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STUDY REPORT

CRISP



Coral Reef InitiativeS for the Pacific
Initiatives Corail pour le Pacifique

COST-BENEFIT ANALYSIS OF COMMUNITY-BASED MARINE PROTECTED AREAS: 5 CASE STUDIES IN VANUATU



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CRISP



Coral Reef InitiativeS for the Pacific
Initiatives Corail pour le Pacifique



The CRISP Coordinating Unit (CCU) was integrated into the Secretariat of the Pacific Community in April 2008 to insure maximum coordination and synergy in work relating to coral reef management in the region.



The CRISP Programme is implemented as part of the policy developed by the Secretariat of the Pacific Regional Environment Programme to contribute to the conservation and sustainable development of coral reefs in the Pacific.

The Initiative for the Protection and Management of Coral Reefs in the Pacific (CRISP), sponsored by France and established by the French Development Agency (AFD), is part of an inter-ministerial project that began in 2002. CRISP aims to develop a vision for the future of these unique ecosystems and the communities that depend on them and to introduce strategies and projects to conserve their biodiversity, while developing the economic and environmental services that they provide both locally and globally. CRISP also, has a role in fostering greater integration in this area between developed countries (Australia, New Zealand, Japan, USA), French overseas territories and Pacific Island developing countries.

The initiative follows a specific approach designed to:

- associate networking activities and fieldwork projects;
- bring together research, management and development endeavours;
- combine the contributions of a range of scientific disciplines, including biology, ecology, economics, law and social sciences;
- address the various land and marine factors affecting coral reefs (including watershed rehabilitation and management);
- avoid setting up any new body but supply financial resources to already operational partners wishing to develop their activities in a spirit of regional cooperation. This is why the initiative was established on the basis of a call for proposals to all institutions and networks.

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This approach is articulated through a series of thematic objectives:

Objective 1: Improved knowledge of the biodiversity, status and functioning of coral ecosystems.

Objective 2: Protection and management of coral ecosystems on a significant scale.

Objective 3: Development of the economic potential represented by the use values and biodiversity of coral ecosystems.

Objective 4: Dissemination of information and knowledge; and capacitybuilding and leadership with local, national and international networks.

The CRISP Programme comprises three major components:

Component 1A: Integrated coastal management and watershed management

- 1A1: Marine biodiversity conservation planning
- 1A2: Marine Protected Areas
- 1A3: Institutional strengthening and networking
- 1A4: Integrated coastal reef zone and watershed management

Component 2: Development of coral ecosystems

- 2A: Knowledge, beneficial use and management of coral ecosystems
- 2B: Reef rehabilitation
- 2C: Development of active marine substances
- 2D: Development of regional data base (ReefBase Pacific)

Component 3: Programme coordination and development

- 3A: Capitalisation, value-adding and extension of CRISP programme activities
- 3B: Coordination, promotion and development of the CRISP programme
- 3C: Support to alternative livelihoods
- 3D: Vulnerability of ecosystems and species
- 3E: Economic task force

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Executive summary

The number of reported small Marine Managed Areas (MMAs) driven by local communities has strongly increased in the Pacific region in the last 10 years. They are now presented as one of the main fishery and coastal management tool adapted to the context of many Pacific countries where intervention of the official agency is minimum and where the participation of community is still important.

Almost all the MMAs include a Marine Protected Area (MPA) as one of their main management rules. The characteristics of these MPAs, estimated at more than 500 in 2007 (Govan, 2007), with a usual size in the order of magnitude of hundreds of hectares, differ in many aspects from the classical approach that gives preference to large areas managed by external agencies with a unique and important budget. To our knowledge, very few studies have evaluated their economic benefits and costs for the main stakeholders implicated.

The Agence française de Développement, the French development bank, has supported several community-based MMAs with MPAs in the last 5 years in the Pacific and now request a bottom line analysis of their impacts on economic growth and poverty reduction and on world biodiversity as a public good. The underlying principle is that if these MPAs produce locally and in the short-term visible benefits superior to their costs, people from the village will maintain their support for them in the future and some kind of sustainable development will have been reached.

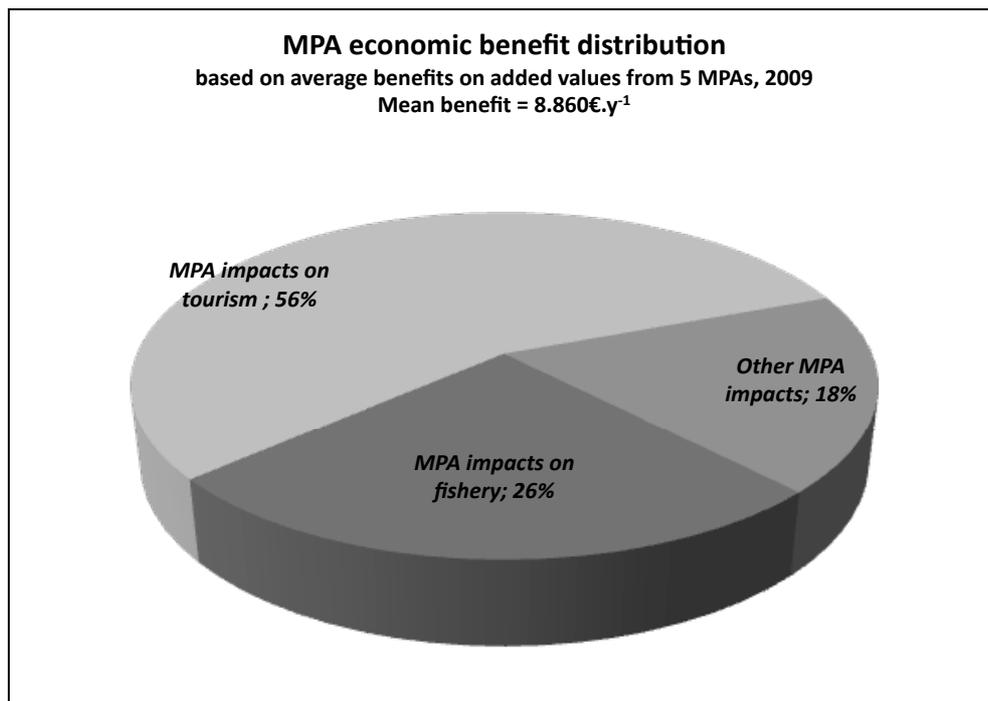
An appraisal of investment in community-based MPAs through a cost-benefit analysis (CBA) and Return on Investment (RoI) has been conducted in 5 selected villages in Vanuatu. Precise criteria on socio-ecological context and on the presence of MPA success key factors have been respected for the selection of the villages with MPA. Main impacts of MPAs on fishery, tourism, social capital, coastal protection service and option value have been assessed. As far as possible impacts have been compared to villages without MPA (control sites) selected on their similarity with MPA villages through a precise socio-ecological assessment. An extensive fishery campaign of CPUE data collection has been setup in MPA and control sites to determine as precisely as possible the benefits from potential MPA spillover on subsistence and commercial fishery. Impacts on tourism were estimated through surveys and Advertising Image Analysis (AIA) to define the role of MPA in the tourism added value. The coastal protection ecosystem service as well as the contribution of MPA to this service has been assessed through damage costs avoided. A transfer benefit protocol was applied to value the impacts on the option values that local people assign to some of the ecosystem services for future generations. Benefits and costs have been identified for the village, national and international stakeholders.

The investments in the 5 MPAs have ranged from 5 000 € to 19 000 € per MPA for the initial setup phase and requested 900 € to 4 000 € per MPA every year for operational costs. The investments in these MPAs

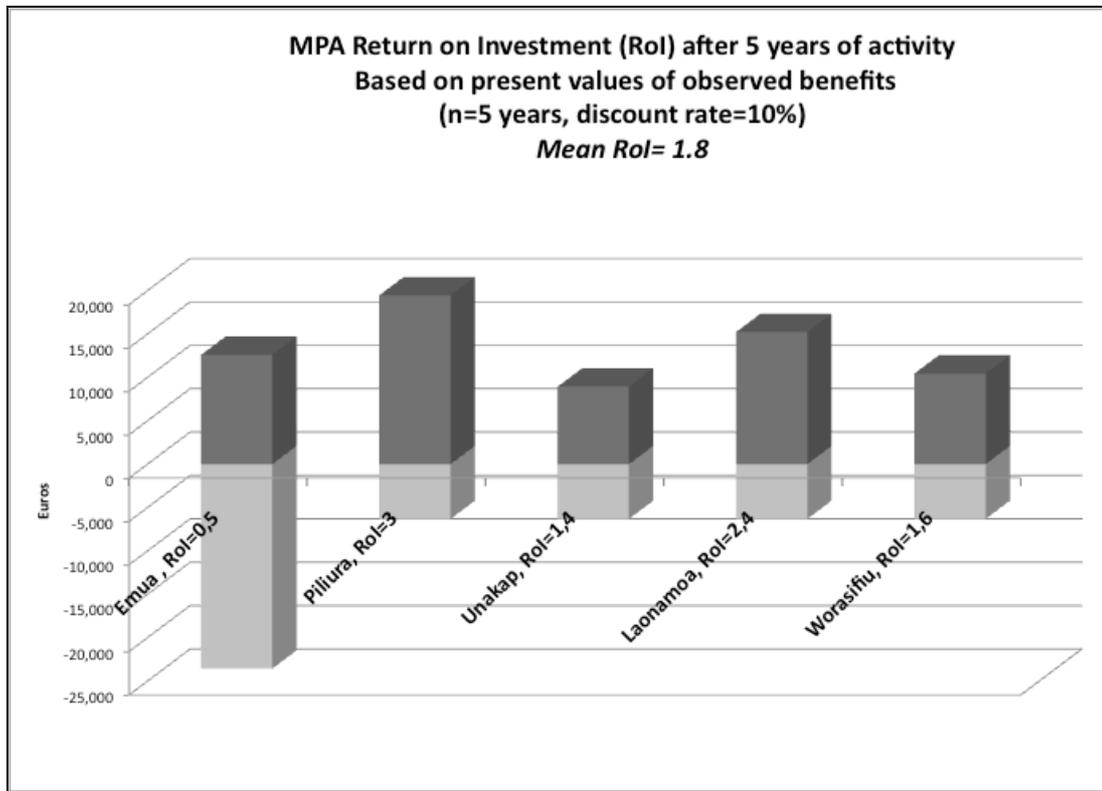
have presented some original aspects: (i) the amounts were relatively low per receptor (village or community) even if it has represented an average annual cost of 14 000 €.km⁻² of protected area, (ii) the investment was mainly centered on capacity building in the villages (70% of the operational costs) and (iii) the communities had the main and final responsibilities of the MPA management.

Regarding the impacts on economic growth and reduction of poverty, the following results have been found:

Result #1 MPAs managed by communities have made an average gross profit of around 8 900 €. y-1 (std=3 000). They concentrated mainly on rural tourism and fishery (56% and 26% of the total respectively), which represent both important sources of local cash incomes (30% of the total cash sources) and proteins for the villages. Less visible in the economic valuation, MPAs have had also positive impacts on the social capital, the ecosystem service of protection against waves and the option value attached to the ecosystem.



Result #2 Mean observed Return on Investment (RoI) is 1.8 after 5 years (std=0.9) with a potential of 5.4 (std=2.5) after 25 years. Not all the investments in MPAs have been recuperated after the first 5 years and for some of them the RoI stays close to 1 after 25 years of projections when main uncertainties on estimations are applied. Some precautions must therefore be taken in the MPA investment decision process (Result #3)



Result #3 If Return on Investment levels drives the investment decision in MPA, the development stage of the village fishery and tourism sectors must be taken into account. When other success key factors for MPA (e.g. ecological adequate context and effectiveness of enforcement) are met, the development stage of both sectors has a direct influence on the level of RoI and therefore on the optimal amount to be invested. Villages with low fishing effort and no tourism potential have given low RoI.

Result #4 Observed benefits on fishery sector from these small MPAs were revealed through an increase in productivity for the principal gears (estimated to vary from 4% to 33% increase in the catch per unit of effort). Both subsistence and commercial fishery were benefited. Other observed effects include: (i) catches more stable every fishing trip and, (ii) higher maximum fish size for villages with MPA. The MPA effects generally follow a gradient from the MPA border up to 500m before disappearing for the main species. For periodic MPA, the impact of opening temporarily the closed area seems to be low on the resource (less than 100kg.y-1) but important for the villages as catches are visible and shared within the community. Few effects have been observed on invertebrates. More generally, all these impacts on CPUES

can be hard to perceive by local people, as increases are subtle for informal and artisanal fisheries. Fishery impacts have represented an average of 25% of the total benefits of the 5 MPAs.

Result #5 Benefits on tourism are present for the niche of rural tourism (through guest house and day tours family own-businesses). The importance of MPA in the choice of the site from visitors was estimated to vary between 40% to 75%. In a similar way, it was observed that, in average, for 60% of the visitors, at least one member of the group has realized some snorkeling activities. Nonetheless, the exact role of specific biodiversity indicators impacted by MPA (such as emblematic species, live coral reef coverage, etc.) compared to other attributes (i.e. transport, infrastructures, facilities) were not possible to be assessed due to the lack of control sites. The tourism benefits have represented more than 55% of the total benefits of the 5 MPAs.

Result #6 Other impacts include benefits on social and human capital, the option value and the ecosystem service of protection against waves. The first benefits have been observed through the estimated impacts of the learning from trainings and workshops. The benefits on the option value have been valued in terms of willingness to work through transfer benefit. This corresponds to the amount that people are ready to give to maintain in the future the potential of some ecosystem services such as fishing or tourism. The last benefit is the contribution of MPA in maintaining the ecosystem service of protection against wave produced by coral reefs. These three values have been estimated to represent 20% of the total benefits of the 5 MPAs.

Result #7 In average 70% of the benefits flows have been directed to the villages. The other 30% went to the national stakeholders (mainly through tourism activities). Main beneficiaries inside the villages are fishermen and tourism business owners. It was not possible to determine any revenue distribution indicators (e.g. Gini coefficient) because of the complex mix between subsistence, customary and market economy. Nonetheless, fishery sector seems to have a wider distributional impact than tourism where benefits are concentrated in a few households.

Result #8 The opportunity costs at local level have been found to be very low and no local stakeholders have been identified as really worse off as regards to before the setup of the MPA. If we take in account that most, if not all, of the direct MPA costs are assumed by external agencies, the cost-benefit ratio is likely to be positive at a village level even when benefits are low (i.e. commercial fishery or tourism sector in a startup phase). The need of compensation for conservation seems therefore not necessary.

Result #9 Observed benefits have represented an average of 7% of the total village Gross Domestic Income (GDI). Impacts have been assessed at a village level to take into account some characteristics of customary, community and subsistence economic specificities.

Result #10 No observations have been found to demonstrate that MPAs have influence on the level of maximum sustainable yield for fishery or for the maximum carrying capacity for tourism. Therefore the hypothesis that MPA can ensure sustainable benefits (from fishery and tourism) at intergenerational scale remains uncertain.

Résumé

Le nombre d'Aires Marines Gérées (AMG) par les communautés a connu un essor important dans le Pacifique pendant les 10 dernières années. Elles sont maintenant présentées comme un des instruments de gestion des pêches côtières et de l'environnement adapté au contexte du Pacifique où l'intervention des pouvoirs centraux est faible et où le rôle des communautés est très présent.

La plupart des AMG incluent le fonctionnement d'une Aire Marine Protégée (AMP) comme une de leurs mesures de gestion. Les caractéristiques de ces AMPs, estimées à plus de 500 en 2007 (Govan, 2007), avec une taille de l'ordre de la centaine d'hectares, diffèrent sur beaucoup d'aspects des AMPs classiques qui privilégient des superficies bien plus importantes gérées par des agences externes avec un budget conséquent.

L'Agence française de Développement a supporté plusieurs projets d'AMPs gérées par les communautés dans le Pacifique pendant les 5 dernières années et a besoin de faire un bilan de leurs impacts sur le développement économique et la réduction de la pauvreté locale ainsi que sur la biodiversité au titre de bien public mondial. Le principe sous-jacent est que si les AMP produisent localement et rapidement des bénéfices supérieurs à leurs coûts, les communautés maintiendront dans le futur leur support à cet outil de gestion de la ressource et une forme de développement durable aura été atteint. A notre connaissance, très peu d'études ont évalué précisément les coûts et bénéfices des AMPs gérées par les communautés et les méthodes employées sont exploratoires.

Une évaluation des investissements dans les AMP a l'aide de l'analyse coût bénéfice (ACB) et le retour sur Investissement (Rsi) a été conduite dans une sélection de 5 villages au Vanuatu. Des critères précis sur le contexte socio écologique ainsi que sur la présence des facteurs clés de succès des AMP communautaires (Pollnac and Crawford., 2000) ont été respectés dans le choix des villages. Les principaux impacts sur la pêche, sur le tourisme, sur le capital social, sur le service de protection contre la houle et sur les valeurs d'option ont été évalués. Dans la mesure du possible, les impacts ont été comparés avec des villages sans AMP (sites contrôles) sélectionnés sur la base de similarités avec les villages AMPs à travers une évaluation socio écologique précise.

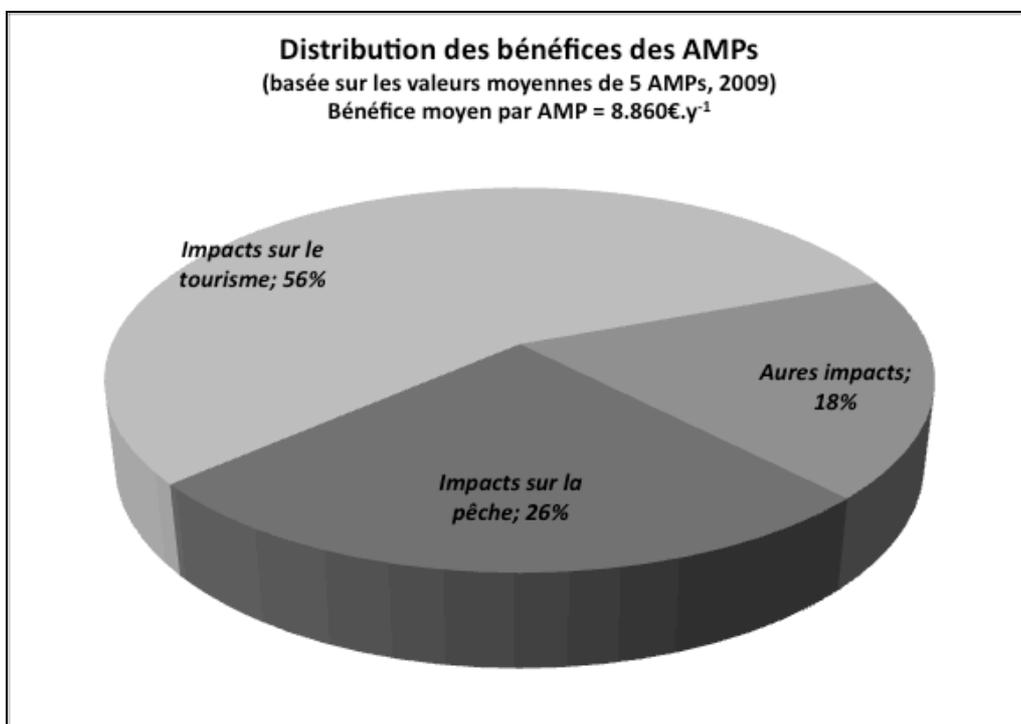
Une campagne de 6 mois de collecte de données sur la productivité de pêche (Catch Per Unit of Effort, CPUE) a été mise en place dans les sites avec et sans AMPs pour déterminer les bénéfices provenant du possible export de biomasse depuis l'AMP. Les impacts sur le tourisme sont estimés à travers d'enquêtes et de l'Analyse d'Image Publicitaire (AIP) afin d'évaluer le rôle des AMPs dans la valeur ajoutée touristique. La valorisation économique du service de protection contre la houle ainsi que l'impact des AMPs sur ce rôle provient d'évaluation de coûts des dommages évités. Les impacts sur les valeurs d'options attachées par les populations locales au maintien de certains attributs des écosystèmes sont estimés avec un protocole de transfert de bénéfice sur des consentements à travailler.

Les bénéfices et coûts ont été identifiés pour les principaux acteurs au niveau communautaire, national et international. Une estimation du poids des bénéfices générés par les AMPs dans l'économie de chacun des villages a été réalisée sur la base d'enquêtes sur les dépenses et revenus des ménages

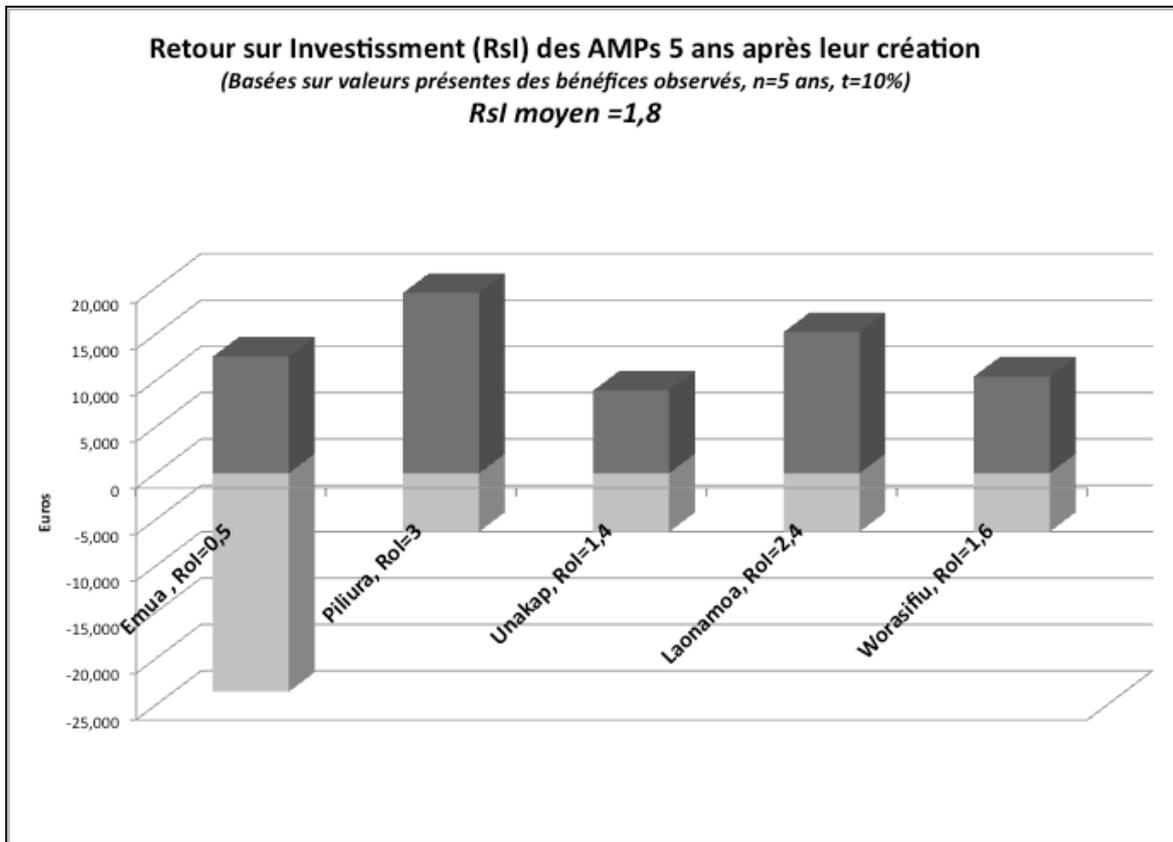
Les investissements dans les 5 AMPs ont varié entre 5 000 € et 19 000 € par AMP pour la phase de montage initiale et entre 900 € et 4 000 € chaque année pour les coûts opérationnels. Les investissements présentent des caractéristiques originales: (i) les montants sont relativement faibles par récepteur (village ou communauté) même si cela représente un cout annuel moyen de 14 000 €.km⁻² de zone en réserve (ii), il est essentiellement centré sur de la formation locale (70% des couts opérationnels) et (iii) les communautés sont les responsables de la gestion de leur AMP.

Les résultats obtenus d'évaluation des impacts des AMPs sur le développement économique sont:

Résultat n°1 Les AMPs gérées par les communautés ont apporté en moyenne des bénéfices bruts de l'ordre de 8.900 €.y⁻¹ ($\sigma = 3.100$). Ces bénéfices ont touché principalement les secteurs du tourisme rural et de la pêche (55% et 25% respectivement du total). Ces impacts se sont concentrés sur deux secteurs qui représentent des sources importantes de revenus pour les communautés (environ 30% des revenus générés localement) et de protéines pour les villages étudiés. De manière moins visible financièrement, les AMPs ont eu des effets positifs sur le capital social des villages, le service de protection contre la houle et sur les valeurs d'options des populations locales.



Résultat n°2 Le Retour sur Investissement moyen (Rsi) est de 1,8 après 5 ans ($\sigma = 0,9$) et de 5,4 après 25 ans ($\sigma = 2,5$). Tous les investissements n'ont pas été récupérés après 5 ans et pour certaines AMP le Rsi sur 25 ans reste proche de 1 quand les principales incertitudes sur les estimations sont appliquées. Des précautions doivent donc être prises en compte dans les décisions d'investissements en AMPs (Résultat n°3)



Résultat n°3 Si le retour sur investissement est un critère de décision dans les choix d'investissements, alors les niveaux de développement des secteurs de la pêche côtière et du tourisme rural doivent être pris en compte dans l'évaluation. Ainsi, même si des sites remplissent les conditions nécessaires au succès des AMPs (comme un contexte écologique adéquat et une surveillance efficace), le montant optimal à investir dans l'AMP dépendra des secteurs pêche et tourisme. L'étude a montré que des villages avec un effort de pêche réduit et un potentiel touristique faible ont présenté des Rsi trop faibles.

Résultat n°4 Les bénéfices des AMPs sur le secteur de la pêche sont provenus d'une amélioration de la productivité de pêche pour les principaux engins (comprise entre +4 et +33% une fois éliminée les effets du contexte). Cette meilleure productivité a affecté aussi bien la pêche de subsistance que la pêche artisanale commerciale. D'autres effets ont pu être observés: (i) des captures plus stables à chaque sortie de pêche et, (ii) des tailles maximum moyenne par espèces plus élevées pour les villages avec AMPs. Les effets des AMPs suivent généralement un gradient depuis la frontière de l'AMP jusqu'à 500 m avant de disparaître pour les principales espèces. Pour les AMPs périodiques, l'impact de l'ouverture ponctuelle de la zone en réserve semble très faible (moins de 100 kg.y⁻¹) et cependant importants pour les villages car cela leur permet de constater des captures remarquables et de les partager en communauté. Peu d'effets ont pu être observés sur les invertébrés (trochas sp.).

D'une manière générale, ces impacts sur la productivité peuvent être dur à percevoir par les populations locales car les augmentations sont faibles.

Résultat n°5 Des bénéfices sur le secteur du tourisme ont été observés pour la niche du tourisme rural (à travers des entreprises familiales de gîtes et de tours touristiques). En moyenne, l'existence de l'AMP semble avoir eu une influence variant entre 40 et 75% dans le choix du site par les touristes. De même, il été observé, qu'en moyenne pour 60% des visiteurs, au moins un membre du groupe a réalisé des activités de Palme-Masque-Tuba. Les volumes de fréquentations ainsi que l'importance relative d'attributs spécifiques de biodiversité influencés par l'AMP (comme par exemple des espèces emblématiques ou une couverture importante en corail vivant) comparés à d'autres facteurs comme les infrastructures, le transport ou le prix n'ont pu être estimés faute de sites contrôle.

Résultat n°6 Les autres impacts des AMPs ont concerné des bénéfices sur le capital social et humain, sur les valeurs d'option des populations locales et sur le service de protection contre la houle. Les premiers ont été observés à travers d'impacts sur le niveau de connaissance acquis lors de formation et d'ateliers, Les valeurs d'options, estimées à travers du transfert de bénéfice sont exprimées comme un consentement à travailler pour maintenir certains attributs de l'écosystème comme la pêche ou son potentiel pour le tourisme. Le dernier bénéfice est la contribution de l'AMP dans le maintien du service éco systémique des récifs coralliens de protection contre la houle. Ces 3 bénéfices ont représentés 20% du total des bénéfices des 5 AMPs.

Résultat n°7 En moyenne, 70% des flux de bénéfices ont été pour les communautés. Le reste est allé au niveau national (principalement des acteurs touristiques). Les principaux bénéficiaires dans les communautés sont les pêcheurs et les propriétaires de logements touristiques. Des indicateurs de distribution des revenus (comme les coefficients de Gini) n'ont pu être calculé du fait du mix entre économie de subsistance, économie traditionnelle et économie de marché. Cependant, le secteur de la

pêche semble avoir un effet ré distributif plus important que celui du tourisme où les bénéfices se concentrent sur peu de foyers.

Résultat n°8 Les couts d'opportunité observés au niveau local sont faibles et aucun acteur local n'a pu être identifié comme réellement affecté par l'établissement de l'AMP. Si a cela nous rajoutons que les coûts directs sont assumés par des agences externes, le ratio coût bénéfice pour les villages a de grande chance d'être positif même quand les bénéfices sont faibles. Le besoin de compensation pour la mise en réserve n'est donc pas nécessaire pour les AMPs étudiées.

Résultat n°9 Les bénéfices observés après 5 ans de mise en place effective de l'AMP ont représenté en moyenne 7% du revenu intérieur brut des villages.

Résultat n°10 Aucune observation n'a pu être obtenue pour démontrer que les AMPs aient une influence sur les niveaux de pêche durables (Maximum Sustainable Yield) ou sur la capacité maximum de charge touristique. L'hypothèse de bénéfices intergénérationnel générés par les AMPs reste donc incertaine.

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Introduction

Community-based MPA in Pacific context

Near shore fisheries remain critically important to virtually all islands of the Pacific countries in promoting easily accessible household food and a diversification of protein sources and livelihoods (2007; Gillett, 2009; Kronen, 2007; Spreng, 2007).

Today most Pacific territories are facing challenges such as (i) increased fish demand from human population growth (planned to increase by 50% by 2030 with projected food requirements well in excess of what coastal areas are currently likely to produce without significant improvements in management and productivity) (Bell et al., 2009) (ii) the rapid introduction of market economy with its associated rural migration, loss of traditional customs and urban poverty (Cinner and Aswani, 2007), (iii) a small island context with limited economic options (Beukering et al., 2007) and, (iv) potential climate change effects on their coral reef ecosystems services (Baker et al., 2008; Knowlton, 2000). These challenges are reinforced by the fact that national budgets are usually small and face considerable demands to meet human development priorities such as health, education and food production.

As a result, local populations and local governments would greatly benefit from improved understanding of the means to manage marine resources sustainably with inexpensive and strong performing tools. For some actors, CBM approach is now proposed as the main basis for securing the well-being of both reefs and communities of most of the Pacific Islands (Johannes, 2002; Johannes and Hickey, 2004; Tawake and Aalbersberg, 2002; UNEP, 2004)

South Pacific community-based marine protected areas

Community-based Marine Protected Areas (MPAs) have experienced an impressive development during the last decade (Aalbersberg et al., 2005). They usually form a part of a larger management scheme named Marine Managed Area (MMA) and more than 550 documented MMAs now exist in the South Pacific (Govan, 2009). An MMA is defined as an area of nearshore waters and coastal resources that is largely or wholly managed at a local level by the coastal communities, land-owning groups, partner organizations, and/or collaborative government representatives who reside or are based in the immediate area (Govan, 2009). Community-based management (CBM) starts from the basic premise that people have the innate capacity to understand and act on their own problems (Ruddle, 1994). Essentially, CBM builds on what the community thinks and allows each community to develop a management strategy that meets its particular needs and conditions. Its approach is people centered and driven by consensus. The core of CBM is community organization, where empowerment is a

primary concern. The management is carried out primarily by the community through the relevant user groups and also involves appropriately the locally and nationally institutional and private stakeholders.

Management rules such as fishing closure, temporary bans, size restriction, gear controls can be very diverse and some of them are still based on Traditional Ecological Knowledge (TEK) (Cinner and Aswani, 2007; Johannes, 1998, 2002). In recognition of these characteristics a regional term has been adopted since 2000, Locally Managed Marine Area or LMMA.

The detractors of protected areas critique their establishment and management for three reasons (Ruddle and Hickey, 2007; Wilkie et al., 2006). First, they argue that only initiatives related to poverty alleviation will lead to successful biodiversity conservation because only these initiatives address the root cause of environmental destruction (Leisher et al., 2007; UNEP, 2004). Second, protected areas take away the property and rights of local people and can be an unjust drag on their present and future welfare (Dixon, 1993). Third, even if protected areas do generate economic value, the distribution of these benefits is so skewed against poor rural people that the role of such areas in local development is negligible and they neither justly compensate for lost property and rights nor contribute to poverty alleviation (Garaway and Esteban, 2002; WFC, 2008).

Following the descriptions realized by several authors (Govan, 2009; Johannes and Hickey, 2004; UNEP, 2004), the MMAs (with MPAs) of the Pacific present therefore some specificity that apparently solves the three previous identified issues of protected areas. First, the theory of MPAs tells that they should produce benefits for fishery as well as other benefits from a potentially long list including tourism, access to information, enhancing property rights and so on (Angulo-Valdes and Hatcher, 2010; Gell and Roberts., 2003; Roberts and Hawkins, 2000). These benefits should be an incentive for permanency of the MPA inside the MMAs. Second, their management through village committees respecting customary rights and land tenure should improve the chances of acceptance by local communities. (Johannes, 1984). Third, due to the size and remoteness of these small MPAs the distribution of benefits on fishery and tourism are more likely to be directed to local community stakeholders (Tacconi and Bennett, 1997)

From theory to reality: what do we know really about MPAs benefits for people?

The previous benefits and distributional patterns expected from the community managed MPAs have been observed by very few studies in the Pacific context as highlighted by a recent bibliographic study on socio-economic and ecological impacts of marine protected areas in Pacific Island Countries (Cohen et al., 2008). So, what is the present status of knowledge about MPAs? In table 1 we describe the “state of the art” in MPA science based on several reviews and meta-analysis of MPA effects (Cote et al., 2001; Pascal, 2005; Sale F.P. et al., 2005). It can be affirmed that the theoretical

mechanisms that drive MPA performance are now well described (Gell and Roberts., 2003; Polunin, 2002; Roberts and Hawkins, 2000). (described in Figure 1).

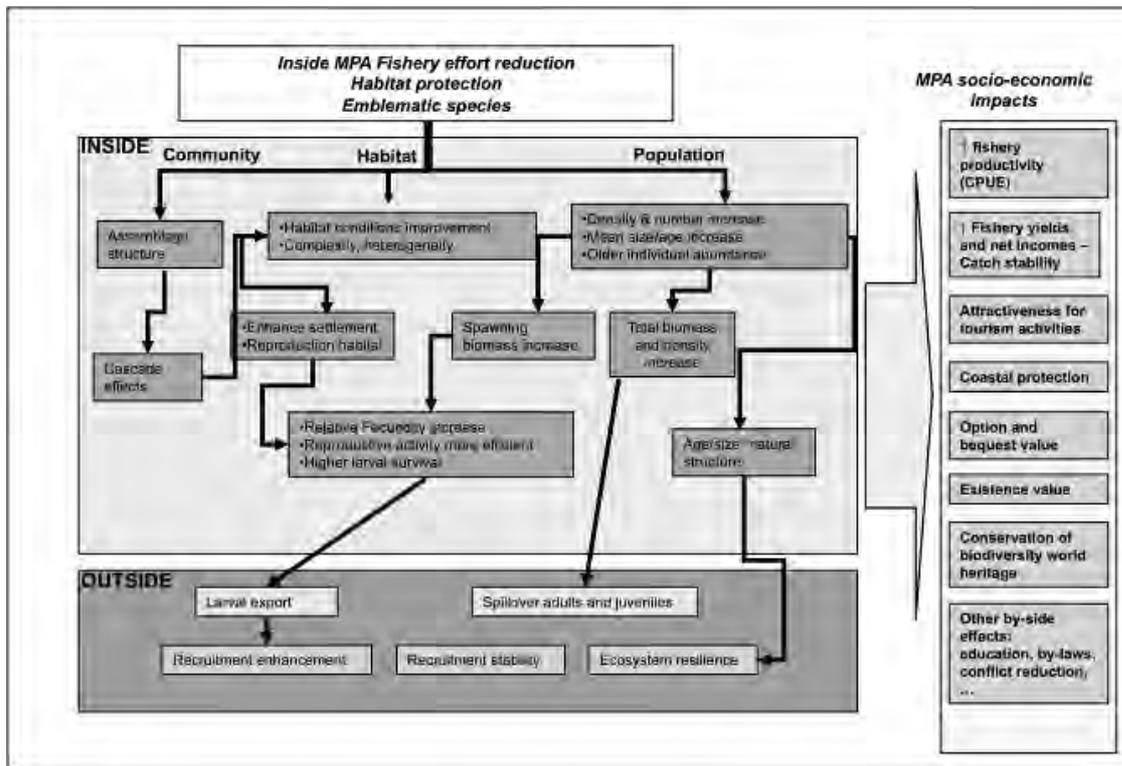


Figure 1 : Expected ecological processes of MPAs and main socio-economic impacts. Adapted from Pascal (2005)

Although, a good deal has been written about what MPAs could or should do, few empirical studies demonstrate what they actually do for people (Mumby and Steneck, 2008).

MPA ecological effects:		Status of science
Inside MPA effects:		
Biomass and density increase for fishery target fish and invertebrates		Widely demonstrated - high variability
Increase of average age/size		Widely demonstrated - high variability
Increase of reproductive capacity		Confirmed by few studies so far
Change in assemblage structure		Confirmed by few studies so far
Habitat conditions and functionality improvement		Expected but not demonstrated
Trophic cascade effects on algae and invertebrates		Confirmed by few studies so far
Biodiversity indices		Confirmed with mixed results (positive/negative/no impact)
Outside MPA effects:		
Spillover of biomass (gradient from the border)		Confirmed by few studies so far
Larval export		Expected but not demonstrated
Recruitment stability and enhancement		Expected but not demonstrated
Ecosystem resilience		Confirmed by few studies so far
MPA socio-economic effects:		Status of science
Use value	Change in fishery productivity (CPUE)	Confirmed by few studies so far
	Total fishery catches and net incomes	Confirmed by few studies so far
	Catch stability	Expected but not demonstrated
	Attractiveness increase for tourism	Confirmed by few studies so far
Non-use value	Maintenance of coral reef coastal protection services	Expected but not demonstrated
	Existence value	Expected but not demonstrated
By side effects	Education, by-laws, conflict reduction, ...	Expected but not demonstrated

Modified from Mumby et al. (2008)

Table 1 : Status of science knowledge about MPA effects . Adapted from Mumby and Steneck (2008)

The findings of these authors have shown that the very extensive scientific and technical literature produced on MPAs during the last 10 years has concentrated mainly on biological impacts inside the closed area. The effects inside MPA on fishery biomass, density and diversity are now well demonstrated in many sites. Even if uncertainties on MPA size and species remain, it can be considered that the management of a zone reducing the fishing effort will create a build-up of biomass and diversity of exploited species inside the closed area after a period of 5 years (Gell and Roberts., 2003). These effects have had remarkably consistent effects throughout the world (Halpern, 2003; Halpern and Warner, 2002). Nonetheless, outside effects on fishery yields through spillover of biomass or larval dispersion from MPA are expected but only confirmed by few studies so far (Castilla and Bustamente, 1989; McClanahan et al., 2009; Roberts et al., 2001; Russ and Alcala, 1996). In a similar way, MPA are usually presented as a powerful attractor for tourism but evidences remain scarce (Andersson, 2007; Asafu-Adjaye and Tapsuwan, 2008; Beukering et al., 2003; Depondt and Green, 2006; Harrison, 2007). The relationship between underwater tourism and the impacts of MPA on some ecological attributes is also not well known (Andersson, 2007). Scientific knowledge gaps, technical difficulties to separate MPA effects on fishery and tourism from other context variables, expensive costs of studies, late participation of social sciences in MPA science and effects too weak to be proven have been proposed as reasons for this lack of studies of MPA benefits on people ((Sale F.P. et al., 2005)Ferrarris, pers. Comm.). Some recent studies have intended to overcome some of the difficulties to identify individually sectorial benefits of MPA (e.g.. fishery, tourism, social capital) by measuring directly the impacts on household welfare. (Guzman, 2004; Hoagland et al., 1995; Leisher et al., 2007).

MPAs and the AFD in the Pacific

The AFD aim is to reduce poverty and inequalities, promote sustainable economic growth, and protect “Global Public Goods” of benefit to all humanity. The activities cover 8 sectors (environmental protection, forests and forestry, forest industries, fishing, agriculture, water and sanitation, tourism, urban development and management). Projects for protected areas are realized with the main objective to preserve local or national biodiversity and contribute to economic growth and poverty reduction.

In the Pacific region, the AFD has used several intervention instruments for the coral reef ecosystems protected areas (direct support via a project approach, programs, trust funds, capacity building or alternative livelihood promotion) to both large MPAs and small MMAs (with MPAs). Thirty-nine MPAs or MMAs with marine reserves in 10 pacific countries and territories have been supported since 2005 (Oréade-Brèche, 2008).

Project objectives

The financial investment in small MPAs from the AFD perspective must then be analyzed from a double bottom line perspective: (i) impacts on economic growth and poverty reduction and, (ii) impacts on world biodiversity.

Another important criteria of AFD investments is the continuity of the investment. As described before, the existence of local benefits and their distribution patterns are often identified as a success key factor for continuity and projects should be marketable not only to donors but also to stakeholders and government (UNEP, 2004).

To respond to the previous requirements of AFD investment appraisal and to increase the ownership of the project by local stakeholders, a cost benefit analysis per stakeholders has been conducted in selected case studies of community-based MPAs.

The research was designed to focus on observed and, as far as possible, proven impacts of the investment and results have come from an extensive one-year and in situ field studies.

Method

General approach

The study has proceeded through the following steps: (i) monitoring of the selected MPA impacts through a control-impact protocol, and (ii) a cost-benefit analysis (CBA) per MPA and per stakeholder (village, national and international). CBA has been realized on observed historic values (ex-post) and on projections. CBA results are then used to: (i) compare the benefits of MPA with the calculated annual village GDP to give an idea of their relative importance for villages and, (ii) realize a financial analysis of MPA cash flows to present the Internal Rate of Return (IRR) and the Return on Investment (RoI) for development banks.

Selection of MPA sites

Criteria

A dozen villages recommended by local stakeholders or identified by the project PROCFISH were visited in Efate, Vanuatu. The identified sites were visited and the communities contacted to explain and gain approval and support for the project's activities in their areas. The initial appraisals were carried out in each community over a 2-3 days period.

5 villages with MPA and 2 villages without MPA were selected in the North Efate zone (Figure 2 and Table 2). Each of the MPA sites respond to the three following criteria: (i) fringing coral reefs as dominant ecosystem, (ii) MPA managed and adequately enforced by communities for at least five years with the reserve covering at least 10% of the fishing ground area. These criteria correspond to the minimum prudential time and fraction of fishing ground for effects of MPAs to build-up and to be visible on fishery yields (Gell and Roberts., 2003) and, (iii) fulfill at least 3 of the 6 success key factors identified for community-based MPA (Pollnac and Crawford., 2000). The success key factors met by the selected sites are: (a) population size and the village area are relatively small, (b) a visible level of community participation in decision making and (c) continuing presence from the implementing agency. These factors tend to make community consensus building easier and make community compliance with rules of the MPA easier in smaller geographic areas. Periodic outsider visits to MPA sites help reinforce their value among the community and may help stimulate continued implementation activities. As explained further, the other three success key factors: perception of a crisis in fish abundance, successful alternative income projects and inputs from the municipal government were not present in the selected sites.

Socio-ecological and institutional context

Population are comprised between 40 and 220 residents with a mean household size of 5 persons (generally an extended family). Most of the villages have a young age structure with an important part of the population (40% approximate) aged less than 15 years and only 5% aged over 60 years. Results are similar to the last demographic census (Vanuatu National Statistics Office, 2009). Most of the houses in the villages are permanent houses with a galvanized iron or similar roof and cement floor. No village has access to electricity service. All the households received income on their own account through subsistence production (e.g. food, firewood, house building materials) and the majority was engaged in the sale of agricultural products, fish and handicrafts. The Household Incomes and Expenses Survey (Vanuatu National Statistics Office 2008) estimated the average income of rural households in Vanuatu to be around 500 € per household per month. This revenue is equivalent to international 1.300 usd when applying PPP and Geary–Khamis dollar conversion (Heston et al., 2009). Approximately 40% of this income comes from subsistence production. The surveys conducted in some of the villages based on the same protocol as the HIES confirmed similar results with some variations (please refer to the description made in “Control site validation”)

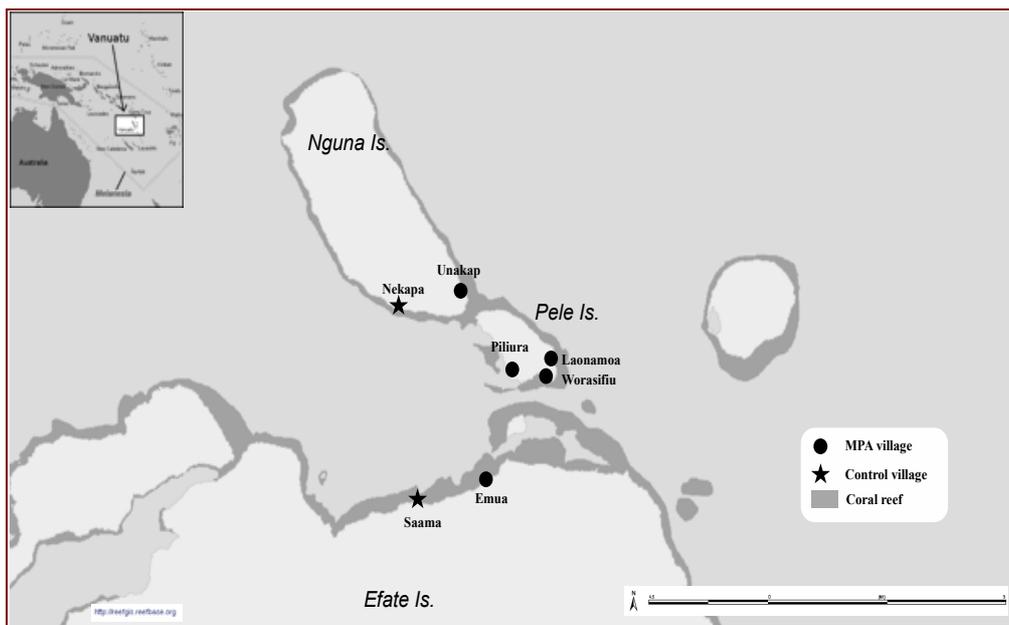


Figure 2: Village locations, MPA and control sites.

When analyzing selected descriptors (Table 2), some differences among the villages are notable in the fishing effort index and access to modern goods (the number of private electric generators per household is selected as indicator). Following Cinner and Aswani (2007), this variability may be explained mainly by proximity to the capital (Port-Vila), that facilitates the access to salaries and commercial markets. This applies to Emua and Saama based on the main land and with easier access to the city. This translates in a different mix between subsistence and market economy among villages, even if neighbors. Nonetheless within these variations, the subsistence economy represents an important source of income for a great number of the households.

Table 2: Socio-ecological context of the villages (descriptions in the text)

	MPA sites					Control sites	
	<i>Emua</i>	<i>Piliura</i>	<i>Unakap</i>	<i>Laonamao</i>	<i>Woraxifu</i>	<i>Nekapa</i>	<i>Saama</i>
Resident population	240	110	90	250	50	110	130
Number of private electricity generators per household	0,15	0,05	0,06	0,06	0,11	0,05	0,12
Tourism infrastructure (number of beds)	5	-	8	14	5	-	-
Reef geomorphologic dominant class	Intra-seas exposed fringing, forereef	Intra-seas exposed fringing, forereef	Ocean exposed fringing, forereef	Ocean exposed fringing, forereef	Intra-seas exposed fringing, reef flat	Intra-seas exposed fringing, forereef	Intra-seas exposed fringing, forereef
Fishing ground (km ²)	1,5	1,1	1,3	1,3	0,5	1,2	0,9
Demographic pressure on reef (hab/km ²)	157	102	71	188	104	92	144
Main fishing gears	Net Speargun Line	Net Speargun Line	Speargun - Line	Speargun - Line	Speargun - Line	Net Speargun Line	Net - Speargun - Line
MPA creation date	2 005	2 003	2 003	2 003	2 003	-	-
MPA size (km ²)	0,24	0,13	0,12	0,14	0,13	-	-

Fishing activities

Each village has the customary tenure of their fishing ground (from the shoreline to the end of the reef) (Johannes, 2002) and fishing ground size varies from 0.5 to 1.5 km² (Table 2). Subsistence and commercial fishing are present. Subsistence catches are for the consumption of the family (direct and extended), to share with friends or for the community through customary events and fund raising activities. Fishing activity seems to be well spread among the population. The last HIES conducted in 2006 (Vanuatu National Statistics Office 2008) estimated that in Vanuatu, more than 75% of the adult population is implicated in one form of fishing. Nonetheless, as described by several authors (Amos, 2007; Bartlett et al., 2009; Hickey, 2008) the commercial fishery is not developed as a formal activity and represents for most of the households a complementary and irregular income to agricultural activities.

The 2 main gears in terms of fish catches are the gillnets (7,2 units.km⁻² (25m nets)) and the spearguns (6,4.units.km⁻²). These gears usually target species related with the effects of protection from marine reserves (Russ and Alcalá, 1996) such as *Scaridae sp.*, *Acanthuridae sp.* and *Serranidae sp.*. Some other gears with a more irregular activity are: cast nets (depending on the migration timing of some species), hand line (from the shore or canoe), hand collecting (common at low tide coefficient for *Octopus sp.* and shells) as well as some other traditional gears (e.g. hand spear). Few fishing activities are conducted by women (hand collecting and handline from the shore principally). The gillnets are used principally in the form of drive-in nets. A fishing trip is composed by 4 to 8 fishermen and up to 100 m length of nets. The nets are fixed in some kind of corridors formed by fringing reefs at a depth between 3 to 10 m. Fishermen drive the fish into the nets by creating some sort of commotion. They can repeat several times this action without moving the nets or nets can be setup in a new location. Depending on water conditions and fish catches, a fishing trip can last from 1 to 5 hours. Nets are monofilament gillnets with 3-inch diagonal mesh. Spearfishing in the village fishing ground is realized from the shore or from a non-motorized boat. Depth is comprised between 2 to 15 m and coral reefs habitats are the main target. Fishing trips are usually made alone. Night spear

fishing is common with diving lamps when targeting *Scaridae sp.* and especially bumphead parrotfish (*Bolbometopon muricatum*). Invertebrates (mainly *Trochus sp.*) are collected during the opening of the Trochus ban with snorkel gears from the shore.

MPA and other fishery management rules description

Every MMA is associated to a unique village. The MPA included in the MMA size varies from 0.1 to 0.2 km², which is similar to most of the small MPAs in the Pacific (Govan, 2009) and represent an average 15% of the reef fishing ground. Even if difficult to track precisely the precise origin of the MPAs, each village councils proposed them with different degree of assistance from external agencies. They are all managed by the village through a MPA or environment committee formed by members of the village. Some of the MPAs are non-permanent closures where periodic harvest events can occur for village subsistence or celebration. Many activities around MPA have been observed during our presence in 2009 and 2010 (e.g. regular meetings, participation in workshops and trainings, collection of crown-of-thorn (*Acanthaster planci*), rubbish cleaning, organization of environment awareness campaign, monitoring, maintenance of buoys).

Management involving:	<i>Emua</i>	<i>Piliura</i>	<i>Unakap</i>	<i>Laonamoa</i>	<i>Worasifiu</i>	<i>Nekapa</i>	<i>Saama</i>
Periodic MPA	No	No	Yes	Yes	Yes		
Number of MPA opening in 2009		no	2	1	1		
Clam (<i>tridacna sp.</i>) ban	x	-	x	x	x		
Trocha (<i>Trochus sp.</i>) ban	Inside MPA and size limits	Inside MPA and size limits	All fishing ground closed	Inside MPA and size limits	All fishing ground closed	All fishing ground closed	All fishing ground closed
Turtles ban	x	x	x	x	x	x	x
Spearfishing at night prohibited						x	
Chanos sp. Ban during spawning	x						

Table 3: Description of the main fishery management rules (modern and traditional)

Four villages (*Piliura*, *Unakap*, *Laonamoa*, *Worasifiu*) belong to a MPA network. This implies that all the funding, assistance and workshop invitations are received through the network and redistributed among the active MPAs by the network committee. Nonetheless, each village of the network has also its own committee and managed with independence its marine zone. One village, *Emua* receives directly the assistance from a local NGO and does not form part of any network. The level and quality of enforcement, which are critical factors to evaluate effects of MPA (Pollnac and Crawford., 2000) have been assessed through interviews with village and fishery department representatives. As anecdotal evidence, during the 10 months that our program lived with the villages, we were able to confirm that members of the communities in all villages actively managed enforcement of the MPAs. Discussions with key person revealed that only one trespass had been reported in the last 2 years. The village council through the person of the paramount chief has applied a fine in local goods and money to the poachers. Visible buoys delimit the selected MPAs. Differences in governance will be reflected through the costs and social capital impacts.

Other fishery management rules are in place. They are described in Table 3. The classification is adapted from Johannes and Hickey (2004) who have realized a study of fishery management in more than 20 villages in Vanuatu. The trochus (*Trochus sp.*) bans are in place in most of the villages in North Efate since the last 90s. These bans are usually opened every 3 to 4 years for a controlled harvest (in minimum size and volume) by villagers. A fishery act limits the size of specimens harvested. The giant clam (*Tridacna sp.*) follows the same pattern. Many villages have developed the concept of clams and trochus “garden” gathering together collected specimens and enhancing the spawning success. All the villages have put a ban or tabu on their harvest of turtles and their eggs. The Vanuatu Fishery Department (VFD) regulates some catches with a previous authorization. The public awareness about the turtle regulation is surprisingly high (Johannes and Hickey, 2004) and the presence of voluntary “turtle monitors” trained from a local NGO is common in every village. In 2008, a five-year ban on the harvest and sale of beche-de-mer has been setup to let the stocks recover. In addition to those specific rules reported in Table 3, there is an additional ‘rule’ related to controlling the access permitted for non-locals. This rule originated at the local level among communities to control access to their natural resources has since been incorporated into national legislation. Article 74 of the Constitution states that ‘The rules of custom shall form the basis of ownership and use of land in the Republic of Vanuatu’. The implication of this Article for individuals or companies who do not have primary access rights (i.e. they are not members of a clan or community) is that the resource custodian must be consulted and his permission sought prior to access being granted. This implies the existence and official recognition of fishing rights for the villages. These rights apply from the shore up to the end of the reef.

Tourism activities

Small-scale rural tourism activities take place in every village. The tourism activities include (i) day tours, (ii) snorkel tours, (iii) scuba diving, (iii) guesthouses, (v) scientific tourism, and (vi) the other activities associated with the previous activities such as restoration and selling of handicrafts.

The day-tour activities correspond to visits coming from Vila to spend a whole day in the village. Tour operators from the capital organize them and a fee is paid to village for each visit. The snorkel tours are realized in the MPA and a fee is charged to visitors to get inside the MPA with a guide. All the scuba diving clubs (3) are based in or near the Port-Vila city. The mean capacity for each club varies from 12 to 40 dives per day. The most frequented scuba diving sites are close to the capital (time to access less than 1 hour by boat).

Guesthouses are small structures corresponding to the niche of adventure and nature travel. The standards are adventure lodge standards (bush toilets, no electricity,...). They usually have a capacity comprised between 2 to 6 beds. They are developed without external financing (except occasional aid) and can survive even with low occupancy rate as they do not borrow funds from banks and keep their

costs very low. Some of them have no established product: description, price list, brochure, etc... Owners have little training in business and management. Marketing initiatives realized by the government for the development of rural tourism are reduced. All the guesthouses studied belong to a local family or to the community. No foreign or domestic investment was identified. The land tenure system (custom land unregistered) creates an investment disincentive due to the insecurity of land tenure. Statistics about occupancy rates are scarce. Some statistics from 1998 (Vanuatu Tourism Office) indicate that average occupancy rate for rural tourism varies from 3% to 18%. This occupancy rate is very far from usual breakeven point of 40% for rural tourism in other countries (King Sturge, 2001) and reflects the low level of initial investment and operational costs. The majority are managed privately but some are owned and managed by the community.

Scientific tourism represents the visits from researchers, NGOs members or other professionals. It takes usually the form of payment for sporadic visits in food and accommodation. Some of the visits implicate long-term residence in a village.

The main attractions of Vanuatu rural tourism (VTO pers. Comm..) consist of : (i) nature (volcanoes, sites of natural beauty such as volcanoes, cascades, forests, beaches, coral reef and sites with specific attributes: turtle spawning places, fish biodiversity, emblematic species presence...) (ii) culture: the different lifestyles and languages constitute one important asset for tourism (iii) adventure: bushwalking, treks, discovery of custom sites, dancing grounds, volcanoes, scuba diving, etc. These attractions are the reason why travellers choose the rural tourism, since the accommodation and catering standard are generally well below the international standard. Efate is the most visited island in Vanuatu and has a mountainous centre, some good beaches and is surrounded by several small islands. Efate does not have the original custom and culture found in the outer islands but it has the advantage of its international airport and relatively good transport infrastructure. A study (Trip consultants, 2008) revealed that international and domestic (non-affinity tourism) visitors coming to the North Efate zone were around 8 000 in 2007. This number is expected to increase after the improvement of the main road and access to all the villages in the study zone. This huge public work through the Millennium Challenge Account was completed in mid 2010 and effects were therefore not visible in our research.

Ecological habitats

Data extracted from the Millennium Coral Reef Mapping Project show that the dominant reef geomorphologic type is the ocean and the intra-seas exposed fringing reef (classes 222 and 230 respectively) (Andréfouët et al., 2005)

Validation of control sites

The control-impact approach is proposed by several authors (Balmford et al., 2008; Underwood, 1994) as a way to solve the difficulty of separating and identifying MPA effects from site or context effects.

Two villages acting as control sites have been chosen to be compared with the selected MPA villages. Ideally they had to be similar with the MPA sites on ecological attributes, fishing effort, tourism and socio-economic context to make possible comparison among the sites and identify the MPA effects. Specific methods have been employed to validate the degree of similarity.

Ecological attributes

For ecological attributes, a first categorization of the marine habitats has been made following the geomorphologic classification proposed by the Millennium Coral Reef Mapping Project (Andréfouët et al., 2005). More precise attributes of habitats were collected with the Medium Scale Approach (Clua, 2006), which is designed for commercial fishery ecological assessment. It is based on a semi-quantitative description of 20 quadrats of 25 m² (500 m² in total) for assessing habitat–fish assemblage of certain stocks of commercial reef fish. Sixteen substrate components, totaling 100% coverage, were recorded if present. Each component was quickly estimated using a semi-quantitative scale (SQS): 0 (0%), 1 (1–10%), 2 (11–30%), 3 (31–50%), 4 (51–75%) and 5 (76–100%). Transects were surveyed by an experienced diver and 3 transects were made in each village (MPA border and 500 m) covering 1.500m² (~0,1% of fishing ground). Due to time constraints, the MSA transects were conducted only in Emua, Piliura (MPA sites) and in Saama and Nekapa (control sites). Exact locations is given in Figure 2.

As described in Table 4, the variances on the substrate components with high influence on commercial fish presence (dark grey color) are relatively small. The latter confirms the ecological similarity among the MPA and control sites in the aim to compare their fishing productivity.

Substrates	Emua	Nekapa	Piliura	Saama	Total	Average	SD	SD importance
Sand	1,0	0,5	2,3	1,0	1,5	1,2	0,6	++
Dead Coral debris	0,2	0,0	0,8	0,4	0,5	0,4	0,3	++++
Small Boulders	0,0	0,5	0,0	0,6	0,2	0,3	0,2	+++
Large Boulders	0,0	1,5	0,1	0,0	0,4	0,4	0,6	++
Eroded Coral	2,4	2,6	1,7	1,8	2,0	2,1	0,3	+
Old Coral	2,1	0,1	0,6	2,1	1,0	1,2	0,8	++
Live Coral	1,4	1,2	1,4	1,2	1,3	1,3	0,1	+
Habitability	2,3	2,0	1,4	2,1	1,8	1,9	0,3	+

Table 4 : MSA analysis for MPA sites (Emua, Piliura) and control sites (Nekapa, Saama).

Substrates components influencing fish presence are segmented in three colors : light grey (light influence), grey and dark grey (High influence) (Clua. Pers. Comm.)

Fishing effort attributes

A synthetic index has been developed to compare the fishery effort potential between MPA sites and the control sites. The index is a score based on several characteristics of fishing effort standardized per km² of fishing ground for each village.

Table 5: Fishing effort index based on selected criteria.

Fishing effort index		Emua	Piliara	Unakap	Laonamosa	Womasifu	Nekapa	Saama
number nets (25 m) / km ²	number.km ⁻²	15,0	7,4	2,4	1,5	2,1	7,5	14,4
number dugout canoe	number.km ⁻²	2,0	1,9	1,6	6,0	4,2	2,5	3,3
number spear guns	number.km ⁻²	7,8	4,6	1,6	7,5	14,6	0,8	7,8
number icekeys (25 kgs)	number.km ⁻²	3,3	4,6	0,8	6,0	4,2	2,5	4,4
number regular fishermen	number.km ⁻²	3,9	4,6	1,6	9,0	8,3	5,8	4,4
Score		3,10	3,00	1,35	3,75	3,65	3,05	3,25

The number of operative gillnets and spear guns, the number of cold storage devices (ice keys), the number of dugout canoe and the number of “regular” fishermen (regular defined as fishing at least 2 times every week) were analyzed. A score from 1 to 5 was given to each characteristics as well as a specific weight to reflect the importance of each factor in the fishing potential pressure. The number of regular fishermen was given a weight of 30% of the total, operative gill nets and speargun 25% and number of canoes and ice keys at 10% each (Vanuatu Fishery Department, pers. Comm.). Data has been collected through focus group with most of the fishermen in each of the villages, and discussions based on semi-opened questionnaires. Results (Table 5) were completed with direct observations.

Socio-economic attributes

As described in Table 2, the control sites present similarities in terms of demographics, areas and some indicators of consumer goods. A more detailed comparison has been made through household expense surveys. As the results of the HIES (Household Income and Expense Survey) undertaken by the statistics office of Vanuatu in 2006 were only available at a provincial level, a specific survey was conducted in two of the villages during 3 weeks. The survey was similar to the HIES but with a focus on expenses only to determine monetary and non-monetary needs of the households. The objective was to have some comparative base with the HIES 2006 consolidated results.

A sample of households (n=12) was selected in Nekapa and Unakap (25% aprox. of the total households). The survey is based on a logbook of daily expenses filled by the households during 3

weeks. The logbook was in the Bislama language. A visit every 2 days during the first week was made to each household to ensure a good comprehension of the logbook. The households were selected through random walking. A more detailed description of the method used is given in the HIES 2006 final report (Vanuatu National Statistics Office 2008). Extrapolations of results give us the value of monetary and non-monetary expenses of the village.

In the same way as for MPA sites, control sites have had to fulfill some common factors with the success key factors identified for community-based MPA (Pollnac and Crawford, 2000). The common factors met by the selected control sites are: (i) population size and village area relatively small, (ii) visible level of community participation in decision-making. As for MPA sites, the other success key factors: perception of a crisis in fish abundance, successful alternative income projects, inputs from the municipal government were not observed in the selected sites.

For tourism, MPA villages and non-MPA villages are contrasted. The control sites have none or little tourism activities related to marine ecosystems. Saama has developed a different market niche with the cultural tourism whereas Nekapa has only accidental tourism visits. Nonetheless all villages are in a geographical perimeter with similar tourism context characteristics. External variables such as transport, distance from airport and accessibility are similar. Other factors such as business skill levels and facilities (e.g. access to water and electricity) are also very similar (pers. observation.).

	<i>Unakap</i>	<i>Nekapa (Control)</i>
Monthly average household expenses (monetary and non monetary) (Euros)	388	438
Monthly average non monetary incomes (% total expenses)	40%	36%

Table 6 : Household Expenses surveys (description in the text)

Other considerations about control sites

The control sites have been chosen also with the minimum potential spillover effects from other neighboring MPAs. They are upstream from MPA sites diminishing potential for export of larvae or biomass from MPAs (main current is NW).

Control sites were chosen initially as sites only without MPAs but they resulted to be also sites without any management rules on finfish and with very few rules on invertebrates (Table 3). It is therefore reasonable to consider that these sites act not only as control site for MPA evaluation but also for MMA comparison.

A special attention has been given to understand the reasons why the control sites do not have MPA. Even if difficult to fully repertoriare all the factors, historic land dispute and chief or family clans?

conflicts were observed as the main reasons. This situation does not seem to have an influence in the validity of the sites to act as control sites for comparison purposes.

Selected MPA impacts

A selection of 5 economic impacts was made among more than 25 potential ones (Angulo-Valdes and Hatcher, 2010). The choice was based on local observations and preliminary meetings with stakeholders. The 5 selected potential effects of MPA are: (i) impacts on the subsistence proteins and commercial reef fishery added value (ii) impacts on the underwater tourism and other tourism sector added value (iii) impacts on the existence and option value of biodiversity, (iv) impacts on the service of protection against waves and, (v) impacts on the social capital. The underlying ecological processes implicated in the production of these impacts are identified in many works (Gell and Roberts., 2003; Halpern, 2003; Polunin, 2002; Roberts and Hawkins, 2000) and presented in Figure 1. Table 7 presents in detail the selection of the economic impacts that will be valued. A distinction is made between ecological and governance processes (Leisher et al., 2007; Mangos and Rojat, 2008). Some of the ecological processes take place inside the MPA zone such as effects on biodiversity indicators, on the live coral reef coverage or on the presence of emblematic species. Others are outside the MPA: the spill over of fish and invertebrates biomass, the export of larvae or the reproduction enhancement.

Expected ecological effects from MPA:		Spatial perimeter of effects	Expected associated economic impacts:	Spatial perimeter of economic impact
Outside MPA:	Biomass export (spillover), larval export, reproduction enhancement & recruitment stability	Spillover and larval dispersion zone	Fish protein and fishery added values	Fishery ground tenants and fisheries business residency
Inside MPA:	Ecological attractiveness for tourism	MPA	Added values of underwater and other tourism sector	Tourism operator residency
	Biodiversity and biomass build-up, ecosystem resilience	MPA	Option value and existence value	Village, nation and international level
	Live coral reef cover and physical absorption of wave energy	MPA coastline	Coastal protection value	Coastline tenants
Expected governance processes from MPA:			Expected associated economic impacts:	Spatial perimeter of economic impact
MPA governance and information processes			Differential on bridging social capital (fund raising capacity, trainings)	MPA stakeholders residency

Table 7: Selected economic impact. (Details in the text)

Spatial perimeter of analysis

The definition of the spatial perimeter of MPA impacts must take in account (i) the spillover and larval dispersal effects of MPA, (ii) the area where the uses take place such as the fishing grounds or the diving sites and, (iii) the residence of the stakeholders such as fishermen or tourism businesses.

The task of identifying the fishing grounds is made easy in Vanuatu due to the customary tenure of every fishing grounds which belongs to the communities (Hickey, 2008). Only fishers belonging to the

same community or authorized fishermen can have access to the fishing ground. This situation limits the spatial scope of uses and users. Nonetheless the spatial distribution of the MPA ecological processes such as spill over or larval export is more complex. The spatial distributions of the spillover effect have been estimated upon present knowledge about species home range and migration patterns. Many of the commercially valuable fish species harvested within the sites (*Scaridae sp.*, *Acanthuridae sp.*, etc.) have small home ranges (e.g., on the scale of hectares to kilometres) (Kramer and Chapman, 1997). Following the conclusions of different authors (Halpern, 2003; Jennings et al., 2001; McClanahan and Graham, 2005; Russ and Alcala, 1998) and given the small size of the studied MPAs (less than 50 ha), it was assumed that the potential spill over area would cover maximum 1 km on either side of the MPA when habitat was continuous. This spatial effect applies for the main local commercial reef fish species (*Scaridae sp.*, *Acanthuridae sp.* and *Siganidae sp.*). For invertebrates a spill over area of 500 m was assumed for trochus (*Trochus sp.*) (Tawake and Aalbersberg, 2002). Therefore, considering the size of the fishing grounds of the villages, it is found that most of the potential spillover effects from MPA benefit mainly the village with the MPA.

When considering larval export, more uncertainties and knowledge gaps exist. Many authors (García Charton et al., 2000; Hilborn et al., 2002; Planes et al., 2000) have shown the unpredictability and variability of recruitment patterns. They identify hydrology and current patterns, the inter- and intra-species differences in larvae behaviours, the habitat features and the distribution of adults as main influencing factors in larval export. Many, if not all, of these factors are unknown or impossible to collect in the study sites with the available resources. To fix a spatial range of larval export would be totally unfunded and the larval export effect from MPA has not been studied.

Regarding effects on pelagic and deep-sea fisheries it was chosen not to include them in the valuation. MPA has very little effect on the benthic species of the continental shelf and offshore pelagic species. The only demonstrated effects would be the trophic exchange through export of reef fish species larvae from MPA. These reef fish species larvae form part of the diet of some non-coastal fish species. However, studies analyzing stomach contents show that the contribution is relatively low (between 5-10% of the total diet) (Allain, 2009).

For tourism impacts, it was determined that additionally to activities taking place in the selected villages, all tourism activities and facilities within a 15 minutes walk perimeter from the MPA should be surveyed for potential MPA benefits.

Valuation methods

Quantification and valuation

The valuation of the impacts is based on a two-step bio-economic approach. The first step covers the quantification of the MPA benefits (e.g. volume of extracted biomass). The second step is the economic valuation per se to calculate the monetary value of the impacts. The valuation is focused on the financial value of the impacts.

Financial value

The financial value is formed by the added value (or producer surplus) and a multiplier effect of this added value and is recommended for its similarity with GDP calculations (Beukering et al., 2006). The added value can be defined as the value of benefits and salaries created by an economic agent (people, companies, organizations and public institutions) and are obtained by deduction of the intermediate goods (all goods and services purchased) from the gross output (quantity produced and sold). The multiplier is the sum of the indirect and induced impacts of the activity (Pagiola, 2004)

Data collection approaches for quantitative valuations

Data collection has implicated several techniques: interviews and questionnaires, focus group, experimental fishery, fishing logbooks and monitoring. As revealed by several authors (Caddy, 2000; Pickering et al., 2003), MPA impacts on fishery are usually small and their identification require precise data. Preference was given to collect data through field observations and experiments instead of surveys when the objective was to get quantitative data (e.g. fishery). Several studies have shown the limitations of interviews with villagers or fishermen in the Pacific context to quantify precisely fishing efforts, catches or visitors (Aswani and Hamilton, 2004; Hubert, 2009). In the villages, the fishing activities are informal, highly variable in effort and run without any accountancy by an important number of households. Respondents do not have the data in memory or enough motivation to answer in a reliable way (Johannes and Hickey, 2004; Kuster et al., 2006). Additionally, some cultural differences exist between the Western approach educated to quantify things as precisely as possible and the Melanesian approach where precise quantification is only secondary (Bensa and Freyss, 1994). As far as possible and as described later, methods not based on interviews were used to collect quantitative data about fishing effort, catches or number of tourist visitors.

Valuation methods adapted to subsistence and customary economy

The present analysis has taken in account that individuals living in the community may make different resource allocation decisions from those they may make when acting in their own interests. The basic statements of neo-classical economy based on Pareto efficiency do not apply integrally in this context

and must be adapted (Cinner et al., 2007; Flores, 2002; The World Bank, 2000). The life in community implies the existence of many links between people and a constant inter-connection with the other households. Many services and goods are given without direct and rapid compensation among families or with the community. For example, it is usual that a day of the week is dedicated to some work decided by the village council and that will benefit the community or a family without any kind of retribution (except from receiving in the future the same kind of assistance from the community or from using the community goods). In the same way, un-reattributed help and exchange of services are very common (Johannes, 2002). Another feature are customary obligations to kin and reciprocity of exchange in material possessions or cash, whereby the measure of a person is not by how much they own, but rather by how much they can give (Bensa and Freyss, 1994). These aspects are reflected in the choice of consolidating results at the village level instead of individual end-users level such as fishermen or tourism business-owners. For the same reasons, it was not possible to realize a Lorenz curve analysis on the distribution of benefits.

MPA impacts on fishery productivity (or spillover effect)

Experimental fishery and logbooks

The Catch Per Unit of Effort (CPUE) (e.g. kg of fish captured per hour of a standard fishing effort) has been chosen as indicator of fish productivity. CPUEs have been collected and differentiated by gears in order to cope with the complexity of multi-métier and multi-species fishery. CPUEs for gillnets and spear fishing are collected in MPA and control sites. Experimental fishing is used for gillnet métiers and fishing logbooks for spear fishing.

Experimental fishing is useful in MPA's evaluation to test expected gradients of abundance in time and space e.g. (Rakitin and Kramer., 1996) ideally using a BACI (Before-after, Control-impact) design (Underwood, 1994). The experimental fishing consists of a program of standardized fishing effort repeated in selected locations at selected moments. The fishing experiment consist of a 1 hour fishing time with a group of 4 experimented fishermen maximum, 2 monofilament nets of 25 m each with a diagonal mesh of $\frac{3}{4}$ inch and 1,8 m height. This gear corresponds to the most common and accessible fishing gillnet in North Efate. The 1 hour-time duration starts when the nets are first setup in the water. Nets can change place 2 or 3 times during this experiment. As recommended by several studies (Sánchez Lizaso and Goñi, 2000), a preference has been given to make more replica in time than in different places due to the high variability of catches over time. 2 locations in each site were chosen. In MPA village, the first one is close to the MPA border and the other is ~500m away from it (**Erreur ! Source du renvoi introuvable.**). Site selection came from discussion with fishermen. 56 experiments (45 hours) were realized from June to November during the dry season corresponding to 14 replicas per site. A total of 276 kg of fish have been scaled and weighted. As far as possible experiments were intended to be made in MPA and control sites on the same day or in the same tide cycle. Different moon and tide cycles have been tested after discussions with fishermen. The presence of the same experimented fishermen has been pursued to reduce the human skill effect. Data are collected at a species level for selected families. Weight per species is measured with a spring balance and specimens (Fork Length) are counted by length class (2 cm).

For spear gun, the situation is different. The know-how and personal skills of the fisherman are very important in the output of the fishery. As it was not possible to have the same level of fishing effort in MPA and control site, the results of the repeated experiments would not have been comparable. The logbook method is then employed to monitor the fishing catches and efforts (Hubert, 2009). It consists of logbooks filled by fishermen containing the details of their fishing trip. Data about duration, place and catches are collected. The place corresponds to a simplified zoning of the fishing ground to identify distance from MPA. The time (in hours) starts from the first dive. Transport time was not taken in account. The catches are described through local names, number of fish per group size (FL 2 cm class) and total weight per species. When species detail was not possible catches were grouped by

family level. Implicated fishermen are the most active fishermen of the village with recognized experience in spearfishing. From 2 to 4 fishermen in each village have participated in this program. Individual meetings were held with every fisherman to explain the logbooks followed by a weekly visit to motivate participants and collect the data. As far as possible, data reliability was checked with personal observations. Logbooks have been filled irregularly during 4 months (July to October). Data from 96 hours of spearfishing were collected, 80 hours were considered as valid for an average of 20 hours per village.

The data collected from the logbooks and fishing experiments have made possible the calculations of mean CPUEs in $\text{kg}\cdot\text{h}^{-1}$ of gillnet and $\text{kg}\cdot\text{h}^{-1}$ of spear-gun for every place. CPUEs have been calculated at a species or family level when recognition was not possible.

Selected fish families, functional and mobility categories

The selected families for the study are Acanthuridae, Haemulidae, Labridae, Lethrinidae, Serranidae, Siganidae and Scaridae, considered as the main commercial families (Amos, 2007). To facilitate the analysis, 2 groups were realized. The first one is the trophic group with four categories (herbivorous, omnivorous, planktivorous, and carnivorous). The other group is the mobility one with four mobility categories based on mobility patterns and home-range sizes: M1, migratory species or highly mobile species with schooling behavior; M2, demersal species with wide horizontal displacements (e.g. *Scaridae sp.* and *Acanthuridae sp.*); M3, demersal, relatively sedentary species that live in close association with the habitat substratum, such as *Serranidae sp.* ; and M4, site-attached species with very small home ranges showing a territorial behavior. This mobility classification is an adaptation of the categories originally distinguished by several authors (Cote et al., 2001; Eristhee and Oxenford, 2001; Guenette and Pitcher, 1999; Harmelin, 1987; Rowley, 1994; Russ and Alcala, 1996; Smith and Wilen, 2003).

Context data

One of the main difficulty of MPA evaluation is to identify what effects are due to the existence of the MPA or due to the socio-ecological context. In other terms, many factors from the environment can explain difference in CPUEs when comparing MPA to control sites. Different habitat characteristics, distinctive fish populations and unequal fishing effort are some of the factors to take in account when comparing fishing productivity (Labrosse et al., 2000). As described previously in the “control site validation” part, data have been collected about ecological habitat characteristics through MSA transects and a fishing effort index have been developed.

Additionally, fish populations were surveyed with underwater visual census (UVC). The stationary point method was chosen (Labrosse et al., 2002) where the observer counts fish from a determined

point while slowly turning in a circle. The variable distance counting method was used to maximize sampling coverage. Maximum area surveyed was depending on water visibility. Length (FL) data at a species level were collected for the selected families. Census surveys (n=48) were made during 6 months (June to November). UVC occur before fishing experiments to avoid human interferences. UVC locations were closed to the fishery experiments. An additional survey inside MPA was realized in the MPA villages. To eliminate the observer bias, the same observer realized the UVC campaign. Species richness (i.e. the number of species) and abundance (number of fish) are estimated. The density (the number of fish per m²) is calculated with the following formula:

$$D = \sum n_i / \Pi r^2$$

where n_i: number of fish seen

r: radius for observation.

Data analysis

Test of homogeneity of variance (P = 0.05) by Cochran's test (Underwood 1981) have been applied on (i) CPUES for every group (trophic and mobility) per mobility group, (ii) the variability of cpues, (iii) the mean size and the maximum size of fish catches.

Anova Spearman rank correlation tests and patterns of functional redundancy are then used to determine explaining factors (i.e. Distance from MPA, Substrate, Fishing pressure index, tide cycle).

Multiple regression analysis completed the analysis to isolate and identify the effects on CPUES due to the MPA. A more complete description is given in Pascal et al. (In press).

Economic valuation of impacts on subsistence fishery

Definition

The subsistence fishery corresponds to the non-commercial fishery where all catches are auto consumed, given or exchanged but no monetary transaction takes place. This definition applies also to the recreational fishery but it was non-existent in the studied sites. The fishery ceremonies for specific events or celebrations form part of the subsistence fishery. Even if monetary transaction may occur, fish sold in the village during fund raising activities have been included in this category due to their low price of fish (less than 10% of the normal commercial price).

Formula

The financial values of the impacts of MPAs on subsistence fishery are calculated through (i) quantification of the effects of MPAs in terms of catches (kg.y^{-1}) and, (ii) its economic valuation. The quantification is based on determining the CPUEs, the fishing effort and the effect of MPA on CPUES.

The effects on the catches due to MPA (A_{ie}) per fishing métier (i = gillnet or spearfishing) and per fish and invertebrate family (e) are deduced from the following formula:

$$A_{ie} = (\sum_{ie} f_i * cpue_i * m_i)$$

With:

f_i : Fishing effort per fishing métier in hours of activity

$cpue_i$: catch per unit of effort per fishing métier (i)

m_i : CPUE differential (%) attributable to MPA per fishing métier (i)

The valuation of the MPA impacts on added value (VA_{fmpa}) is based on :

$$VA_{fmpa} = ((A_{ie} * s * Pr_e * p) - \sum_i CI_i) * b$$

With:

s : proportion of catches for subsistence fishery.

Pr_e : Protein equivalent content per family

p = Price of basic replacement protein (euro/g)

CI_i : Intermediary costs per fishing métiers (i)

b : Weight factor to correct resource dependency

Data collection methods

Several methods are applied in the collection of fishery effort data (i) logbooks auto-filled by fishermen to determine fishing effort (ii) regular interviews with fishermen (selected individuals or

with group every week) to complete the previous data and, (iii) regular monitoring of fish commercialization (with transporters).

The methods applied to determine effects of MPAs on CPUEs have been described before.

Fishing effort

Fishing effort (f_i) per métier was estimated through weekly semi-structured questionnaires with a sample of the most active fishermen during 6 months (June to November) and completed by direct observations. The sample comes from the most active fishermen and was updated regularly to reflect the variability of the subsistence fishing (Hickey, 2008). The surveys used only short memory to improve the reliability of answers and had a very reduced number of questions. The number, the approximate duration of their fishing trips during the last 6 days (no fishing on Sunday) for gillnet and spear fishing and the destination of their catches (sold or consumed) were asked. Data from the logbooks (described before) have completed the estimates for spear fishing. Effort for gillnet was estimated as the number of hours (h) during which nets are setup (50 m long nets). The number of hours (h) of permanency in the water per spear gun was used as a measure of the effort.

An additional regular monitoring of commercialized fish landings has been set up during 2 months with transport professionals carrying fish to be sold or given in the capital to check the validity of the observed data.

Annual catches estimates

The estimates of annual catches are the product of the fishing effort per métier (e.g. number of hours p.a. of net fishing) by the average CPUEs (e.g. average fish catch in kg.h⁻¹ with net). Catches for reef fish are estimated for every village during the study-sampling period. Variability of CPUEs estimated through their variance has been taken into account in presenting minimum and maximum values of annual catches.

Additionally the fishing catches during the temporary opening of the MPA for some special event have been taken in account in the valuation when it was possible to be present.

Protein conversion

The monetary valuation for subsistence fishing catches was realized in two steps. First the protein equivalent of catches for the most representative species of fish was estimated. The database developed by Ramseyer (Ramseyer, 2000) was used to convert the catch of fish in protein weight. The weight of the catch of the principal families is converted into protein weight (Pr_e), which is then transformed into the equivalent weight of a basic food. Canned tuna (in oil) was chosen as a very common and affordable product. The Vanuatu Statistics Office uses its market price as a reference in regular macroeconomic indicators. The price was relatively stable during the observed period and converted in Euros/g of protein (p).

Added value

The intermediary costs (CI_i) associated with the 2 main fishing métiers are estimated through interviews with fishermen. The methods described by several authors (Gillett and Lightfoot, 2001; Kronen, 2003; Kronen, 2007) have been used to take into account all cost categories for the coastal fishery métiers (motorized or not).

Correcting factor for subsistence fishery

One of the problems of the economic approach is that it considers substitutable all the benefits withdrawn from subsistence fishing activities. In this case it was chosen to measure the benefit in protein weight leaving aside many aspects of the subsistence fishing. For example the following benefits are not reflected in the valuation: (i) the fishing activity needs low requirement of investment and training (Sprep, 2007), (ii) it can be a factor of social cohesion in villages because it contributes to maintain the women in the villages instead of seeking a cash income outside (Bensa and Freyss, 1994), (iii) for some household the part of the protein obtained from fishing in the total diet is non-replaceable (Pollnac et al., 2000), (iv) fishing is a stable food source against future uncertainties and a way to spread alimentary risks (Johannes, 2002). To reflect these benefits of the subsistence fishery, a weight-correcting factor (b) of 1.3 is applied on the results of added value (Seidl and Pascal, 2011)

Economic valuation of impacts on commercial fishery

Definition

Commercial catches include all captures of fish and invertebrates sold for food or for shells. Food can be sold as fresh or prepared.

Formula

The same method than subsistence fishery was applied to calculate the financial value of the impacts of MPAs on commercial fishery. First a quantification of the MPA effects on annual catches was estimated and then economic valuation was applied on this result.

For the valuation, the formula is:

$$VA_{fc\ mpa} = ((A_{ie} * (1-s) * pm) - \sum_i CI_i)$$

With:

Pm : average market price for commercial catches

CI_i : Intermediary goods per fishing métiers and other related businesses (i)

A_{ie} : Fishery catch volume differential due to MPA (same as for subsistence fishery)

s : proportion of catches for subsistence fishery .

Fishing effort

The data collection methods are the same ones as for subsistence fishery. No difference exists between both fisheries in the target species or in the métiers except for trochus fishery (*Trochus sp.*), which are collected to be sold for their shells in the capital.

As described before, all the studied villages have setup a temporary ban on trochus. The ban can cover all the fishing ground or be limited to the MPA area. Most of these bans were created as a response to the severe depletion of trochus stocks in the late 90's (Johannes, 2002). In theory, it was planned to open the bans every 3-4 years and a limited quota of trochus catch would have been given to each household. As both MPA and control village have a ban on trochus it was not possible to compare them and determine the effect of the ban. Following expert opinions, we make the following assumptions that catches of Trochus have been possible only if the ban was present. This comes from the historical experience of stock overfishing when no ban (as well as size control) is present. No opening of ban or trochus collection occurred during our presence. Therefore catches of trochus have been assessed through interviews with fishermen relying on their memory. Consultations with the fishery department experts have been held to complete and validate the data. Data was transformed on an annual base. The contributing factor of trochus ban on trochus catches is assumed to be 100% (m_{ie}).

Price

Finfish are sold as fresh fish or used in food preparation as the main prepared dish or as a complement. Commercialized fresh or prepared fish are valued on their market price. This allows covering all the added value generated by reef fishery sector. The price of reef finfish is species independent and does not seem to fluctuate according to criteria of supply or demand. The price for Trochus has been collected with intermediaries.

When used as a complement in prepared food, the commercial value is based on the final consumer price converted with the estimated weight of fish in the preparation.

Added value

The commercial circuit for fresh fish is short. The fishermen have 2 options: sell directly to consumers (in the village or in the city) or to an intermediary who will sell in the city. Sales in the city can be made informally in some neighborhood or through the market place. No direct sales of reef fish have been observed with consumers such as restaurants or fish retailers.

In the studied villages, all the intermediaries belong to the same village as fishermen. The distribution of the fishery benefits per actor is then limited to the village level.

Intermediary costs per fishing métiers are the same ones as for the subsistence fishing. The costs related to commercialization such as ice, transport, market place and labor costs were collected.

Details of method common to both fisheries

Annual extrapolations

The data collection took place mainly during the cold and dry period of the year in Vanuatu, from June to November. The extrapolation of observed results to an annual base has needed some corrections. The hot and wet season lasts from November to April and is characterized by higher temperatures. The period has an impact on the fishing effort as fishermen can stay longer in the water or more fishing trips can be made. As described by Amos (2007), fishing activity is often correlated to the agriculture calendar and the wet season corresponds to a weaker crop activity. These 2 potential sources of bias are taken into account in the extrapolations through the application of a factor of 1.3 on the catches from spear gun and 1.2 for gillnets. Factors were deduced from a previous study (Mees and Anderson, 1999) which surveyed a full year of fishing effort for the same gears.

Maximum sustainable yield corrector

The obtained catches were aggregated and reported to the fishing grounds area (in $\text{t.y}^{-1}.\text{km}^{-2}$) and compared to a reference of Maximum Sustainable Yield (MSY) value for reef fisheries. The value of $5 \text{ t.y}^{-1}.\text{km}^{-2}$ of reef is proposed as an indicator of sustainability for coral reef fisheries (Armada et al., 2009; Jennings and Polunin, 1995; Mumby and Steneck, 2008; Munro, 1984; Newton et al., 2007). In case of village with yields over-passing the MSY, only the yields under this level were taken in account. The underlying idea is to limit the valuation of MPA effects to sustainable activities only.

MPA impacts on tourism visit motivations

For each of the following tourism activities, the role of MPA in the visit motivation of tourists has to be assessed (Wielgus et al., 2002). The tourism activities include (i) day tours, (ii) snorkel tours, (iii) scuba diving, (iv) guesthouses, and (v) scientific tourism. The option of comparing MPA sites with control sites was rejected as only one of the control village's had of a day-tour activity. Comparisons were not robust enough to detect the role of MPA in tourism motivations. Direct assessment through different techniques in the MPA sites was chosen.

For the guest houses and the other associated activities not all the expenses should be attributed to the MPA. During their stay in the village, most of the tourists can realize several activities such as trekking, participation in cultural ceremonies, relax on the beach, etc. As described before, several niches of rural tourism exist (e.g. cultural, nature, adventure, leisure, etc.) and the degree in which MPA will serve as an attraction will vary between them. The share of the activities related to marine ecosystem must then be identified. Two methods are used: (i) interviews with business owners to define a distribution of activities undertaken by the tourists and, (ii) a tourism Advertising Images Analysis (AIA) to estimate the weight that marine related activities has had in their choice of destination. The AIA is a method based on the fact that tourists take their decision to come to a specific site influenced by previous information received through advertising (Andersson, 2007). The AIA was realized through a counting of the number of images suggesting different activities or ecosystems. The activities categories were: culture and people, terrestrial landscapes or activities, beaches, other leisure activities and underwater landscapes or activities. Then the relative weight of each category is calculated. The relative number of images containing underwater landscapes or activities was used as a proxy of the role of MPA in the tourist destination choice. It takes mainly the form of pictures of healthy colorful reef, emblematic species or activities related to marine environment. Advertising media printed or web pages available to international and domestic tourists were collected. In total 21 media were analyzed and 151 images categorized.

The results from interviews and the AIA are used to calculate the contributing factor (c_i) of the MPA for guesthouse and other tourism associated activities. Average, minimum and maximum estimates have been assessed.

For scuba diving clubs, semi-structured interviews ($n=3$) were conducted with business owners to understand the motivations in their choices of diving in the MPA sites. 2 main groups of attributes were tested: (i) infrastructure attributes such as accessibility or transport costs and, (ii) ecological attributes such as the presence of emblematic species, the coral reef health or the tameness of fish. The respondents made a ranking of attributes. When ecological attributes dominated, a contributing factor of 100% was applied to the added value of dives realized in the MPA. Otherwise the factor was reduced to 50%.

For all MPA entrance fees, the contributing factor is obviously equal to 100%. The same apply to scientific tourism when field of research is related to the MPA.

Economic valuation of impacts on tourism

Definition

The tourism activities include (i) day tours, (ii) snorkel tours, (iii) scuba diving, (iv) guesthouses, (v) scientific tourism, and (vi) the other activities associated with the previous activities such as restoration and handicrafts. A description of these activities has been given previously.

Method

The approach is relatively straightforward. The added values of each of the activities taking place in the villages are assessed following classical methods (Beukering et al., 2007; Cesar et al., 2003). Then, estimates of the role of the MPA in tourism visit motivations are applied to each added value (see previous part). The total MPA impact on tourism is then the sum of the added values obtained.

Additionally, the distribution of the added values among the different actors is determined upon the residence of the business owners (village or national level). For villages, the added values come from MPA entrance fees, day-visit fees, direct expenses in village, local guesthouse and scientific tourism. At a national level, the added value of day visit and scuba diving activities are accounted.

A multiplier effect of the tourism sector is applied on the added value results. It was chosen to apply it only on the added values at national level as very few village tourism businesses have employees or subcontractors. Based on the existing literature (Jin et al., 2003; Pascal, 2010), a multiplier of 1.3 is chosen as the best estimate.

Formula

The value of the MPA impacts on tourism (V_{mpa}) follows the formula above:

$$V_{\text{mpa}} = \left(\sum_i VA_i * c_i \right) * m$$

With :

VA_i : added value from the different tourism activities (i= day tours; snorkel tours; scuba diving; guest houses; scientific tourism; other activities)

c_i : contributing factor of the MPA (%) for the different tourism activities (i)

m_i : multiplier of tourism sector

Data collection

Data were collected through interviews (n=45) with almost all the tourism professionals implicated in the study zone. Interviews with guesthouses were conducted on a monthly basis during 6 months (June to November) for added value details and occupancy rates estimates. When possible, access to visitor guest books and private accountant books completed the data set for better estimates of quantitative figures. Interviews with other professionals have covered all the diving clubs and most of the tour operators. For all business categories, information about business activity, revenues, cost structure and visitor profiles were collected. Main activities of visitors during their visits were observed.

Annual projections

The observations took place during the cold (or dry) season in Vanuatu, from June to November. This period has an impact on tourist flows as the high touristic season takes place during the dry season . For annual projections, a correction factor of 0.9 was applied to the average monthly number of visitors. This factor is based on interviews with professionals and results from tourist exit survey (Trip consultants, 2008).

Economic valuation of impacts on coastal protection

As described in several works (A. Lugo-Fernandez et al., 1998; Pendleton, 1995), coral reef ecosystems contribute to the coastal protection ecosystem service. The physical presence of coral reef contributes to the absorption of the energy of waves. A better description of the service is given in Brander et al (Brander et al., 2004). Some studies have shown the relationship between the live coral reef coverage and the existence of MPA (Mora et al., 2006; Mumby and Steneck, 2008). The MPA may have then an impact on the coastal protection ecosystem service that needs to be reflected.

The first step of the method is to quantify the coastal protection ecosystem service in terms of land protected. The second one is to value this ecosystem service provided by coral reef and the third one is to apply the MPA contributing factor. A methodology to value this coral reef ecosystem service is developed by Burke (Burke et al., 2008) and Pascal (2010) to Caribbean and New Caledonian reef respectively. One of the main difficulties is that coastal protection against waves is a complex process implicating many factors such as geomorphologic patterns of the coast, the presence of other ecosystems such as mangroves, etc. The identification of the contributing role of each of the different factors is a difficult task and is out of the scope of this study. Based on the results of the two previous studies, it was then assumed that the contributing factor of the morphology of the coral reef present in the studied sites would fluctuate between 10% and 30% of the total protection. An avoided damage valuation is assessed on potential residential and infrastructure damages. Estimates are realized on the land zone comprised between an altitude of 0 and 5 m upper the high tide sea level. This level comes from the historic maximum height of non-tsunami waves during the last 25 years in the region (source: Meteo France and Vanuatu Meteorological Office). A projection of this height was made with GIS topographic data on every village to project potential impacts of flood events (Source: Land department, Geosat 2006). Based on meteorological data, a probability of cyclone and important storms has been estimated. Costs are calculated on the average costs of a cement and traditional house for a household of 5 persons. An average cost of 8 000 € has been applied to cement house and 4 000 € to traditional house built with local materials (pers. observ.). To our knowledge and based on the analyzed literature, the role of MPA in coral reef live coverage has never been quantified. A role varying from 20% to 50% has been proposed following a study linking biodiversity with ecosystem services (Worm et al., 2006). These values mean that without MPA the coral reef service of wave absorption would have been diminished in these proportions.

Economic valuation of the impacts on biodiversity

The method to value impacts on biodiversity is not straightforward. If the quantification of the effects of MPA on biodiversity is quite consolidated with the use of adequate biological indicators (e.g. biomass, diversity index increase) (Cote et al., 2001; Gell and Roberts., 2003; Halpern, 2003), the economic valuation of this effect is complex (Balmford et al., 2008; Jin et al., 2003; Pagiola, 2004). With the methods described in the previous chapters, the contributive role of biodiversity in fishery and tourism ecosystem services as well as in coastal protection has been partially taken into account. Evaluating again the value of these ecosystem processes would generate double counting (Abaza, 2004). We must now turn the analysis to different values. We can distinguish (i) the option value (ii) the bequest value and, (iii) the existence value of coral reef ecosystems. As described by several authors (Beukering et al., 2007; Pagiola, 2004; Pendleton, 1995), the option value can be defined as the value now of potential future direct (fish, tourism) and indirect uses (coastal protection) of the biodiversity. Bequest value represents the value attached to preserving an ecosystem for use by future generations, independent of one's own use of the ecosystem. The existence value corresponds to the value people give to biodiversity independently of any present, future or altruistic use. Existence can be categorized as a non-use value in the TEV approach (Groot et al., 2002).

The most common methods employed to figure out these values of biodiversity through stated preferences approaches require very extended and complex questionnaires to determine a willingness to pay (WTP). These methods have been discarded due to their costs and the resources needed as well as their lack of solid background in the context of subsistence economy (David, G, pers. Comm.).

When primary or secondary data from the studied sites are not available or possible, the transfer benefit is a recommended method (Wilson and Hoehn, 2006). It has to be employed with precaution (Wiley, 2003) and is not recommended for the existence values (Rudd, 2009; Spash, 2007). Only one study on option and bequest values about coral reef in Fiji was selected (O'Garra, 2007, 2009). It presents some similarities with the socio-ecological context of Vanuatu: customary management of marine tenure, small villages, small fringing reef and mix between non-market and market economy. The economic values were obtained from villagers through willingness to contribute (in hours/week) towards conservation of their marine zone to maintain some of the ecosystem services (option and bequest value). A transfer benefit protocol has been setup to adapt adequately the results to this study and correcting factors were applied on the data. The protocol was based on a comparison of the main socio-economic characteristics between the 2 countries. The average size of the household, the proportion of households owning a television, the main source of income have been compared with data from the studies villages. The monetary monthly income and the Human Development Index have been compared with data for rural zone and whole country respectively (source: UNEP). Corrective factors of Purchasing Power Parity (PPP) from the World Bank and the Geary-Khamis

dollar conversion (Heston et al., 2009) have been applied. The PPP for Vanuatu and Fiji are 0,96 and 36,1 respectively and the Geary–Khamis dollar for Vanuatu and Fiji are: 13 and 13,5 respectively. Other data were obtained through official statistics and the Household Income and Expenses Survey (HIES) conducted in both countries. The HIES is described in a different chapter.

The option and bequest value for the marine ecosystem is first expressed in hour.year⁻¹ per adult and converted in money with the mean average wage rate. This value represents the time (converted in money) that people are ready to give to ensure a future use (fishing and tourism mainly) of the ecosystem for themselves or not for themselves (option and bequest value respectively).

With the present knowledge, is not possible to apply a precise quantitative impact of MPA on this value. For example, how to apply a 20% increase in fish diversity to an option value expressed in euros.y⁻¹per household? Therefore, a MPA contribution factor varying from 20% to 50% has been proposed on the same base as for coastal protection. This contribution has relied on existing evidence of MPA support to biodiversity and some ecosystem processes (Mosquera et al., 2000; Palumbi, 2001; Sale F.P. et al., 2005). This means that without MPA 20% to 50% of the option value would be lost.

Economic valuation of impacts on social capital

Definition

According to Putnam (Putnam, 2006) the social capital can be separated in two. On one side, the bonding capital represents the cohesion of the group, the solidarity, and the trust in the community. It forms one of the bases of the common pool resource management, which is enhanced in community-based management (Ostrom et al., 1999). One form of this capital is the political empowerment of groups that may not have been represented before MPA establishment (Wilkie et al., 2006).

On the other side the bridging capital is formed by the capacity of the community to be represented in external events. It refers to the value assigned to social networks between socially heterogeneous groups (Putnam, idem). One example of the bridging capital is the belonging to networks (e.g. MPAs, monitoring). Another one is the ability to attract external assistance through grants or assistance.

For facility of understanding, the social capital in this study has included also the human capital which refers to the knowledge and capabilities of individuals that contribute to the process of production (Deardorff, 1982; Heckman and Klenow, 1998). The trainings and education received through MPA workshops are assumed to have an impact on the capabilities of individuals.

Impacts on physical capital are present too. Some physical assets of MPA such as a boat can be used for other uses (transport) and to simplify analysis have been mixed with this category of social capital.

Data collection and method

Data was collected from the census of all grants and assistances received in villages with MPA and the control sites. The objectives of these funds can be very diverse. The processes and people implicated in this process of fundraising as well as the capacities and abilities needed for it have been assessed through interviews with village stakeholders. The objective is to determine if the MPA village has a different capacity of fundraising than non-MPA villages. This will be valued in terms of social capital impacts in the process following the method described by Matous et al. (Matous and Ozawa, 2010).

All the activities of meetings, trainings and workshops related to MPAs and MMAs (distinction was not possible) have been identified. They are considered as investments in human capital. An economic estimation of their cost was assessed since the creation of the MPA to reflect all the potential trainings received. To our knowledge and as mentioned by Woehr (1994), very few references exist to quantify the efficiency of these trainings on other processes of production and none on these topics are for rural audiences. Based on discussions with trainers visiting villages, it is proposed that 30% of the costs are transformed annually in human capital and effects disappear rapidly during the next 2 years. Costs are then used as a proxy value of their impact as a replacement cost (Heckman and Klenow, 1998).

For physical capital impact, the assets of MPA were identified and valued. When these assets produce some monetary flows, the added value of these flows was determined. In case of no monetary flows

but effective use by people, the proportion between dedicated use to MPA and other uses is determined. This proportion is applied to the replacement cost of the asset based on the purchasing price minus amortizing.

Impacts of MPA on the village economy

Definition

The objective is to determine the relative importance of the MPA (through its local economic impacts) for each village. It was chosen to use the annual incomes generated in the village as an indicator. Monetary and non-monetary incomes are included and have been called village Gross Domestic Income (GDI). The GDI will be used as a base to evaluate the weight of the economic cash flows generated by MPAs at a village level.

Method

The incomes are determined at the household level. As described by the HIES protocol (Vanuatu National Statistics Office 2008), the household is defined as a group of people who usually live together and have a common arrangement for food, such as using a common kitchen or a common food budget. Household incomes are defined by: (i) income from employment (both paid and self-employment); (ii) property income; (iii) income from the production of household goods and services for own consumption; and (iv) current transfers received.

Household consumption expenditure is the value of consumer goods and services acquired, used or paid for by a household through direct monetary purchases, own-account production, barter or as income in-kind for the satisfaction of the needs and wants of its members.

Results from the surveys conducted in Nekapa and Unakap (see description of the method in control site validation) have permitted to adapt the HIES provincial results to the village level. As observed by HIES 2006, the irregularity of incomes and cash generating activities makes difficult any quantification of incomes on a short term study. Following the HIES conclusions, it is then assumed that (i) incomes should equalize expenses at the annual scale and, (ii) an average 33% of incomes are generated locally.

Costs of MPAs

Definition

Different kind of costs of MPA are distinguished: direct, indirect and opportunity costs (Sanchirico, 2000). The first ones cover the costs of establishment, administration, employment, monitoring and enforcement. The second ones refer to some possible compensation payments to people adversely affected by MPA (e.g. alternative employment packages or infrastructure costs of increasing tourism). The third ones consider all the losses of potential earnings such as loss in the fishery revenues, longer displacement time for fishermen or loss from the time spent in the MPA management. For the direct costs, 2 categories were analyzed. The first one corresponds to the setup phase, which covered activities that served in the implementation of the MPA. The activities included some preliminary studies, organization of MPA management, capacity building, formulation of the management plan and the physical setup of the MPA (house, buoys, signboards, launching events, etc.). Costs covered the expenses for assets and materials, for coordination time, training, meetings and incentives. A second category corresponds to the operational costs, which covered the period after the formulation of the management plan and physical implementation of the MPA. The activities include mainly enforcement, realization of awareness campaigns, environmental education activities, resource monitoring and management, livelihood project enhancement and regular meetings. Materials, human resource, activities and meetings form the main costs. We have considered that the costs of training and the costs of awareness campaigns respond to a similar objective of “capacity building”. Even if differences between MPA and MMA have been described before, the specific direct costs for each one was not possible to be identified in the field.

Method

Data was collected through interviews with managers of MPAs and the various stakeholders. The value of the time spent in the planning, follow-up and monitoring activities was estimated based on (i) direct salaries received and, (ii) the minimum national daily wage when no salary is received. The establishment costs were amortized on a 10 years period, corresponding to a classic accountancy rule for establishment costs (replacement of materials and assets, reformulation of management plan, etc.). Trainings received by village members (e.g. monitoring techniques or environment awareness) are valued with the individual average daily cost of a regular training workshop. The origins of funds among villages, national actors or international stakeholders were identified. Government institutions or other agencies financed from the national budget were considered as national (even if maybe a part of their resource comes from external source). International refers to NGOs, institutions and initiatives financed from external donors or agencies. A management administrative fee of 30% was applied to all international funding received locally to reflect the whole transaction costs. For the MPAs inside the network, costs were divided equally by the number of active MPA (n=5). Opportunity costs were

assessed through informal interviews with different fishermen to reflect all the different kind of métiers (e.g. reef gleaning with women, line fishing, cast nets, etc.)

Financial analysis

Cost-Benefit analysis

Following a classic approach described by several authors (Whitten and Bennett, 2004; Wielgus et al., 2008) a cost-benefit analysis has been realized on 2 scenarios. It is based on the present values of projections of the impacts. Commercial and subsistence fishery added values, tourism added values, bequest value and social capital value are the forecast variables.

An additional analysis was made specifically only on fishery and tourism impact to reflect “real” financial cash flows results.

Projected variables	Units	Projections	Maximum value
Commercial fishery yields	Catch volume	from +10% to +30% per year	5 t /km ²
Subsistence fishery yields	Catch volume	from +5% to +15% per year	
Tourism at village level	Added value	from +10% to +15% per year	+300 to 400%
Tourism at national level	Added value	from +10% to +15% per year	
Social capital	Added value	constant value	

Table 8: Parameters used in projections

Projected impacts

Projections are made under simplifying hypothesis incorporated in 2 scenarios. The first scenario is the stagnant one and corresponds to the 2009 observed values projected without any changes. This scenario is quite unrealistic, as we have seen before that commercial fishery and tourism are still in a startup phase. The objective of this exercise is to be used as a reference against the other scenarios. The second scenario wants to take in account the potential of development of tourism and fishery. The parameters of the second scenario are described in Table 8. The annual growth for fishery is based (i) on experiences from other villages and opinions from fishery experts about maximum development of commercial reef fisheries ((Amos, 2007)), (ii) on the demographic growth for subsistence fishing (source: Vanuatu statistics office) and, (iii) an hypothesis of a growing fish demand from the capital that would absorb all the increase in commercial fishery (Bell et al., 2009). No projections on price were made. The maximum projected values were compared to the chosen and previously described MSY level for each village. We use this concept as an indicator of sustainability of the fishery to determine the maximum effects of MPA in case of increasing fishing effort.

For tourism, the projections are based on the cycle theory of business (Burns and W. C. Mitchell, 1946; Morgan, 1991). Most of the Vanuatu tourism sector is today in a start-up phase with a very low level of visitors (80 000 international visitors per year). Domestic and international tourism

projections are based (i) on interviews with experts, (ii) a tourism sector survey which revealed that total visitors coming to the North Efate zone were around 8 000 in 2007 (Trip consultants, 2008) and, (iii) other tourism references in the region (source: national tourism office from Fiji and Solomon Islands). Projections on guesthouse capacities and occupancy level were made. It was considered that motivations and type of tourism were not modified from present situation. Distinction is made between village and domestic added values.

Social capital and bequest values are assumed to remain stable on an annual base. The costs were projected on the average operational costs of the last 5 years and a 10-year recurrent cost was planned to replace assets. As no published data has been found, it is hypothesized that the estimated MPA effects on fishery productivity and tourism motivation visit will remain the same, independent of the level of fishing and tourism.

It is important to emphasize that the objective of this approach is to provide potential values for MPAs projections. The results reflect many approximations and do not take in account many external factors on reef productivity (such as climate change) or on tourism (e.g. macro economic context).

Time perimeter:

The projections necessary to the cost-benefit analysis covered a period of 25 years after the creation of the MPA. This range is most often proposed in similar studies to reflect the ecological responses of ecosystems to scenarios tested (Balmford et al., 2008). The period starts from the first payment of establishment costs.

Profit & loss 2009

A simplified profit and Loss (P&L) analysis was done for every villages for 2009. The figures are based on the observed data and takes in account all the benefits and costs. Setup costs are amortized on a 10-year basis. The objective was to give an easy reading of the costs and benefits.

NPV on observed cash-flows

In order to reflect the real cash flows of cost and benefits observed, a NPV has been estimated since the setup of the MPA up to 2009. In average this period has covered 5 years. As no observations of MPA benefits were available before 2009, it was assumed that they had started 2 years after the setup of the MPA and increased gradually every year up to 2009 level (25%-50%-75% of total MPA benefits). The cash flow of costs has come from the data collected. A discount rate of 10% is applied. A discussion is held further on this topic.

RoI and IRR

A capital budgeting method is proposed to make an appraisal of the investment in the MPA. Several manuals described precisely the approach (Campbell and Brown, 2003; HM Treasury, 1991). The principal objective is to give funding agencies a tool to rank different prospective projects. Based on cash flows projections, the internal rate of return (IRR) and the Return on Investment (ROI) are calculated as financial ratios. The IRR can be defined as the discount rate that reduces to zero the net present value (NPV) of a stream of income inflows.

$$NPV = \sum F_n * (1+r)^{-n} = 0$$

Where :

F_n = cash flow during period n

r= internal rate of return

n= period of time (years)

The ROI is calculated through the values of cash flows divided by the cost of the investment; the result is expressed as a ratio and all values are calculated in present values.

$$ROI = \sum P_n *(1+d)^{-n} / \sum I_n *(1+d)^{-n}$$

Where :

P_n = positive cash flow during period n

d= discount rate

n= period of time (years)

I_n = cost of investment

ROI and IRR have been calculated on the sum of all the benefits and on the fishery and tourism benefits only to reflect “real” financial cash flows. Analysis were conducted using real or constant values, i.e., by measuring benefits and costs in units of stable purchasing power (2009). All local currencies results were converted in Euro with the average 2009 rate of change (1 VUV= 0,0083 EUR).

Discount rate

In order to compute present values, it is necessary to discount future benefits and costs. This discounting reflects the time value of money. As described by several studies (Balmford et al., 2008; Beukering et al., 2007; Cesar and Chong, 2006; Cousens and Tom Steinberg, 2002; OECD, 2006; Panayotou, 2003) no consensus exists on the discount rate to be applied. An alternative choice has

been to apply a discount rate of 10% coupled with a sensibility analysis on 3% and 7% discount rate (Holland, P. pers. Comm.)

Sensitivity analysis

A clear identification of the main uncertainties is compulsory to ensure a reliable use of this analysis. Evaluation methods of uncertainty on assumptions (min-max, best estimate) were used to reflect the variability to results (Mullan and Kontoleon, 2008). Major assumptions were changed sequentially and present values were recomputed to determine how sensitive outcomes are to uncertainties. The assumptions tested are (i) the minimum and maximum range of estimations of the effect of MPA on fishing yields, (ii) the range of estimations of the MPA contribution on tourism, (iii) the projected growth of the 2 sectors during the next 25 y, and (iv) a discount rate of 5, 7% and 10%.

Results

Importance of fishery and tourism sector added value for the villages

Fishery sector

The estimations of the reef fishing yields for the year 2009 are presented in Table 9. Total reef fish catches per village are estimated between 1 to 5.2 t.y⁻¹.km⁻² of fishing ground.

In average, 30% of the fish catches are sold and the rest is used for own consumption in the village. Values differ from every village and reflect the level of fishing effort synthetic index. The non-monetary consumption of fresh fish corresponds to an average 17 kg.y⁻¹ per capita. The distribution between net and speargun gears is variable among villages and depends on the ecological context (for example, some villages can not use gill nets due to their reef geomorphology).

The resulting added value for subsistence and commercial fishery is 2.7 € .kg-1 and 3.04 € .kg-1 respectively. Intermediary costs for commercial fishery represent an average of 16% of the market price.

Even if activity with other gears is not continuous or very intensive, they are well spread out among households. Reef gleaning, cast nets, line, shell collection have been observed with a certain regularity.

	Unit	Emua	Piliura	Unakap	Laonamoa	Worasifu	Nekapa (control)	Saama (control)	Average
Total yields *	kg.y-1	4 300	2 500	1 100	5 400	2 500	3 500	2 600	3 100
min	kg.y-1	3 450	1 990	900	4 290	1 990	2 780	2 110	2 501
max	kg.y-1	5 180	2 980	1 350	6 430	2 990	4 170	3 160	3 751
Fishing net	% total catches	41%	43%	27%		18%	61%	43%	33%
Speargun	% total catches	59%	57%	73%	100%	82%	39%	57%	67%
% commercial sales	% total catches	21%	36%	13%	40%	48%	26%	23%	30%
Equivalent catch per area	t.y-1.km-2	2,8	2,3	0,9	4,0	5,2	3,5	3,7	3,2
Equivalent fresh fish consumption	kg.y ⁻¹ per capit:	14	16	11	15	26	23	16	17
Total fishery added value: subsistence *	euros	9 400	4 300	2 700	8 800	3 500	7 000	5 400	5 871
Total fishery added value: commercial *	euros	2 700	2 700	800	7 200	3 800	2 800	1 800	3 114
Total fishery added value (subsistence and commercial)*	euros	12 100	7 100	3 400	16 000	7 400	9 800	7 200	9 000

Table 9: Estimated yields for the reef fisheries during the year 2009.

*: truncated values at 10²

Tourism sector

The estimates of the tourism activities are presented in Table 10. In 2009 the mean annual occupancy rate for Guest houses was 8% with a maximum value of 15% in one guest house. Day tours activities are not present in every village. Mean annual number of day tour visitors is around 100 tourists with a maximum value of 480 in one village.

The distribution of the activities is different among villages. Some villages have a consolidated activity of day tours without guest house business whereas for others, the tourism is based only on guesthouse visits. Scuba diving activities have occurred only in one village and with a very reduced activity. The scientific tourism has brought a significant number of visits (residing scientist, visits from NGOs, etc.) and has represented as much as 60% of the total visits to guesthouses for one village.

Results of interviews show that visits to guesthouses are relatively short ones: in average 1 night per every week of total visit to Vanuatu for international visitor and 2 nights for domestic visitors. These short stays reveal that this kind of tourism is highly dependant on the transport connectivity with main tourism destinations. Repeat visitors seem important for domestic and are very low for foreign visitors. As described before all but one of the guesthouses are privately owned and revenues go to the owners without any distribution to the community. The day tours activities are different because benefits are shared between an operator in the capital (80% of the added value) and a village representative that redistributes to some families in charge of restoration and the community.

The estimated added value of activities represent more than 80% for local guest houses where intermediary costs are mainly the amortizing costs of construction, advertising and maintenance. For day tours the average added value is 55%, including benefits made at village and national level through the tour operators. Day tour main costs include transport and advertising. Added value of scientific tourism is similar to guest house as main expenses are realized in the form of accommodation and food. The intermediary costs of diving clubs are estimated to represent 50% of the revenues.

Year 2009 added value (€)		Emua	Piliura	Unakap	Laonamao	Worasifui	Nekapa (control)	Saama (control)	Average
Daytour visitors with marine activities	Euros	1 565	12 518	782	1 565	782	730	782	2 675
Guest house	Euros	2 952		787	2 132	4 100			2 493
Occupancy rate	%	11%		2%	3%	15%			8%
Visits to MPA	Euros		1 920	240	240	400			700
Scientific MPA tourism	Euros	880	120	1 080	240	120			488
Diving visits	Euros			980	1 568				1 274
Total	Euros	5 397	14 558	3 870	5 745	5 402	730	782	5 212

Table 10: Estimated added values for the tourism sector. Annual figures for 2009.

Village Gross Domestic Income

The mean annual expenses per village are estimated at 154 000 € and the mean GDI per village (i.e. the part of the incomes generated in the village) is 49 000 €.y-1. The previous results mean that villages are able to produce approximately 30% of their needs locally.

The added value of fishery and tourism represent an average of 19% and 8% respectively of the village GDI (extreme values are omitted). Added value of tourism is considered only at village level.

The subsistence fishery represent in average 10% of the non-cash needs of a village.

		Emua	Piliura	Unakap	Laonamoa	Worasifiu	Mean
Total annual expenses	euros	275 811	98 380	80 493	270 084	45 392	154 032
Total annual monetary expenses	euros	189 117	58 645	47 982	161 000	31 775	97 704
Estimated GDI for the village	euros	96 534	25 579	20 928	81 025	20 427	48 899
Fishery contribution to village GDI	%	13%	28%	16%	20%	36%	* 19%
Tourism contribution to village GDI	%	4%	14%	11%	4%	23%	* 8%
Subsistence fishery contribution to village non monetary incomes	%	11%	11%	8%	8%	26%	* 10%

(* Extreme values have been omitted)

Table 11: Consolidated results of village monetary and non-monetary needs

Impacts of MPA on fishery productivity (spillover)

Impacts on CPUEs

For gillnets, the mean CPUEs for MPA village is $7.2 \text{ kg}\cdot\text{h}^{-1}$ (std=2.8) and $2.8 \text{ kg}\cdot\text{h}^{-1}$ (std= 1.8) for non-MPA villages. The mean CPUE for all the villages is equivalent to $5.2 \text{ kg}\cdot\text{h}^{-1}$ (std=2.5).

For speargun, the villages with MPA fish on average $3.18 \text{ kg}\cdot\text{h}^{-1}$ (std=0.8) and villages without MPA: $2.1 \text{ kg}\cdot\text{h}^{-1}$ (std=0.6). The mean CPUE is $2.9 \text{ kg}\cdot\text{h}^{-1}$ (std=0.7) for all the villages.

The multivariate analysis has shown that MPA sites present a fish productivity higher than non-MPA locations. Increase in catch productivity is situated between 15% and 33% ($\text{kg}\cdot\text{h}^{-1}$) for gillnet and 6% to 22% ($\text{kg}\cdot\text{h}^{-1}$) for speargun métiers. These results represent the impact on CPUEs that can be attributed to the MPA.

The Figure 3, 4 and 5 describe more precisely the average CPUEs observed at different locations with and without MPA and at a variable distance from the MPA border.

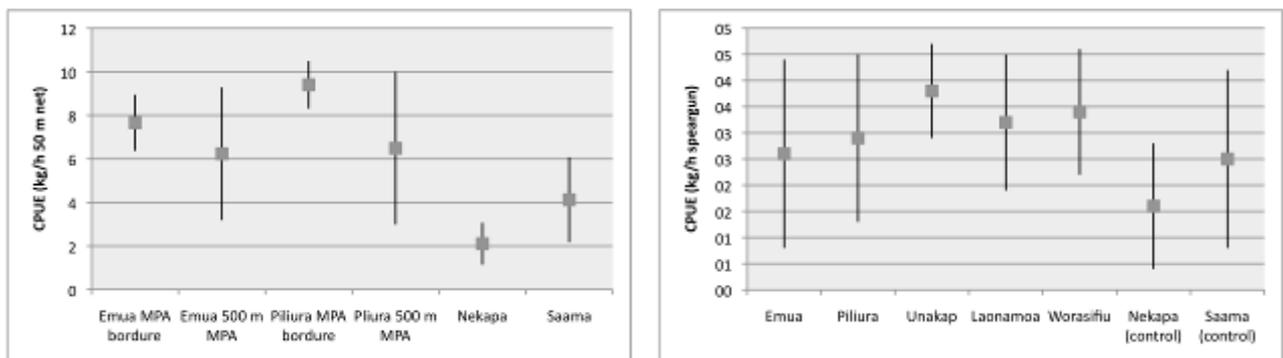


Figure 3 : Mean CPUEs for gillnets (n=76h) and speargun fishing (n=170h) at different locations.

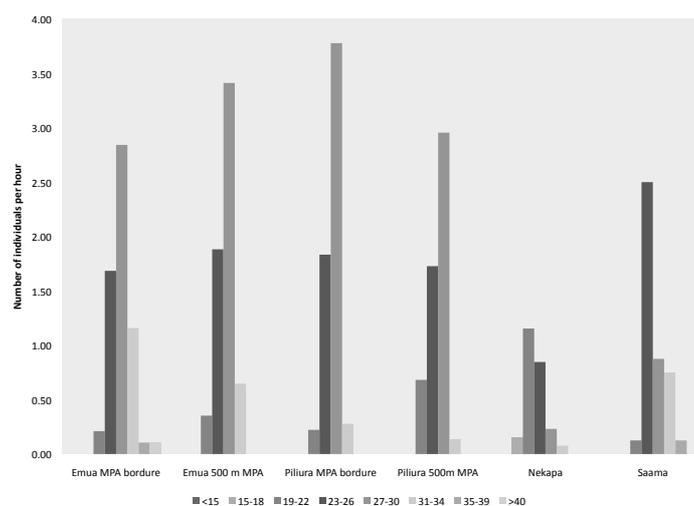


Figure 4 : Size distribution of the catches from different locations.

Results are expressed in number of individuals caught per hour of standard effort of gillnet for *Scaridae* sp.

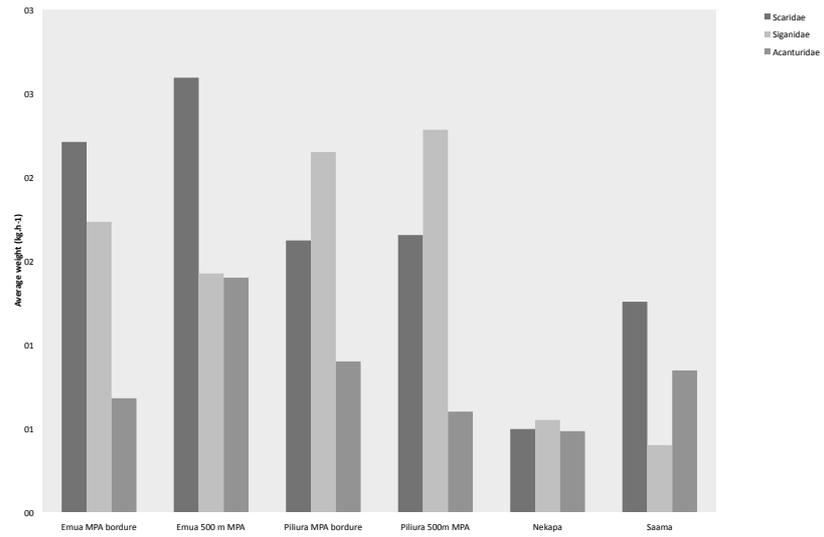


Figure 5 : Average weight of catches for different families.

Results are expressed in kg per hour of gillnet standard effort.

Economic impacts of MPA on fisheries

The results of the MPA impacts on fishery yields are presented in Table 12. The impacts of MPA on the CPUEs for the different métiers represent an average benefit of between 500 and 870 kg.y⁻¹ for each MPA village. Sporadic ceremonial catch inside MPA have represented an average of 96 kg.y⁻¹ for each village.

In monetary value the average impact on fishery is estimated at 2 300 €.y⁻¹ (std=1 050). Mean benefits for subsistence and commercial fishery is 1 300 €.y⁻¹ and 940 €.y⁻¹ respectively.

Average maximum and minimum values reveal a difference in the order of 1 000 € (41% of the mean) and reflect the uncertainties on fish yields and the MPA impact estimates.

		Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
MPA contribution in finfish catches volumes	min kg.y ⁻¹	710	430	204	743	392	496
	max kg.y ⁻¹	1 288	766	342	1 279	678	871
MPA contribution to trochus fishery	€.y ⁻¹	--	--	473	1 014	338	608
Mean MPA contribution to fishery added value	min €	1 981	1 212	1 020	3 083	1 441	1 747
	max €	3 600	2 168	1 402	4 613	2 262	2 809
	Best estimate	2 800	1 700	1 200	3 800	1 900	2 280

Table 12: Estimates of MPA impacts on fishery yields in volume (kg) and added value (€).

As all the species are sold with the same price, the effects of MPA on specific commercial species are not revealed by the valuation. In the same way, the effects of MPA on the mean size of catches were not reflected either. The size has some influence in prices (normally bigger fish represent a bonus in price) but differences observed in the market price were hardly discernible and very variable. On the opposite, in the case of reef fish that are considered ciguatoxic, price is usually lower (or null) for big individuals. The effects of MPAs on catch variability are reflected in the annual benefits of the MPA villages and in the projections of the fishery (Cost Benefit chapter).

As explained, no catch of trochus fishery has occurred during our stay in the villages. The results of the surveys and expert interviews show that for some MPA villages no trochus collection was done in the last 3 years and stocks are still depleted or with a too low density for exploitation. Experts are very pessimistic about recovery for future exploitation. For other MPA villages (2 of them), fishermen have reported trochus collection and commercialization. Volumes were dependant on the size of the village in terms of fishing ground area and number of households. For the two villages, the average volume of trochus collection has been estimated to be 510 kg of shells every 3 years. Transformed to an annual basis with 2009 price this represents an average added value of 600 € per annum per village. As described before, all the benefits have stayed in the villages through fishermen or intermediaries.

MPA impacts on tourism visit motivations

The results of the AIA Analysis and professional interviews are presented in Figure 6 and Table 13 to determine the contributing factor (Ci) of MPA in tourism visit motivation. This factor is relatively important for most of the tourism activities and varies from 40 to 75%. It represents the contribution of the MPA in the choice destination by the tourist or in the activities undertaken locally.

In a similar way, it was estimated from the professional interviews, that, in average for 60% of the visitors, at least one member of the group has realized some snorkeling activities.

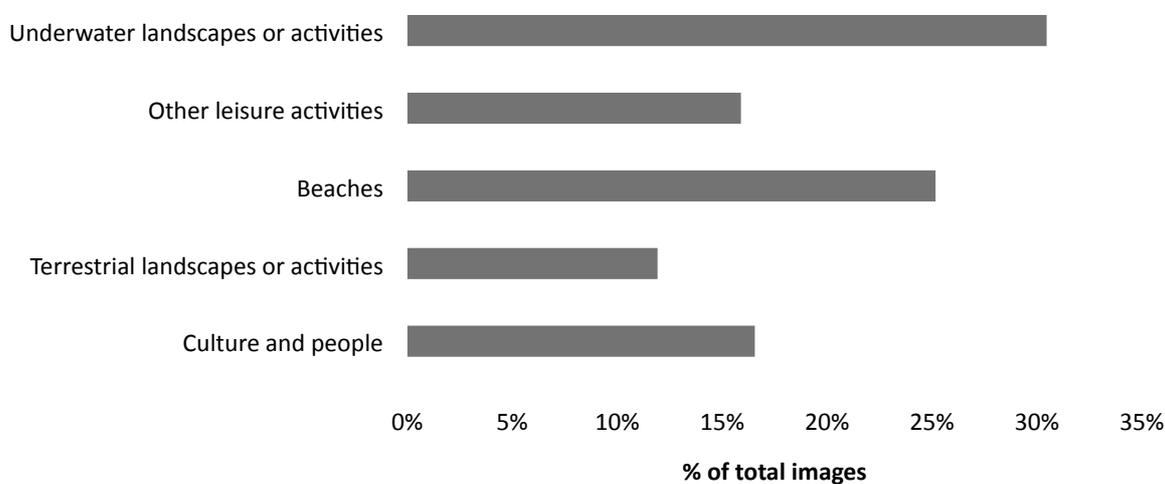


Figure 6 : Advertising Image Analysis based on 21 media support and 151 images.

MPA contributing factor (% of expenses)		<i>Emua</i>	<i>Piliura</i>	<i>Unakap</i>	<i>Laonamo</i>	<i>Worasifu</i>
Day visits	min	50%	60%	65%	50%	45%
	max	70%	80%	85%	65%	60%
Guest houses	min	45%		40%	60%	56%
	max	60%		60%	75%	75%

Table 13: Contributing factor of MPA in tourism activities expressed as a proportion of total expenses during the stay.

Economic impacts of MPA on tourism

The mean valuation of MPA impact (Table 14) on tourism visits represents an average added value of 4 900 € .y⁻¹ (std= 2 900) generated by each MPA. These benefits are mainly generated by day tour and guesthouse activities that received the main benefits from MPA.

MPA benefits are distributed among stakeholders at village and domestic level. Villages with guesthouses tend to keep all benefits in the village (private or community owned) whereas villages with day tour activities have a great part of the added value is for domestic stakeholders (operators, intermediaries).

Year 2009 MMA estimated impacts (€)		Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
Daytour activities	€ . y ⁻¹	939	9 861	638	1 140	548	2 625
Guest house	€ . y ⁻¹	1 550		394	1 439	2 691	1 215
Visits to MPA	€ . y ⁻¹			120	240	400	152
Scientific MPA tourism	€ . y ⁻¹	968	236	1 476	328	164	634
Diving visits	€ . y ⁻¹			600	960		312
Total	€ . y ⁻¹	3 457	10 097	3 228	4 107	3 803	4 938
Minimum impact valuation on tourism	€ . y ⁻¹	3 079	7 675	3 019	3 590	3 222	4 117
Maximum impact valuation on tourism	€ . y ⁻¹	3 835	12 519	3 436	4 625	4 383	5 760
Village level	€ . y ⁻¹	2 633	1 311	2 062	2 118	3 305	2 286
Other national stakeholders	€ . y ⁻¹	824	8 786	1 166	1 990	498	2 653

Table 14: Estimates of MPA impacts on tourism added value

Economic impacts of MPA on the social, human and physical capital

Both MPAs and non MPAs villages have received funds for assets purchased such as solar panels or water pumps. It was not possible to identify clearly through the interviews the role of the MPA in this fundraising activity. Therefore potential benefits in bridging social capital have not been valued.

For each village, sums comprised between 1 200 € and 2 400 € have been invested every year in trainings and workshops linked with MPA activities. The part of the skills and knowledge acquired during this trainings that may be useful for other sectors have been assessed in approximately 300 € to 630 €.y⁻¹ depending on the villages. This represents the valuation of annual impacts of MPA in human capital.

For physical impact, boats have been identified as the main MPA assets and both MPAs in the network disposed of a boat in 2009. In average, it has been estimated that 10% of its available time was dedicated to activities related to the MPA (e.g. monitoring, COTs collection, transport for meeting). The rest of the time was whether inactive or used for transport of goods or people from the village to closed places. The estimated added value of these other activities is close to zero meaning that incomes have compensated the running costs of the boat (i.e. inputs, maintenance and taxes).

Impacts of MPA on bequest value

A comparison of selected variables in the transfer benefit approach between the Navakavu study (O’Garra, 2009) and the present one is presented in Table 15. Data are harmonized with the respective PPP and Geary–Khamis dollar from CICP 2007 (Heston et al., 2009). Based on the study of these variables, the mean willingness to contribute per adult found in Fiji has been adapted to the Vanuatu study. An average contribution time of 2.4 hours per month per adult is proposed instead of the original 3 hours. The main explicative factor in this correction was “the most important livelihood activity” variable. The other variables of Human Development Index, average household incomes are mostly similar. As fishing was a main source of income for most of the households in the Navakavu zone, the willingness to contribute to ensure future fishing was probably higher than in Vanuatu.

	Unit	Fidji-Navakavu	Study	Source of data
Mean household size	Person	4,8	4,9	HIES, Fiji (2008-2009) - Vanuatu (2006)
Average wage rate	Euro.h ⁻¹	0,87-1,68	0,8-1,4	HIES, Fiji (2008-2009) - Vanuatu (2006)
Proportion of households owning a television	%	69,0	37,0	
Most important livelihood activity (% of revenue)	%	Fishing	Growing crops	
Monthly household cash income (PPP usd 2007)	PPP usd	928,6	1 103,9	(National Statistics office, PPP 2007: CICP)
Human Development Index	HDI	0,669	0,693	(UNDP , 2007)
Mean Willingness to contribute per adult	h.month⁻¹	3,0	2,4	

Table 15: Variables used for the transfer benefit approach on Willingness to contribute in time per adult to maintain ecosystem services of coral reef for future generations.

		Emua	Piliura	Unakap	Laonamo	Worasifu	Mean
Total bequest value (Willingness to contribute per village)	€·y ⁻¹	3 041	1 394	1 140	3 231	570	1 875
MPA contribution to bequest value	€·y⁻¹	1 064	488	399	1 131	200	656
MPA contribution to bequest value - minimum value	€·y ⁻¹	608	279	228	646	114	375
MPA contribution to bequest value - maximum value	€·y ⁻¹	1 521	697	570	1 616	285	938

Table 16: Estimates of Bequest values (annual figures) and MPA contribution

The mean result for the MPA impact on the annual option/bequest value is estimated to be: 650 €·y⁻¹ per MPA. Benefits for each village depend directly on each village population.

Impacts of MPA on coastal protection ecosystem service

Areas above 5 m height from sea level (at maximum high tide) have been identified in site and the number of houses was counted. The probability of cyclone and important storms has been estimated to 1 every 5 years. It was not possible to have a clear vision of the height of the waves but we assumed that it corresponds to the maximum height. A probability of 1/5 is then used to convert the value of avoided damage costs in annual figures. Coral reef ecosystem contribution (from 10% to 30%) and MPA contribution on coral reef live coverage (from 20% to 50%) are applied. Results reflect the high level of uncertainties.

		Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
Number of houses at flood risk		1	6	6	8	2	5
Avoided damage costs	€	8 000	48 000	48 000	64 000	16 000	36 800
MPA contribution	€·y ⁻¹	136	816	816	1 088	272	626
MPA contribution - minimum value	€·y ⁻¹	32	192	192	256	64	147
MPA contribution - maximum value	€·y ⁻¹	240	1 440	1 440	1 920	480	1 104

Table 17: Parameters used in valuation of the coastal protection ecosystem service and MPA contribution

Costs of MPAs

The total costs for Emua MPA were 6 182 € p.a. and 7 100 € p.a. for the MPA network (1 400 € p.a. for each of the 5 MPA inside the network). These values include amortizing setup costs on a 10 year basis (Table 18). For international comparison purposes, the average cost is equivalent to 14 100 €.y⁻¹.km⁻² of protected area or 2 100 €.y⁻¹.km⁻² of managed area.

Costs during all the setup phase were estimated at 25 500 € (5 100 € per MPA) for the network whereas Emua MPA spent 19 000 €. The weight of external assistance human resource costs is relevant (from 40% to 50% of the total) and reflects the role of NGOs or other agencies in the initial phase. The network has permitted to distribute the cost among different MPAs. The other costs are common to every MPA and cover equipments and meetings. Both the network and Emua MPA have received a boat.

Annual operational costs for 2009 is 900 € for each MPA in the network. Emua MPA has a running cost of 4 300 € p.a. Costs of human resource from external agencies or from staff from the village have represented the main item. Activities have covered the setup of the MPA management plan, the secretary tasks of meetings, budgets, proposals, etc. and the organization of awareness or monitoring campaigns. The transaction costs of the funding agency (through their estimated administrative cost of funding) represent the second one. The time dedicated to the boat for MPA activities has been estimated to be very low (10%) but other activities (e.g. transport) have allowed covering the annual running costs.

	Unit	Emua	Piliura	Unakap	Laonamosa	Worasifiu	Average
Total costs w/amortizing setup costs	Euros.y ⁻¹	6 182	1 424	1 424	1 424	1 424	2 376
Total Costs per km2 of MPA	Euros.y ⁻¹ .km ⁻¹	25 756	11 304	11 869	10 277	11 304	14 102
Total Costs per km2 of MMA	Euros.y ⁻¹ .km ⁻¹	4 040	1 319	1 130	1 071	2 967	2 106

Table 18: Total annual costs for each MPA (description in the text)

The capacity building costs have represented more than 25% of the observed costs in 2009 and have been directed to the village people in the form of (i) trainings on resource management, monitoring or environment and, (ii) campaign organized in the village to increase awareness about the environment. Costs of meetings and follow up visits were one important item due to the remoteness of the villages. Surprisingly, monitoring of resource and maintenance of MPA equipment have had a very low weight in annual budget and reflect that very few activities of this kind have been realized.

Opportunity costs have come from the time dedicated by voluntary members of the MPA (288 € for Emua and 60 €.y⁻¹ for each other MPA). No extra cost or time due to fishing ground displacement has

been observed with the different kind of métiers (cast nets, hand line, hand collecting as well as some other traditional gears (e.g. hand spear).

EUROS			
	MPA network	Per MPA	Emua
Setup costs	12 400	2 480	11 328
Meetings and workshops	1 920	384	1 640
External assistance (days)	9 520	1 904	8 928
Materials, misc.			360
Celebration event	960	192	400
Equipment	13 552	2 710	7 600
House /office	2 600	520	
Boat	7 440	1 488	5 600
Computer and others devices	1 560	312	
Signboard and signalisation	512	102	1 200
Buoys	960	192	400
Diving gears	240	48	240
Other	240	48	160
Operational costs	4 526	905	4 289
Training (in site and external)	662	132	573
Awareness campaigns	307	61	520
Monitoring costs (materials and transport)	480	96	192
Meetings & follow-up visits	720	144	640
Boat costs and others (gifts, communication)	216	43	
Administrative fee of funding agencies	1 093	219	659
Human resource	1 048	210	1 046
Staff	760	152	
Voluntary members (days)	288	58	384
External assistance			661

Table 19: Details of MPA costs

The distribution of costs of MPA is relatively straightforward. Except the opportunity costs, all the costs have been funded by external agencies with international funding. We can therefore assume that the MPA has had very low costs for local and national stakeholders.

2009 Average operational costs distribution

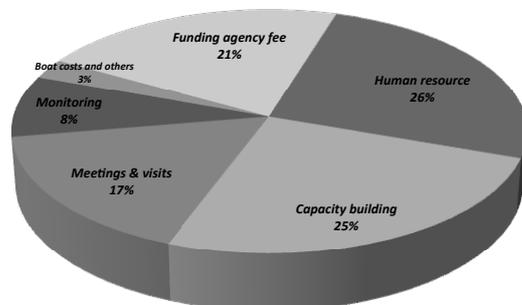


Figure 7: MPA operational cost distribution (2009)

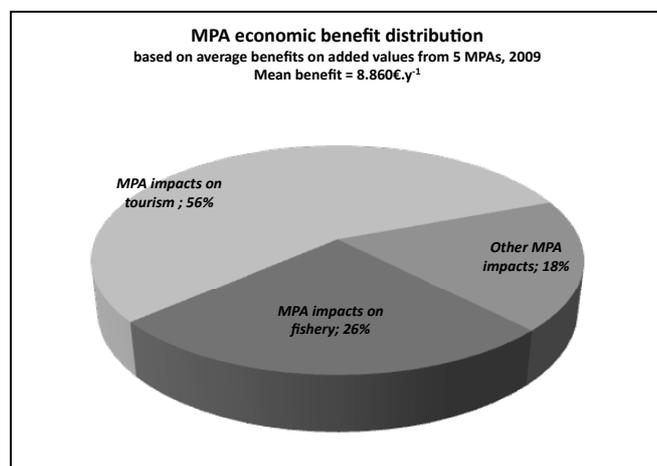
Consolidated results

	Euros	Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
MPA impacts on subsistence fishery	€·y ⁻¹	2 250	1 146	671	1 768	866	1 340
MPA impacts on commercial fishery	€·y ⁻¹	541	544	540	2 081	986	938
MPA impacts on tourism village stakeholders only	€·y ⁻¹	2 633	1 311	2 062	2 118	3 305	2 286
MPA impacts on social capital	€·y ⁻¹	633	291	291	291	291	359
MPA impacts on bequest value	€·y ⁻¹	1 064	488	399	1 131	200	656
MPA impacts on coastal protection ecosystem service	€·y ⁻¹	136	816	816	1 088	272	626
MPA impacts for tourism national stakeholders only	€·y ⁻¹	824	8 786	1 166	1 990	498	2 653
TOTAL MPA impacts	€·y ⁻¹	8 081	13 382	5 945	10 465	6 416	8 858

Table 20: MPA economic valuation of impacts. Consolidated results. Year 2009 , annual figures. Added values .

The mean MPA economic impacts in 2009 have been estimated at 8.900 €·y⁻¹ (minimum: 6 000 € and maximum: 13,400 €). The effects of MPA on tourism added values have represented the major part (55%) followed by effects on fishery added value (26%) and other impacts (19%) (Figure 8). Results vary among village reflecting a different socio-ecological context on fishing effort and tourism activities (Figure 9). Impacts are proportional to the level of fishing pressure and tourism business development stage found in each village.

Figure 8 : MPA economic benefit distribution.
Based on average benefits for 2009.



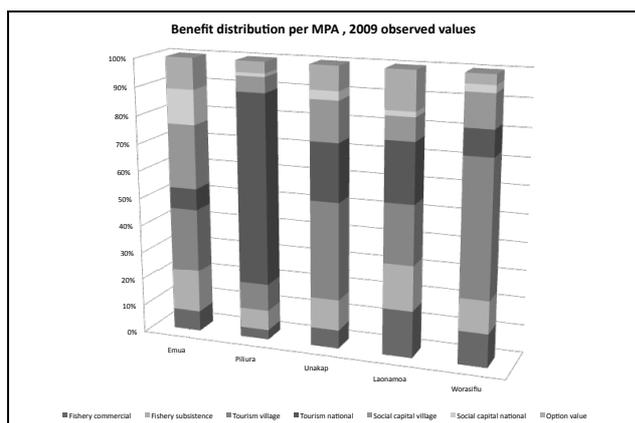


Figure 9: Benefits distribution per MPA. Based on 2009 estimated values.

The villages are the main beneficiary (65%) of the MPA impacts with a mean value of 6,200 € p.a. (Figure 10) Except one village (Piliura) where day tourism activities produce important benefits for national stakeholders, the distribution village/domestic level has been relatively homogenous.

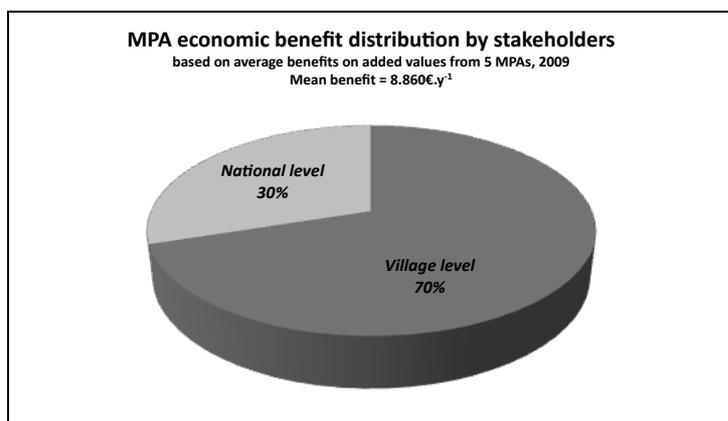


Figure 10: Stakeholder economic benefit distribution. Based on average benefits for 2009.

In terms of “real” financial cash flow and proteins, the benefits at village level from fishery and tourism represented a mean value of 3,200 € p.a. for each MPA (Table 21). Average effects on tourism and fishery added value for villages have been similar.

The importance of these local benefits on the village varies from 4% to 21% of their GDI (Table 21). The average impact (without Worasifu) is 7% (std=4) meaning that the MPA has produced benefits representing approximately 7% of the total 2009 cash and non-cash incomes generated in the village.

		Emua	Piliura	Unakap	Laonamoa	Worasifu		Mean
Total monetary impacts of MPA at village level (fishery and tourism)	euros	3 174	1 855	2 601	4 198	4 291		3 224
Total protein impacts of MPA at village level	euros	2 250	1 146	671	1 768	866		1 340
% impacts of MPA on village GDI	%	3%	7%	12%	5%	21%	*	7%

Table 21: 2009 annual MPA impacts in proportion to village annual GDI.

Ex-post financial analysis: P&L and RoI

Profit and Loss statement

The profit and loss (P&L) statement for 2009 is based on the previous estimated values. The P&L show positive results for all villages meaning that annual benefits have overcome costs even when amortizing of the setup costs is included. The mean bottom line of MPA P&L is 6 500 € with a minimum and maximum value fluctuating between 4 370 € and 8 600 €. Results for Emua in terms of positive P&L are sensitive to main uncertainties with a switch value to a P&L close to zero when minimum estimates are applied. Results are presented in Table 22. As a reference the net benefits per km² of MPA are given (mean=49 000 €.km⁻²).

		Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
Profit & loss 2009							
Minimum MPA impacts	€·y ⁻¹	6 333	9 648	4 750	7 866	5 132	6 746
Maximum MPA impacts	€·y ⁻¹	9 828	17 115	7 140	13 064	7 701	10 969
Cost of MPA (w/amortizing)	€·y ⁻¹	-6 182	-1 424	-1 424	-1 424	-1 424	-2 376
MPA net benefit		1 899	11 957	4 521	9 041	4 992	6 482
MPA net minimum benefits	€·y ⁻¹	152	8 224	3 326	6 442	3 707	4 370
MPA net maximum benefits	€·y ⁻¹	3 647	15 691	5 715	11 640	6 276	8 594
Total net benefits per km ² of MPA	€·y ⁻¹ ·km ⁻²	7 913	94 899	37 671	65 229	39 618	49 066

Table 22: MPA Profit & Loss statement for 2009

Return on Investment

When analyzing the cash flows since the creation of MPA up to 2009, the mean NPV is positive (approximately 7 000 €). This means that after 5 years after the initial investment, benefits are greater than the costs. Nonetheless NPV has been negative for one village reflecting (i) that more time is necessary to compensate for the costs of MPA and/or (ii) the investment was too high.

		Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
Present values (n=5, t=10%)							
MPA impacts on fishery added value	PV, euros	4 352	2 409	1 589	5 262	2 596	3 242
MPA impacts on tourism added value	PV, euros	5 571	14 393	4 784	6 087	5 636	7 294
Other MPA impacts	PV, euros	2 671	2 666	2 560	3 873	2 202	2 795
Costs of MPA	PV, euros	-23 553	-6 301	-6 301	-6 301	-6 301	-9 751
MPA net present value	PV, euros	-11 002	13 040	2 508	8 569	4 072	7 047

*Based on estimated cash flows, 5 years after création with a 10% discount rate, * negative values have been omitted.*

Table 23: MPA Net Present Values from cost-benefit analysis.

The mean Return on Investment after 5 years of activity is 1.8 (std=0.9) meaning that 1 euro invested has already produced almost 2 euro in benefits. In terms of IRR mean values are 41% when considering all benefits and 21% when only considering monetary cash flow (commercial fishery and tourism). Values for this last indicator varies from negative values to 44% (Table 24 and Figure 11)

		Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
Present values (n=5, t=10%)							
MPA net present value	PV, euros	-11 002	13 040	2 508	8 569	4 072	7 047
Return on Investment (RoI)		0,5	3,1	1,4	2,4	1,7	1,8
IRR (%)		neg	60%	24%	48%	31%	41%
IRR (%) on real cashflow (commercial fishery and tourism)		neg	44%	4%	22%	14%	21%

Table 24: RoI and IRR for each MPA. Based on estimated values starting from MPA creation to 2009.

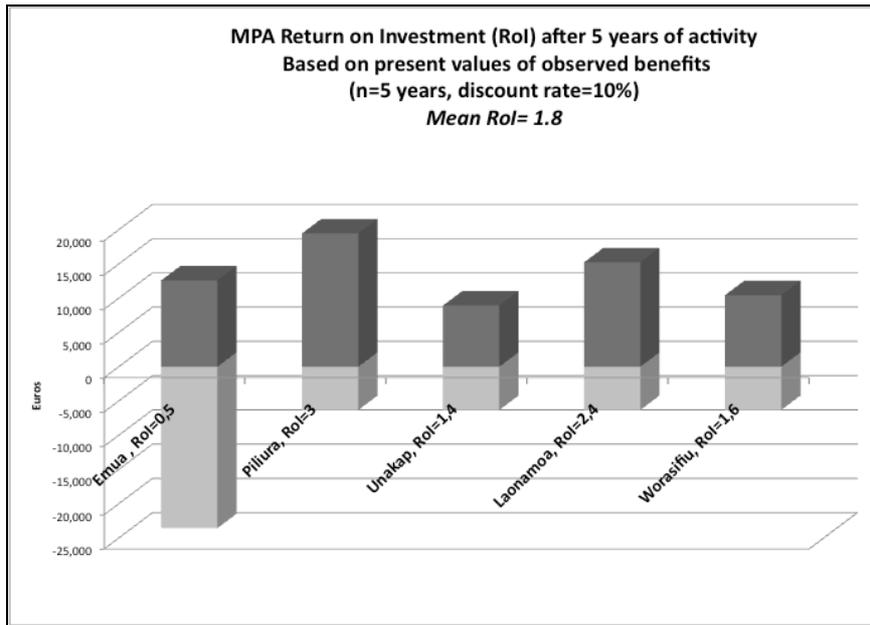


Figure 11 : MPA Cost Benefit Analysis and Return on Investment, 5 years of MPA activity.

For the stakeholder distribution, as observed before, almost all the MPA costs are assumed by external agencies. This involves that all the benefits generated in the village are net benefits for them (average= 6 200 €.y⁻¹).

Scenarios

The results of the 25-year projections on fishery and tourism added value are presented in Table 25. The MSY for each village based on its reef area vary from 2.4 to 7.7 t.y-1 with a mean value around 5.7 t.y-1 for an added value of 17 000 €.y-1. Tourism at national and village level has been projected to represent an average maximum added value of 47 000 €.y-1 with a maximum value of 71 000 €.y-1.

		Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
Fishery maximum yield	kg	7 650	5 400	6 300	6 650	2 400	5 680
Fishery maximum added value	euros	22 343	15 772	18 400	19 423	7 010	16 590
Tourism maximum added value (village level)	euros	12 245	7 483	6 411	12 499	15 951	10 918
Tourism maximum added value (consolidated)	euros	22 333	23 655	13 535	21 963	20 683	20 434

Table 25: Projected values at 25 years for fishery and tourism sector.

Cost benefit analysis

The results of the cost benefit analysis on projected values are presented in the Table 26. The present values (PV) are consolidated at village and national level.

		Emua	Piliura	Unakap	Laonamoa	Worasifu	Mean
Present values (n=25, t=10%)							
MPA impacts on fishery added value	PV, euros	21 078	12 137	12 257	23 572	9 638	15 736
MPA impacts on tourism added value	PV, euros	37 100	59 256	32 473	42 374	31 016	40 444
Other MPA impacts	PV, euros	15 305	10 689	8 930	14 156	7 504	11 317
Costs of MPA	PV, euros	-39 661	-10 503	-10 503	-10 503	-10 503	-16 334
TOTAL MPA net benefits	PV, euros	33 639	86 477	53 615	84 513	47 258	61 100
Return on Investment (RoI)		1,9	7,8	5,1	7,6	4,6	5,4
IRR (%) on real cashflow (commercial fishery and tourism)		12%	56%	34%	44%	35%	36%

Table 26: Present values of benefits and costs of MPA (25y , discount rate=10%)

The cost/benefit analysis through the NPV presents positive returns for every MPA meaning that benefits flows have overcome costs in all the cases. In average the NPV at 25 years for each MPA is approximately 61 100 €. The main benefits are generated by impacts of MPA on tourism and fishery added value. In these projections the tourism benefits represent almost 3 times the fishery ones. In the projected timeline, the fishery benefits reach quickly their maximum value as the MSY is close to the present level whereas the tourism development is in a startup phase and has a larger potential. Tourism sector presents heterogeneous results reflecting the different mix of tourism services.

As shown in Table 26, the benefits are relatively homogeneous for each village in terms of potential values for fishery and tourism but differences in MPA costs are present. This explains the differences in RoI levels.

In terms of RoI, mean return is around 5.4 meaning that 1 € invested by the funding agency is expected to return 5.4 € (Figure 12). About 4 € will be directed to village stakeholders whereas domestic ones will receive the rest. IRR on monetary cash flows varies from 12% to 56% with a mean value of 36%.

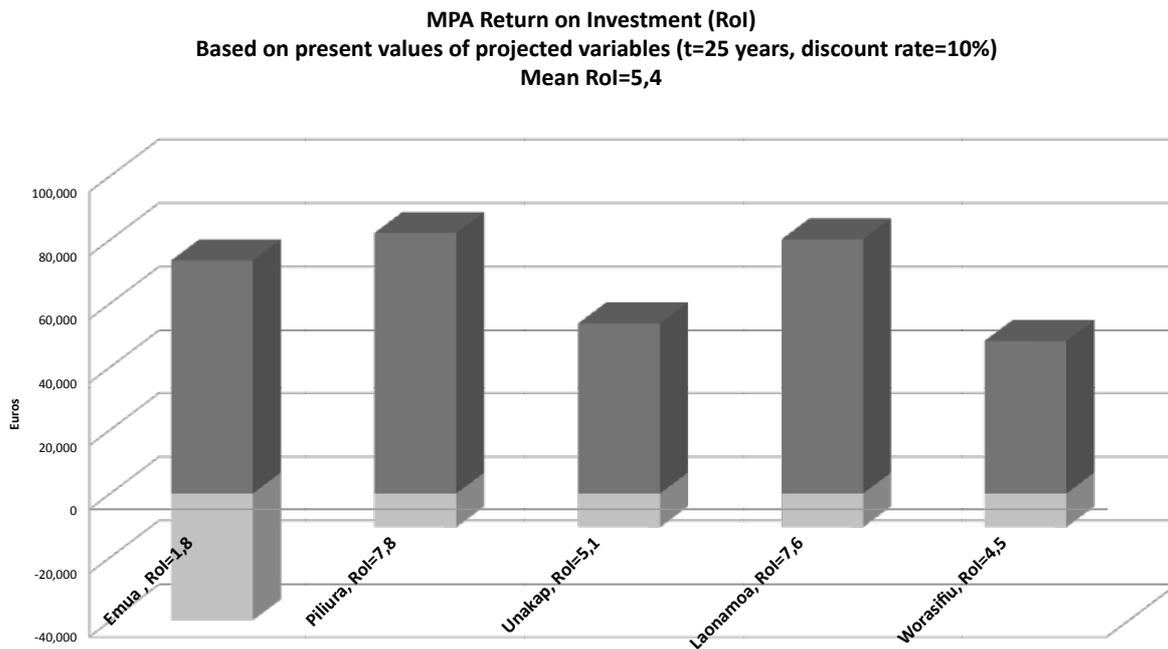


Figure 12: MPA cost benefit analysis and Return on Investment, projected values at 25 years , discount rate t=10%

Sensitivity analysis

Results of sensitivity tests have been applied to MPA P&L for 2009. Results with main uncertainties are presented in Figure 13. No uncertainties on a unique benefit have been enough to switch positive results from P&L statement to a negative one. Nonetheless the combination of all minimum estimates is a switching value for one of the village (see P&L chapter).

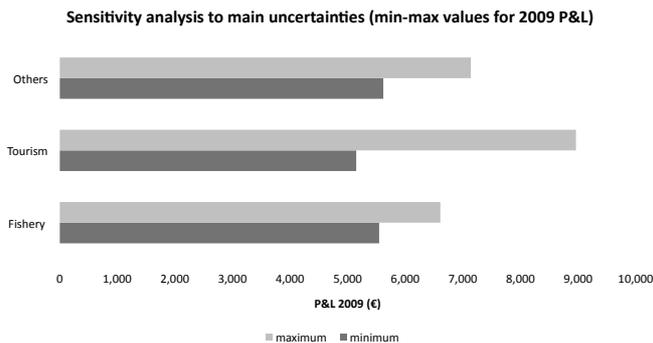


Figure 13: sensitivity analysis to main uncertainties on impact estimates

Sensitivity analysis conducted on discount rate are presented in Figure 14. The results of the study show a low sensitivity to different levels of discount rate on 25 years projections. The mean RoI has increased from 5,4 to 7,1 when the minimum discount rate level is applied (5%).

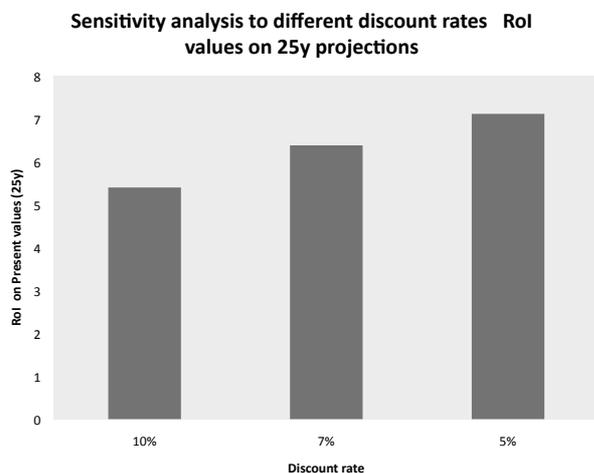


Figure 14: sensitivity analysis to discount rate (t= 10%, 7% and 5%)

Conclusions

Investing in community-based MPA for the development bank: is it worth it? An investment appraisal has been made in 5 MPAs to respond to this question through a bottom line analysis on their impacts on economic growth and poverty reduction for local stakeholders.

The objective of the investment appraisal is to give some criteria to support the decision-making process and facilitate comparison among projects.

Investment description

The average investment per community-based MPA is 2 400 €. y^{-1} (including amortizing of setup costs). Investments for each of the five MPAs have represented values ranging from 5 000 € to 19 000 € for the initial investment phase (setup and assets) and 900 € to 4 000 € for the annual operational costs. The investment has presented some original aspects: (i) the investment has been relatively low per receptor (village or community) and, (ii) investment was mainly focused on building capacity in the villages (70% of the operational costs) which will be the primarily responsible of the management of the MPA.

To be taken as a reference, the average annual cost observed has been 14 000 €. km^{-2} of protected area (including amortizing of setup costs).

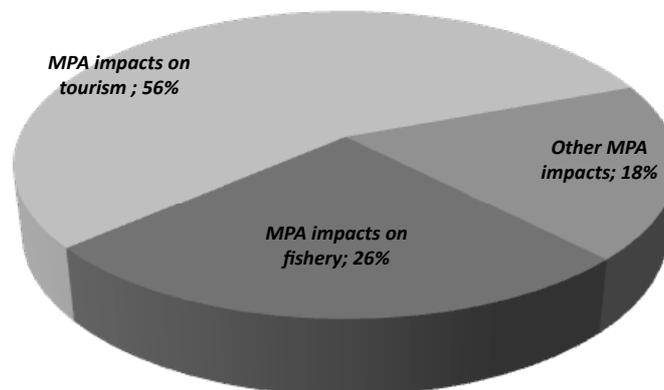
More than 95% of the origin of the costs has come from external agencies. Observed opportunity costs have been weak (estimated to be less than 400€. y^{-1}) and have mainly consisted of voluntary time dedicated to MPA management.

Investment appraisal

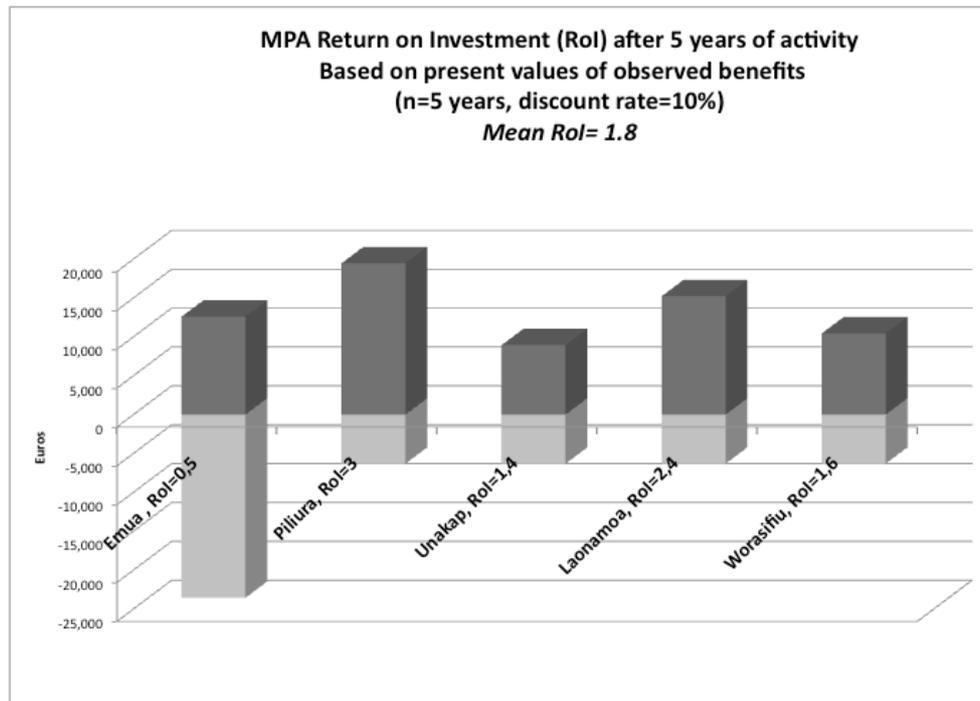
Regarding the impacts on economic growth and reduction of poverty, the following results have been found:

Result #1 MPAs managed by communities have made an average gross profit of around 8 900 €. y-1 (std=3 000). They concentrated mainly on rural tourism and fishery (56% and 26% of the total respectively), which represent both important sources of local cash incomes (30% of the total cash sources) and proteins for the villages. Less visible in the economic valuation, MPAs have had also positive impacts on the social capital, the ecosystem service of protection against waves and the option value attached to the ecosystem.

MPA economic benefit distribution
based on average benefits on added values from 5 MPAs, 2009
Mean benefit = 8.860€.y⁻¹



Result #2 Mean observed Return on Investment (RoI) is 1.8 after 5 years (std=0.9) with a potential of 5.4 (std=2.5) after 25 years. Not all the investments in MPAs have been recuperated after the first 5 years and for some of them the RoI stays close to 1 after 25 years of projections when main uncertainties on estimations are applied. Some precautions must therefore be taken in the MPA investment decision process (Result #3)



Result #3 If Return on Investment levels drives the investment decision in MPA, the development stage of the village fishery and tourism sectors must be taken into account. When other success key factors for MPA (e.g. ecological adequate context and effectiveness of enforcement) are met, the development stage of both sectors has a direct influence on the level of RoI and therefore on the optimal amount to be invested. Villages with low fishing effort and no tourism potential have given low RoI.

Result #4 Observed benefits on fishery sector from these small MPAs were revealed through an increase in productivity for the principal gears (estimated to vary from 4% to 33% increase in the catch per unit of effort). Both subsistence and commercial fishery were benefited. Other observed effects include: (i) catches more stable every fishing trip and, (ii) higher maximum fish size for villages with MPA. The MPA effects generally follow a gradient from the MPA border up to 500m before disappearing for the main species. For periodic MPA, the impact of opening temporarily the closed area seems to be low on the resource (less than 100kg.y-1) but important for the villages as catches are visible and shared within the community. Few effects have been observed on invertebrates. More generally, all these impacts on CPUES can be hard to perceive by local people, as increases are subtle for informal and artisanal fisheries. Fishery impacts have represented an average of 25% of the total benefits of the 5 MPAs.

Result #5 Benefits on tourism are present for the niche of rural tourism (through guest house and day tours family own-businesses). The importance of MPA in the choice of the site from visitors was estimated to vary between 40% to 75%. In a similar way, it was observed that, in average, for 60% of the visitors, at least one member of the group has realized some snorkeling activities. Nonetheless, the exact role of specific biodiversity indicators impacted by MPA (such as emblematic species, live coral reef coverage, etc.) compared to other attributes (i.e. transport, infrastructures, facilities) were not possible to be assessed due to the lack of control sites. The tourism benefits have represented more than 55% of the total benefits of the 5 MPAs.

Result #6 Other impacts include benefits on social and human capital, the option value and the ecosystem service of protection against waves. The first benefits have been observed through the estimated impacts of the learning from trainings and workshops. The benefits on the option value have been valued in terms of willingness to work through transfer benefit. This corresponds to the amount that people are ready to give to maintain in the future the potential of some ecosystem services such as fishing or tourism. The last benefit is the contribution of MPA in maintaining the ecosystem service of protection against wave produced by coral reefs. These three values have been estimated to represent 20% of the total benefits of the 5 MPAs.

Result #7 In average 70% of the benefits flows have been directed to the villages. The other 30% went to the national stakeholders (mainly through tourism activities). Main beneficiaries inside the villages are fishermen and tourism business owners. It was not possible to determine any revenue distribution indicators (e.g. Gini coefficient) because of the complex mix between subsistence, customary and market economy. Nonetheless, fishery sector seems to have a wider distributional impact than tourism where benefits are concentrated in a few households.

Result #8 The opportunity costs at local level have been found to be very low and no local stakeholders have been identified as really worse off as regards to before the setup of the MPA. If we take in account that most, if not all, of the direct MPA costs are assumed by external agencies, the cost-benefit ratio is likely to be positive at a village level even when benefits are low (i.e. commercial fishery or tourism sector in a startup phase). The need of compensation for conservation seems therefore not necessary.

Result #9 Observed benefits have represented an average of 7% of the total village Gross Domestic Income (GDI). Impacts have been assessed at a village level to take into account some characteristics of customary, community and subsistence economic specificities.

Result #10 No observations have been found to demonstrate that MPAs have influence on the level of maximum sustainable yield for fishery or for the maximum carrying capacity for tourism. Therefore the hypothesis that MPA can ensure sustainable benefits (from fishery and tourism) at intergenerational scale remains uncertain.

Recommendations

Recommendation #1.

Results of CBA have proven to be sensible to the level of investment and on the stage development of the fishery and tourism sector. As a recommendation a level of annual investment of 6 000 € per MPA including classic amortizing of setup costs seems a maximum level in a context of startup stage for commercial fishery and tourism activities (eq. to 25 000 €.km⁻² of protected reef).

Recommendation #2.

Networks of MPAs present attractive results when compared to unique village-based investment. They have shown the existence of scale costs in MPA investment. Additionally, if the network design is based on fish movement patterns and spillover effects spatial distribution, it can be a multiplier of fishery benefits.

Recommendation #3.

It has been impossible to describe what happens when external assistance is finished after the setup of the MPA. Nonetheless, it can be suggest that external intervention serves as a way to maintain motivation support from the villages. This may compensate for the fact that the discrete MPA effects, revealed by the present research work, may be difficult to perceive by people locally. As described previously, perception and realization of benefits are a key factor in the permanency of the MPA. Therefore it may be prudent to undertake some campaigns to highlight these benefits. On the same way, the role of co management is now recommended as a priority for resource management. The suggested interventions in the villages from external agencies take the form of technical assistance, monitoring and fishery regulation implementation.

Recommendation #4.

Protected areas are not the panacea in front of future challenges in Oceania. Increasing fishing pressure on coastal resources and erosion of traditional management required to complement the MPA with a different set of rules on fishing regulation to ensure sustainable fishery. Rules such as control of fishing effort or fishing quotas have been left aside because of their difficulty to be implemented. These may be proposed again in the context of community-based management. In this sense the MPA can be seen as an attractive governance tool.

Recommendation #5.

At a national level, financing many MPAs at a scale of a village is a challenge due to the potential high transaction costs and difficulty of fund controlling. The network approach has permitted to

reduce this issue covering a reduced number of MPAs but no background exists for larger networks. Driving funds through local NGOs with human resources is one option but represent an expensive solution. The setup of small trust funds with a direct refunding to each village committees seems also a valuable option that needs to be precisely analyzed.

Recommandation #6.

Promote local trainings in rural tourism business skills and sustainable practices in fishery are necessary to improve RoI from MPAs.

Recommandation #7.

If community management is to be used as a basis for resource management, some capacity building activities as well as institutional support should be directed to maintain the community social and governance mechanisms. In the same way, official recognition of village by-laws or other legal instrument may be necessary to compensate the loss of respect to community rules.

Recommandation #8.

Communities are getting involved because they want to better manage their resources for their own benefit. It is therefore important to communicate realistically the benefits of MPAs. This will allow the communities to observe the connection between their actions and accrued benefits and maintain their support to the MPA.

Recommandation #9.

Effects on biodiversity indicators inside the 5 MPAs have not been assessed directly. Evidence from biological assessments in near geographic zones show contradictory results that may be explained by sampling strategy or fishery context than by ecological processes. Even if our study shows a spillover effect from the border of the MPA, the question is to know how these small MPAs work. Do they simply concentrate biomass in a similar way to fishery aggregating device (FAD) for pelagic species (C. Chauvet, pers. comm) or do they create biomass such as described by MPA theory? The understanding of the underlying process is important to value the contribution of MPA as a tool for the conservation of some biodiversity indicators.

Recommandation #10.

More case studies are necessary to complement the investment appraisal and give more precise criteria of factors influencing RoI. Community management institutions might not be resilient to factors such as population growth and market economy (Cinner et al., 2007). Different configuration of socio-economic context (e.g. fishing effort and tourism development) should give complementing results.

Appendices

Appendix n°1: Results from the household survey

The results of the household expenses surveys from Unakap and Nekapa are presented in Table 27. Estimates for the other villages are based on the previous results and the HIES survey (Vanuatu, 2006). The subsistence incomes represent an average 37% (std= 2) of the expenses of a household in the zone. In value, the average expenses for a household are 396 €.month⁻¹ (std= 40).

The salaries represent incomes from family members working in town, abroad or in a business and sharing part of them with the family in the village. It is usual that one or more member of each family is out of the village in construction and/or housekeeping duties. Stays are generally short (1-2 years) to cover some specific needs (house building) but can become permanent in some cases. In the last 5 years, many men have spent between 6 to 8 months in New Zealand and Australia for crop collection. It is an agreement signed with the Vanuatu government. Most of the ni-vanuatu workers succeed in saving money there and bringing it back home. The weight of this income as well as the social impact is important to the village. It was not possible to report and quantify it during the time of the survey.

		(1)		(2)				
		Unakap	Nekapa	Emua	Piliura	Laonamoa	'orasif	Saama
Monetary needs	% total	60%	64%	69%	60%	64%	60%	69%
Alimentation		30%	27%	24%	30%	27%	30%	24%
Other expenses		24%	32%	41%	24%	32%	24%	41%
Non merchant expenses (Donations)		5%	5%	4%	5%	5%	5%	4%
Non monetary needs	% total	40%	36%	31%	40%	36%	40%	31%
Total monthly average needs per household	Euros (€)	373	420	479	373	420	441	455
STD		43	47					

Table 27 : HIES results. (1) are results from the surveys, (2) are extrapolated data.

Sales to the market are made by women selling fruits, vegetables, prepared food and handcrafts. Incomes are rapidly limited by the working capacity of the family, the transport capacity and the time spent in the market to sell the goods.

<i>To be filled by operator</i>	Place: _____	Code: _____	Month: _____
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TOURISM SURVEY FOR EFATE

We hope you enjoy your stay in Vanuatu. We need your help to learn more about how you spent your holiday here. We are not selling anything; we are interested in your opinions. Everything you tell us is 100% anonymous. We hope you are willing to participate in this survey. It will take you xx minutes.

1. **What is your country and city of residence?** _____
2. **In which age group are you?** 15-20 21-30 31-40 41-50 51-60 60+
3. **Number of adults?** _____ **Number of children?** (Under 15yr) _____
4. **If not resident, did you travel to Vanuatu on a pre-paid package?** Yes No
 - a. **If yes, did the pre-paid package include:**
 - Accommodation: Yes No
 - Tours/cruises: Yes No
5. **How many nights did you stay in the place where this survey is conducted?** _____
6. **In this same place, how much did you spend on the following items?**

ITEMS	AMOUNT	CURRENCY
Accommodation, meals & drinks		
Bus / Taxi / Car rentals (to transport to this place)		
Pre-paid tour in Port-Vila		
Water sports activities		
Snorkelling (guided tour and/or gear rental)		
Specific activities (caves, cliff jumping, hiking, etc.)		
All other (Handicraft, etc.)		

7. **How did you hear about this place?**
 - Website Brochure Travel guide Friend Travel agency Other: _____
8. **If resident in Vanuatu, do you come regularly to this kind of place in Efate?**
 - Once a year 2-6 times a year 7-12 times a year 13-20 times a year >20 times
9. **To maintain or improve some of the attributes of the coral reef ecosystems, a marine reserve has been setup by the village. This contributes also to the sustainability of its fishery. Would you have agreed to pay an extra fee to the village for your snorkel activities?**
 - Yes No
 - a. **If yes, can you help us specify the amount?** (it is a one time payment during your visit):
 - 100-500 vatu 500-1.000 vatu 1.000-2.000 vatu 2.000-3.000 vatu > 3000 vatu
 - b. **If no, can you tell us why?**
 - Do not agree with the question Do not trust the money management Do not care about it
 - Do not want to pay for others' benefit Other (specify): _____

What were the 1st, 2nd and 3rd most important factors in making your decision to visit this place? (you may also check less than 3 boxes)

	1 st most important	2 nd most important	3 rd most important
Recommendation of friend/travel agency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural activities and life in village	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Accommodations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Price	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beautiful seas and beaches	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bush hiking and/or guided tour	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The marine reserve	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Snorkelling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water sports activities (kitesurfing, kayak, game fishing, etc)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Just to relax/pleasure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Short travel time from Vila	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (please specify) _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Did you know the existence of the marine reserve before you come to this place?

Yes No

Have you (or someone travelling with you) realized any snorkelling activities?

What are the 1st, 2nd and 3rd most important expectations when you or one member of your travelling group go snorkelling? (you may also check less than 3 boxes)

	1 st most important	2 nd most important	3 rd most important
Observe plentiful and colourful species (fish, clamshells, etc)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Meet special wildlife such as dugongs, rays, etc.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Swim in pristine and clear water	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Have a comfortable experience without too much swimming or scratching	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Observe big fish individuals (e.g. big groupers, big lobsters)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Look healthy and colourful coral reef	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (please specify) _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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