *P. areolatus* typically aggregated between depths of 2-30 m, whereas *E. fuscoguttatus* and *E. polyphekadion* can be densely aggregated to depths as great as 60 m. At some monitored sites all three species overlap considerably in shallow water. Large aggregation areas and broad depth distributions with differing densities highlight the need for both sub-sampling and dive safety monitoring protocols.

- Large multi-species aggregations require sub-sampling and the permanent transect method outlined in the Pet *et al* (2006) manual is one way to achieve this. To capture an accurate picture of seasonality and variations in fish abundances transects need to sample as large a percentage of each stratum at an aggregation site as possible. In Melanesia, the two dominant species at aggregation sites are *E. fuscoguttatus* and *P. areolatus*. Typically *E. fuscoguttatus* is in highest densities in water of 15-40 m depth, while *P. areolatus* is typically most abundant between 2-15 m. In such cases the simplest way to sub-sample an aggregation is to run continuous transects through the entire deep and shallow stratums of the aggregation site. Note however that if the aggregation area is very large, it will not be possible to extend transects through the entire site, particularly for deep water transects where diving bottom times and safety factors come into play.

- Some of the main advantages of permanent transects are: they are easy to establish, they are simple to monitor and maintain and they provide repeatable estimates of abundance and density within a known area of the aggregation site. Density estimates made in different months or years but at the same lunar stage and same time of day are comparable. For this reason, transects provide a useful index to evaluate changes in fish density at aggregation sites in relation to seasonality or changing fishing or management regimes. For example, transects were sufficient to determine strong annual seasonality patterns for *E. fuscoguttatus* and *E. polyphekadion* at the majority of sites surveyed in Melanesia, and in Manus transects picked up rapid declines in grouper densities following LRFFT activity at Site 35.

- Placing transects at various depths at a multi-species aggregation site is a useful way to evaluate the way in which different species densities vary with depth. As the Kavieng data from Site 1 demonstrates, it also provides a way in which variation in the vertical distribution of species between months or years can be quantified.

- Density estimates obtained from transects counts can, to some extent, be compared between sites. For example, we know that the shallow water transects placed at Manus, Kavieng and Roviana sites all are located within the high density *P. areolatus* aggregation area. We can therefore make the statement that highest densities of *P. areolatus* at monitored grouper aggregation sites in Melanesia occur at Manus, followed by Roviana and Kavieng

- The Kavieng example of monitoring at Site 10 has shown that in cases where multi-species grouper aggregations are small but the aggregation area is fairly large, placing transects at the site is not advised. Conducting transect counts at aggregation sites that support low numbers of fish will result in very low counts, hereby diluting the ability to determine seasonality with a high degree of confidence. In initial baseline studies of aggregation sites monitors should survey the entire site (or as much as possible). Transects should be placed only if fish numbers are high during peak season (> 100 fish) and if the depth distributions of different species make surveying the entire site in one dive impractical.

- A *minimum* of two continuous years of monitoring is required before inferences about seasonality or status of aggregations can be made. This will be especially important for regions where local knowledge on the seasonality of spawning aggregations is absent or limited. By simply conducting monitoring over several months one might conclude that a site was made up of small numbers of *P. areolatus* only, when in actual fact, large aggregations of *P. areolatus* and *E. fuscoguttatus* and *E. polyphekadion* occurred during several months of the year.

- Once baseline (several years) of data is available for a spawning site, long term site based monitoring protocols should be developed and implemented. Given the longevity of many groupers, it will only be through long term monitoring that the real impacts of management or fishing of aggregations can be accurately assessed. If funding is an issue, then long term monitoring efforts could be scaled back and fine tuned to focus on the months of the year when aggregations are known to peak.

- Spawning aggregation monitoring is expensive and requires a certain level of technical support that is often unavailable at the site level. While technical ability can be built over time, it is unrealistic to think that communities (or even provincial fisheries departments) in Melanesia and Micronesia could fund ongoing spawning aggregation monitoring programs. In the short-term, spawning aggregation monitoring programs can best be co-funded by environmental NGOs and national government agencies (where feasible), while longer term, and more sustainable, funding support is found.

- Involving community members is spawning aggregation monitoring activities is a very effective way to raise the awareness on spawning aggregations and to get commitment by local communities. In Roviana Lagoon for example, involving local spear fishermen who formally exploited a large spawning aggregation site was pivotal to both the monitoring and current management success of this site. With the right training, spear fishermen with limited formal education often make excellent spawning aggregation monitors due to their considerable underwater fish observation skills.

- Based on these results of the comparative assessment, it would appear that the success rate of using the satellite imagery to identify spawning aggregations sites without local fisher interviews is so low that it is not worth pursuing within the Pacific as a viable independent identification method.

Management

- It is clear from the local knowledge surveys and our field observations, that spawning aggregations in Melanesia and Micronesia are in need management. Many are in decline, some are gone. The major threats being the LRFFT and market driven hand-line and night spear fishing.

- While a myriad of management options for fish spawning aggregations exist, few have actually been applied, particularly in a manner that eliminates the potential for spawning aggregation loss or decline. Given the significant variations in implementation contexts, there is unlikely to ever be a 'one size fits all' conservation strategy that tropical marine resource managers can use to provide the necessary level of protection to spawning aggregations. Instead, effective management of coral reef spawning aggregations will require careful consideration of local circumstances and flexibility in implementation, and will involve shared management responsibilities between communities, governments and non-government organizations.

- Based on the management options review, the most effective option to achieve adequate spawning aggregations protection is the total elimination of fishing on reproductively active fishes, specifically spawning aggregations and the (reproductive) migratory pathways that individuals use to reach these sites. We are not aware of any recorded fish spawning aggregations that are fished *and* unmanaged, yet maintaining or increasing its abundance. While this should be the goal, the reality of community-level resource management is that only limited fishing restrictions (methods, seasons, species) may be acceptable to communities, or where total closures are adopted by communities, they may be of a fixed or limited time frame (e.g. 3 to 5 years, or until the species are perceived to have recovered enough to be fished again).

- The effective management of spawning aggregations cannot be achieved by only applying management actions at one level, for example only at the community level, or only at the national level. Multiple, mutually supporting approaches at several levels are required. We need to continue to support communities to develop management strategies and implement them, either through custom means, or within a supporting legal framework at the municipal, local level government, or provincial government. There needs to be government and non-governmental support for monitoring and management. Finally, at the national level there needs to be changes to fisheries policies and licensing.

- Closed seasons for spawning aggregations are an option, but in order to do this effectively data is needed on a fine scale. The quantitative data needed to base seasonal bans typically will take several years to collect (fishery independent or dependent). In some cases (e.g. Manus) local knowledge is very detailed and accurate, and management decisions for a closed season could be based initially on this information alone. However, caution is needed, as one of the surprising findings of the Roviana monitoring was that peak seasons seen in 2004-2005 (January-March) differed somewhat from widespread local knowledge of this peak season being from October-January each year.

- One of the key target species, *P. areolatus*, aggregates on a monthly basis, and is thus vulnerable to over fishing from the LRFFT in all months of the year. A closed season would do little to protect spawning stocks of this species.

- Where not all spawning sites are known in an area or region, if there is effective enforcement capability, lunar bans (e.g. 7 days prior to and including the new moon, and 3 days after the new moon) during every month of the year are a 'dataless', yet effective, way of managing LRFFT operations that target spawning aggregations.

- The Kavieng monitoring data has shown the months of the year in which peak aggregations form can vary on very small spatial scales. Consequently, developing closed seasons (even at a

provincial level) will require a large amount of monitoring data from multiple sites. This data is currently unavailable for the majority of sites where the LRFFT operates in PNG or elsewhere.

- Local knowledge surveys of potential spawning aggregations followed by independent verification checks at these sites by trained SCUBA divers with monitoring training are a very effective way of identifying spawning aggregations in Melanesia and Micronesia. Such surveys can also highlight threats to spawning aggregations, communities' attitudes to conservation and their ability to manage their aggregations through existing customary marine tenure and/or local level government systems.

- The monthly aggregating behavior of *P. areolatus* in Melanesia makes independently verifying the presence of *P. areolatus* aggregation sites a reasonably simple task. Future local knowledge surveys in Melanesia should be scheduled to end a week prior to the new moon so that verification surveys can be conducted immediately after the local knowledge surveys.

- Once spawning aggregations are located, some of these sites can be conserved at a site level by working with communities. However, as Manus and Palau have shown, community desires and commitments can change rapidly, especially when economic incentives are involved. All MPAs, no matter at what level of designation, are vulnerable to the changes in political leadership (community, local level government through to national level governments) and economic forces. It is therefore critical that there is a fundamental understanding of the importance of spawning aggregations to the broader fisheries condition. Where fish resources are limited, alternatives sources of income and food need to be thoroughly assessed.

- The economic pressures to harvest spawning aggregations for commercial ventures remains very strong in Melanesia, and at times in Micronesia, reflecting the overwhelming lack of income generating opportunities for many coastal communities in the western Pacific.

- "Communities" are not homogenous entities. Within Melanesia and Micronesia fundamental aspirational differences often exist within and between various sectors of a community with regards to resource exploitation levels and the management and conservation of marine resources, including reef fish spawning aggregations. The effective management and conservation of reef fish spawning aggregations will require approaches that acknowledge and deal positively with these aspirational differences.

9. CONCLUSIONS AND RECOMMENDATIONS

This project aimed to identify practical ways to improve local resource management and spawning aggregation site protection, increase awareness of these resources' vulnerability to over-exploitation, and enhance capacity to manage reef fish spawning aggregations and MPAs that incorporate these sites.

The intention has been to identify, develop and pilot approaches that are appropriate to the sets of circumstances found in the Pacific, and more specifically in Melanesia and Micronesia. This project was not intended to be a discrete, one off, but rather an on-going set of activities that would evolve over time and as circumstances changed. As such, the duration of activities was anticipated to be longer than the life of the initial funding grants, and the approaches and methods would need to continue to evolve.

The need for sustainability of the project's activities was identified from the outset. The project has integrated the existing activities into on-going TNC and partner work plans and activities, rather than sustain the project activities within a separate program.

The momentum developed through this project will be continued through a new TNC Pacific Island Countries Program fisheries strategy. Through this new strategy we aim to work with partners to ensure that, by 2015, fifty percent of the priority ecoregions' tropical nearshore fisheries in the western Pacific will be managed within an Ecosystem-Based Fisheries Management framework, significantly reducing the levels of destructive and over-fishing outside of MPAs. By FY10, the initial policy and legislative frameworks will be in place to enable management of tropical nearshore fisheries within an EBM framework for priority Pacific ecoregions. This new strategy is currently in the conceptual development stage and will take some months to initiate.

We have learnt through this project that the effective management of reef fish spawning aggregations must be encapsulated in the broader management of nearshore marine resources, and deal with the economic and social contexts of the communities involved. The new TNC fisheries strategy will endeavor to do this.

The following are specific recommendations from the activities undertaken through this project:

- The monitoring of the reef fish spawning aggregation sites that has been initiated must be maintained, and where possible new monitoring sites established. The long-term monitoring of these sites is needed to not only better understand the dynamics of these sites and inter-annual variability, but also to assess the impacts of the management actions that have been taken (and in at least one case, to assess the impacts of commercial fishing on the aggregation).

- There is still a shortage of trained and experienced monitors. We recommend that suitable candidates in partner communities and agencies should receive both SCUBA training and monitoring training. Wherever possible, we should use the existing experienced monitors to help train and mentor these new monitors. This will help build linkages between sites (and countries) and help maintain the interest of the existing monitors.

- Further carefully targeted exchanges between sites of community leaders, monitors and managers should be encouraged for the communities that are taking, or want to take, responsibility for protecting their reef fish spawning aggregations.

- We need to continue to identify and build the skills and experience of the on-site personnel, such as the Community Conservation Coordinators or equivalent positions in partner organizations, as they are the ones that provide the direct and on-going support to communities.

- We need to facilitate further research on the questions related to "connectivity" between sites and surrounding reefs. An understanding of connectivity—both adult movements and larval dispersal—are critical to the effectiveness of MPAs and MPA networks.

- Many of the existing management actions, including closing or restricting spawning aggregations sites, have been initiated through customary closures. We need to continue to develop and support the implementation of appropriate legal frameworks to support and reinforce these customary management actions. In addition to developing and refining these legal mechanisms, we also need to ensure that the communities and relevant agencies fully understand how best to use these mechanisms.

- There is a need to place greater emphasis on understanding the social and political landscapes (within which spawning aggregations are located) before resources are dedicated to assisting communities in monitoring or conserving their spawning aggregations. Effective customary management of spawning sites requires that the traditional ownership of the site is well defined; these customary ownership boundaries are recognized within the local region; that there is little or no poaching by neighboring groups; that there is the local capacity to enforce rules; and that most of the stakeholders are willing to endorse a management initiative. In other words, it is meaningless to implement community-based marine management measures, no matter how rich the biodiversity, if harvest restriction rules and exclusion of non-members cannot be complied with, or cannot be enforced.

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APPENDICES

APPENDIX 1: List of Key Project Documents

Document	Comments
Aitsi, J. and S. Seeto. 2003. A Preliminary Survey of Fish Spawning Aggregations in Stettin Bay, West New Britain Province, Papua New Guinea: 26-30 May 2003. Final Report. (RESTRICTED ACCESS VERSION). Report prepared by the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 5/03	Kimbe Bay, PNG Survey report
Aitsi, J., A. Sapul, R. Hamilton and S. Seeto. 2006. Reef Fish Spawning Aggregations Verification Surveys, Kimbe Bay, West New Britain Province, Papua New Guinea. 23-28 April 2006. Final Report. (RESTRICTED ACCESS VERSION). Report prepared by the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 4/06	Kimbe Bay, PNG Survey report
Colin, P.L. 2006. Study of reef fish spawning aggregations and connectivity on the Palauan reef tract: Final Report and Addendum. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 2/06	Palau spawning aggregation study. Compilation of contract reports.
Hamilton, R.J., P. Mous and A. Smith. 2005. Advanced Workshop on Monitoring Reef Fish Spawning Aggregations Report, Pere, Manus Province, Papua New Guinea, 2-11 June 2005. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 6/05	Manus, PNG. Workshop report.
Hamilton, R.J. 2005. Indigenous Ecological Knowledge (IEK) of the aggregating and nocturnal spawning behaviour of the longfin emperor *Lethrinus erythropterus*. *SPC Traditional Marine Resource Management and Knowledge Bulletin* 18: 9-17.	Roviana, Solomon Islands. Local knowledge paper.
Hamilton, R.J. and W. Kama. 2004. Spawning Aggregations of Coral Reef Fish in Roviana Lagoon, Western Province, Solomon Islands: Local Knowledge Field Survey Report. (RESTRICTED ACCESS VERSION). Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 5/04	Roviana, Solomon Islands. Local knowledge report (restricted)
Hamilton, R.J. and W. Kama. 2004. Spawning Aggregations of Coral Reef Fish in Roviana Lagoon, Western Province, Solomon Islands: Local Knowledge Field Survey Report. (UNRESTRICTED ACCESS VERSION). Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 5/04	Roviana, Solomon Islands. Local knowledge report (unrestricted)
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Hamilton, R.J., P. Lahui, J. Warku, J. Aitsi, A. Sapul and S. Seeto. 2005. Local Knowledge of Reef Fish Spawning Aggregations in Kimbe Bay, West New Britain Province, Papua New Guinea. (RESTRICTED ACCESS VERSION). Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 2/05	Kimbe Bay, PNG. Local knowledge report (restricted)

Document	Comments
Hamilton, R.J., P. Lahui, J. Warku, J. Aitsi, A. Sapul and S. Seeto. 2005. Local Knowledge of Reef Fish Spawning Aggregations in Kimbe Bay, West New Britain Province, Papua New Guinea. (UNRESTRICTED ACCESS VERSION). Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 2/05	Kimbe Bay, PNG. Local knowledge report (unrestricted)
Hamilton, R.J. and M. Matawai (*In Press*) Live reef food fish trade causes rapid declines in abundance of squaretail coralgrouper (*Plectropomus areolatus*) at a spawning aggregation site in Manus, Papua New Guinea. *SPC Live Reef Fish Information Bulletin.*	Manus, PNG. LRFFT impacts paper.
Hamilton, R.J., M. Matawai and T. Potuku. 2004. Spawning Aggregations of Coral Reef Fish in New Ireland and Manus Provinces, Papua New Guinea: Local Knowledge Field Survey Report. (RESTRICTED ACCESS VERSION). Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 4/04	New Ireland and Manus, PNG Local knowledge report (restricted)
Hamilton, R.J, M. Matawai and T. Potuku. 2004. Spawning Aggregations of Coral Reef Fish in New Ireland and Manus Provinces, Papua New Guinea: Local Knowledge Field Survey Report. (UNRESTRICTED ACCESS VERSION). Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 4/04	New Ireland and Manus, PNG Local knowledge report (unrestricted)
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Hamilton, R., and F. Taniveke. 2004. Indigenous Knowledge of Coral Reef Fish Spawning Aggregations in Choiseul Province, Solomon Islands. (RESTRICTED ACCESS VERSION). Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 8/04	Choiseul, Solomon Islands. Local knowledge report (restricted)
Kameata, R. and L. Feginduo. Destructive Fishing Practices: Assessment of Awareness Materials Effectiveness. A Baseline Study of Destructive Fishing Practices Throughout Upper Primary and Secondary Schools in the Selected Provinces of Papua New Guinea: Manus, West New Britain, New Ireland & National Capital District. Report prepared for Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 8/05	PNG Awareness materials baseline study. Report rejected, significant revisions made, due for re-release late-2006
Mous P.J. 2005 (DRAFT). Monitoring of three grouper spawning aggregations near Pere Village, Manus Province, Papua New Guinea. Proposed monitoring protocol. Publication from The Nature Conservancy Southeast Asia Center for Marine Protected Areas, Sanur, Bali, Indonesia.	Manus, PNG. Draft monitoring protocols.
Pet J.S., Mous P.J., Rhodes K. and Green A. 2006. Introduction to monitoring of spawning aggregations of three grouper species from the Indo-Pacific. A manual for field practitioners. Version 2.0 (January 2006). Publication from The Nature Conservancy Coral Triangle Center, Sanur, Bali, Indonesia. 98 p.	Indo-Pacific. Monitoring manual Ver. 2.0
Rhodes, Kevin L. 2003. Spawning Aggregation Monitoring Training Workshop Manual. Version 1 (April 2003). Pacific Island Countries Coastal Marine Program, The Nature Conservancy. 33 p	Original Pacific monitoring manual

Document	Comments
Rhodes, K.L. 2003. Kavieng Spawning Aggregation Monitoring Training Workshop Report, Kavieng, New Ireland, Papua New Guinea, 22-30 April 2003. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 3/03	Kavieng, PNG. Workshop report.
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Rhodes, K.L. 2004. FSM Spawning Aggregation Monitoring Training Workshop Report, Black Coral Island, Pohnpei, Federated States of Micronesia, 31 January – 6 February, 2004. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 1/04	Pohnpei, FSM. Workshop report
Rhodes, K.L. 2004. Solomon Islands Spawning Aggregation Monitoring Training Workshop Report, Gizo, Western Province, Solomon Islands, 13-21 March 2004. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 2/04	Gizo, Solomon Islands. Workshop report.
Rhodes, K.L. 2005. Summary Report on the Utility of Locating Tropical Reef Spawning Aggregations Using Combined Technical and Non-Technical Methodologies. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 4/05. (RESTRICTED CIRCULATION)	Pacific and Caribbean. Assessment report on spawning aggregation identification methods. (restricted)
Rhodes, K.L. 2005. A Guide for locating Coral Reef Fish Spawning Aggregation Sites. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 5/05. (RESTRICTED CIRCULATION)	Pacific and Caribbean. Summary of spawning aggregation locating methods. (restricted)
Rhodes, K.L., R.J. Hamilton and A.J. Smith. 2004. Field Guide for Monitoring Spawning Aggregations of Three Indo-Pacific Grouper Species (*Epinephelus polyphekadion* – camouflage grouper; *Epinephelus fuscoguttatus* – brown-marbled grouper; *Plectropomus areolatus* – squaretail coralgrouper). Draft Version 1.0. Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 6/04	Draft – only hold pending assessment of need.
Rhodes, K., A. Muljadi, P. Mous and J. Pet. 2003. Introduction to Monitoring and Management of Spawning Aggregations and Aggregation Sites for Three Indo-Pacific Grouper Species (*Epinephelus fuscoguttatus*, *Epinephelus polyphekadion*, *Plectropomus areolatus*): A Manual for Field Practioners. June 2003. The Nature Conservancy. 65 p.	Revised manual; precursor to current manual
Rhodes, K.L. and K. Warren-Rhodes. 2005. Management Options for Fish Spawning Aggregations of Tropical Reef Fishes: A Perspective. Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 7/05	Indo-Pacific and Caribbean. Review of management options.
Smith, A. 2003. Protecting and managing reef fish spawning aggregations in the Pacific. *SPC Live Reef Fish Information Bulletin* 11:54-55	Brief article
Smith, A. 2003. Live reef food fish trade – Pacific awareness materials project. *SPC Live Reef Fish Information Bulletin* 11:43-44	Brief article

Document	Comments
Smith, A.J. and R.J. Hamilton. 2006. Protecting and Managing Reef Fish Spawning Aggregations in the Pacific: Project Final Report. Report prepared by the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 3/06	Final project document.
Awareness Materials:	
• Storybook "A Fishy Business"	
• Teachers and Students Activity Manual for "A Fishy Business"	
• Puppet and Drama story	
• Match the Sketch Teaching Materials	
• Match the Sketch Teaching Manual	
• Booklet – What you need to know about Live Reef Food Fish Trade	
• SCRFA. 2006. Spawning Aggregations of Reef Fishes. Awareness brochure. Melanesian version in English.	SCRFA brochure modified for Melanesia (English)
• SCRFA. 2006. Bung Karim Bilung ol Rip Pis. Awareness brochure. Melanesian version in PNG Pidgin.	SCRFA brochure modified for Melanesia (PNG Pidgin)
• Video: "Bung Karim Bilong ol Bikmaus" (Spawning Aggregations in Papua New Guinea) – English narration. (20 mins).	Final draft
• Video: "Bung Karim Bilong ol Bikmaus" (Spawning Aggregations in Papua New Guinea) – PNG Pidgin narration. (20 mins).	Final draft
• Video: "Titans of the Sea" (18 Mins) by Jordan Plotsky/Firelight Films. 2006.	The rights belong to Jordan Plotsky (Firelight Films), TNC has permission to use the video for non-profit purposes.
Presentations:	
Colin, P.L., T.J. Donaldson and L.E. Martin. 2005. GPS Density Surveys: A New Method for Quantitatively Assessing Reef Fish Spawning Aggregations (and other populations of reef fishes). Paper presented at the 7th Indo Pacific Reef Fish Conference. 16-21 May 2005, Taipei, Taiwan.	
Hamilton, R.J., and A.J. Smith. 2005. Supporting community-based inshore fisheries management in Melanesia to achieve conservation goals. Paper presented at the 7th Indo Pacific Reef Fish Conference. 16-21 May 2005, Taipei, Taiwan.	
Hamilton, R., T. Potuku and M. Matawai. 2006. Conserving spawning aggregations of grouper (Serranidae) in Melanesia. Conservation Science in Practice Conference, 27-30 November 2006, Tuscon, Arizona, USA	
Yeeting, B. and A.J. Smith. 2005. Live Reef Fish Trades in the Pacific: Impacts, Issues and Needs. Presentation to the US Coral Reef Task Force Meeting, Koror, Palau, 5 November 2005	

APPENDIX 2: USAID Work Plan Activities

PROTECTING AND MANAGING REEF FISH SPAWNING AGGREGATIONS IN THE PACIFIC		
Activity Number	**Activity Title**	**Status**
Objective 1	**To develop and facilitate the application of cost-effective management controls on the exploitation of aggregating reef fish resources in the Pacific region**	
1.1	Develop and facilitate the application of cost-effective identification, monitoring and assessment programs for aggregating reef fish resources.	Completed
1.2	Develop and have adopted relevant policies and guidelines for application at the regional, national and sub-national levels.	Completed
1.3	Develop and implement specific management strategies, locally and nationally.	Completed
1.4	Develop appropriate design and management criteria for marine protected areas (including LMMAs) for protecting both spawning aggregations and aggregating reef fish.	Completed
Objective 2	**Strengthen the capacity of regional and government agencies, national and international NGOs, and others to identify, assess, monitor, and manage aggregating reef fish resources at all relevant jurisdictions.**	
2.1	Increase the skills of our partners in aggregating reef fish monitoring and assessment.	Completed
2.2	Develop regional and national "teams" composed of fisheries agency staff, locally-based NGOs, and universities to maximize the resources available to identify, assess, and monitor reef fish spawning aggregations	Completed
Objective 3	**To raise the awareness and appreciation among stakeholders of the limited productivity and vulnerability of aggregating reef fish populations and associated ecosystems, the nature and significance of spawning aggregations, and options for improving management.**	
3.1	Compile and develop appropriate awareness materials and hold community-level workshops and meetings on the importance, vulnerability and options for the sustainable management of their reef fish spawning aggregation sites.	Completed
3.2	Develop a set of "fisheries sustainability tools" for aggregating reef fish.	Completed

APPENDIX 3: Spawning Aggregation Awareness Presentations

Date	Location	Target Group	General topics discussed	Outcomes
August 2006	Lorengau, Manus	Manus Provincial Government	Importance of spawning aggregations Overview of LRFFT Impact of :LRFFT on Manus aggregations Recommendations for banning and/or minimizing impact of LRFFT in Manus	Manus Provincial Government has said it will review LRFFT operations in Manus
August 2006	Pere, Manus	Entire Pere community	Results of monitoring at Sites 29, 33 and 35; effect of LRFFT on Site 35 Showing of aggregation awareness film	Greater community awareness of the monitoring work and the importance of conserving spawning aggregations
August 2006	Manus Provincial Radio, Manus	Manus	Spawning aggregations, the LRFFT, results of monitoring, overview of Manus REA.	
July 2006	Kali, Manus	Kali Community	Importance of spawning aggregations Overview of LRFFT Impact of :LRFFT on Manus aggregations Showing of aggregation awareness film	Greater community awareness of what spawning aggregations are and the importance of conserving them.
July 2006	Buke, Manus	Buke community	Importance of spawning aggregations Overview of LRFFT Impact of LRFFT on Manus aggregations Showing of aggregation awareness film	Greater community awareness of what spawning aggregations are and the importance of conserving them.
June 2006	Roviana Lagoon, Western Solomon's	Dundee Community	Spawning aggregation biology History and impact of LRFFT in Roviana Lagoon History of monitoring at Site 1 and monitoring results Recommendations for conserving Site I	Site 1 declared a fully protected MPA by the Dundee community.
June 2006	Poroporo Choiseul	Poroporo community	Importance of spawning aggregations. Overview of LRFFT. Value of community based management. Offer of monitoring assistance for a LMMA they recently established	Greater awareness of importance of MPAs.
February 2006	Pere, Manus	Pere Council of Elders	Feedback on monitoring results and impact of recent LRFFT activities on Site 35 Briefing on purpose of the awareness film we were producing.	Community decided to ban all types of fishing at Site 29 Other MPAs introduced in the Pere region

Date	Location	Target Group	General topics discussed	Outcomes
February 2006	Tawi, Manus	Village leaders	Feedback on monitoring results and impact of recent LRFFT activities on Site 35 Briefing on purpose of the awareness film we were producing.	
February 2006	Brisbane, Australia	TNC PIC staff	Overview of monitoring and management work at various spawning aggregation sites in Melanesia	
November 2005	Koror, Palau	US Coral Reef Task Force	Dr Andrew Smith (TNC) & Being Yeeting (SPC): Live Reef Fish Trades in the Pacific: Impacts, Issues and Needs. (Invited presentation)	
November 2005	Koror, Palau	US Coral Reef Task Force	Dr. Patrick Colin (CRRF): Spawning aggregations of reef fishes: Myths, methods and MPAs. (Invited presentation)	
November 2005	Voza and Chivoko, Choiseul, Solomon Islands	Costal communities	Overview of MPAs, spawning aggregations, LRFFT and TNC's work.	Greater awareness of importance of MPAs that community have established around Voza and Chivoko.
October 2005	Marine Science Department, University of Queensland	University staff and students	Overview of monitoring and management work at various spawning aggregation sites in Melanesia	
July 2006	Marine Science Department, Otago University, Dunedin, New Zealand	University staff and students	Overview of monitoring and management work at various spawning aggregation sites in Melanesia	Established contact with Film producer Jordan Plotsky, who produced the spawning aggregation awareness video in 2006
June 2005	Manus Provincial Radio, Manus	Manus	Spawning aggregations, the LRFFT, thoughts on recent arrival of LRFFT into Manus.	
June 2005	Pere, Southern Manus	Pere community	Spawning aggregations biology. Overview of findings made during the Advanced workshop on monitoring fish spawning aggregations that was held in Pere.	Requests for assistance with marine resource management activities other than just spawning aggregations
May 2005	7th IPRF conference, Taiwan	Scientists	Community-based inshore fisheries management in Melanesia	
March 2005	9 communities in Kimbe Bay, WNBP, PNG.	Costal communities	Overview of what spawning aggregations, their vulnerability to overfishing are and the life history characteristics of some of the species that aggregate to spawn.	Starting point for initiating conservations about local spawning sites. Community at Tarobi turned two spawning sites into community based MPAs.

Date	Location	Target Group	General topics discussed	Outcomes
October 2004	Wagina, Choiseul	Lauru Land Conference of Tribal Community biannual meeting	Overview of what spawning aggregations are and the life history characteristics of some of the species that aggregate to spawn. Overview of the LRFFT and TNC's work in Melanesia.	Significantly raised profile of TNC's presence in Choiseul. Three community based MPAs established following the conference, many others proposed.
June 2004	11 communities in Choiseul Province, Solomon Islands	Costal communities	Overview of what spawning aggregations are and the life history characteristics of some of the species that aggregate to spawn.	Starting point for initiating conservations about local spawning sites.
March 2004	Dunde, Roviana Lagoon, Solomon Islands	Dunde community	Grouper spawning aggregations, threats to aggregations, status of aggregations in Roviana, role of monitoring.	Approval given to establish permanent transects at Site 1
January 2004	Pere, Locha and Peli Southern Manus	Pere, Locha and Peli communities	Grouper spawning aggregations, threats to aggregations, status of aggregations in southern manus, examples of spawning aggregation management measures put in place in other regions in the Indo-pacific.	All communities placed fishing restrictions on spawning aggregation sites 29, 33 and 35.
January 2004	Pere, Locha and Peli Southern Manus	Community elders	Grouper spawning aggregations, threats to aggregations, status of aggregations in southern manus, examples of spawning aggregation management measures put in place in other regions in the Indo-pacific.	Community elders supportive of closures on their aggregation sites 29, 33 and 35, community meetings planned.
January 2004	14 communities in the, New Ireland Province, PNG	Costal communities	Overview of what spawning aggregations are and the life history characteristics of some of the species that aggregate to spawn.	Starting point for initiating conservations about local spawning sites.
June 2003	Koror, Palau	Koror State Governor, Legislature and traditional Chiefs	PowerPoint and video presentation on the spawning aggregation monitoring workshop and suggestions for management changes	Draft bill has been presented to the Palau national Congress to extend the national grouper closed season by one month.
April 2003	Kavieng, New Ireland Province, PNG	Governor, New Ireland Province	Presentation on the spawning aggregation training workshop and suggestions on LRFFT and aggregation management	Governor's support to establish spawning aggregation project in the Province.