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## **Scoping potential livelihood benefits and costs of sport fisheries in Papua New Guinea**

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# 1 Acknowledgments

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## 2 Executive summary

The project investigated the potential for developing local-based sport fisheries in PNG as a means of providing a sustainable alternative livelihood solution that replaced low value extractive capture with high value catch and release. As well as evaluating the potential livelihood benefits and costs of sport fishing, the study evaluated the capacity and knowledge needs required to underpin any future sport fishing development.

The objectives were to:

- Determine the livelihood costs and benefits of existing sport fisheries for local communities;
- Determine the key attributes of commercially and environmentally sustainable sport fishing enterprises;
- Conduct a preliminary exploration of the ecology of the principal species exploited by sport fisheries, and the resources on which they depend, to identify critical gaps in the information needed for effective management;
- Identify significant capacity building needs and resources needed to address those needs.

The study found:

- There are great opportunities for the development of a local sport fishing industry in PNG, with long term benefits to livelihoods, environments and resource sustainability.
- However, there is a lack of even the most basic information across all areas meaning extensive knowledge development will be necessary, in particular:
  - Fisheries Ecology: including life-history details, habitat requirements, movement patterns and biological details
  - Fishing Operational Issues: including identification of prospective sport fishing locations, patterns of mortality relative to different fishing equipment and protocols for handling captured fish
  - Threats and Impacts to Habitat and Water Quality: including the extent of habitat and water quality degradation, and options for mitigation and/or remediation of problems
  - Specific Cost-benefit Analysis of different Business Models
  - Social Impacts and Potential Problems: including resource allocation, ownership and recompense issues, impacts on societies and cultural values, and the development of associated ventures
- There was substantial need for capacity building across all areas: including running a sport fishing business, promotional activities, working with international customers, conducting sport fishing operations, developing and implementing management, increasing awareness about the need to develop ecosystem resilience and sustainability, and understanding the long term trade-offs implicit in developing a long-term sport fishing venture

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### 3 Introduction

Nature-based tourism, such as sport fishing, has been regarded as a potential panacea for creating sustainable livelihoods in developing countries, because it creates value from biodiversity, thus generating an incentive to preserve and manage natural assets. This 'biodiversity linkage' alternative livelihoods model was tested by Salafsky & Wollenberg (2000) across south-east Asia and Melanesia in the 1990s and showed that eco-tourism provided the strongest 'win-win' linkages and enterprise longevity compared to more harvest-based initiatives (Salafsky & Margoluis 1999).

Papua New Guinea (PNG) is a country rich in natural resources, with diverse and unique natural environments, and renowned sport fish found nowhere else in the world, suggesting great sport fishing potential. However, there has not been any structured assessment of the livelihood costs, benefits or commercial potential of sport fishing enterprises in (PNG), despite its unique, world-renowned sport fish such as the endemic Black Bass, *Lutjanus goldiei*. If successful this form of enterprise could generate significant environmental benefits by creating an incentive to conserve the target species' key habitat, and has the potential to diversify rural livelihoods, building resilience to external impacts such as world prices for primary products and climate change.

Experience from sport fishing in other parts of the world has shown that remote indigenous communities can derive livelihood benefits from fisheries. However, there are limitations and costs that need to be managed. These include training, inexperience of business commercialization, fluctuating tourism markets, social networks and inter-community friction and territoriality. Importantly, the planning and development of any enterprise has to be participatory (De Lopez 2003) in order to ensure culturally-appropriate values and goals (Gutberlet et al. 2007). Additionally, the success of community-based eco-tourism depends on initially identifying concrete socio-economic goals, and site-specific market analysis and research on the linkages between those goals and community actions and incentives (Kiss 2004).

It is clear that a study of livelihood costs and benefits, and commercial potential is required before a local-based sport fishing industry could be developed. However, the knowledge needs are much more extensive. A long lasting ecotourism industry is dependent on the health, integrity and resilience of the resources upon which it is based. Consequently, there is a critical need to understand the fisheries biology, the fisheries ecology and the health of the habitat and food resources on which the fishery depends. In addition, the fishing operation itself needs to be managed to promote longevity of the fishery, and as a result best practice for conducting fishing activities needs to be assessed and developed.

This study is aimed at (i) assessing the viability of developing a local based sport fishing industry in PNG, and (ii) assessment of the capacity and knowledge needs required to underpin future sport fishing development.

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## 4 Objectives

The project aimed to explore the potential of developing local-based coastal sport fishing ventures in PNG to enhance livelihoods from smallholder fisheries. The principal objectives were to:

1. Determine the livelihood costs and benefits of existing sport fisheries for local communities.
2. Determine the key attributes of commercially and environmentally sustainable sport fishing enterprises, and so determine the key principles for developing successful small holder sport fishing operations;
3. Conduct a preliminary exploration of the ecology of the principal species exploited by sport fisheries, and the resources on which they depend, to identify critical gaps in the information needed for effective management;
4. Identify significant capacity building needs and resources required to address those needs.

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## 5 Methodology

The initial step in addressing the objectives was to review the current state of knowledge relevant to developing a local-based sport fishing industry in PNG. This comprised a detailed review of the international peer reviewed literature and all other credible sources of information (books, government reports etc.). This literature review informed each of the objectives. The desktop information was extended with interviews and focus groups involving current sport fishing operators and other knowledgeable stakeholders and interested parties, conducted in West New Britain, Port Moresby and in Australia. In addition, two field trips were carried out to the Baia sport fishing venture on West New Britain. This operation was chosen as a case study venture because it has a continuous history of viable operation, so could provide information on all aspects of sport fishing operations in PNG, from business operations, through social issues and fishing operations, to threats to the viability of the sport fishery.

The results of these studies are reported under 5 headings:

1. The current state of knowledge and key issues
2. Livelihood costs and benefits of existing sport fisheries (Objective 1)
3. Key attributes of commercially and environmentally sustainable sport fishing (Objective 2)
4. The mode of sport fishing operations
5. Ecology of the principal species exploited by sport fisheries (Objective 3)
6. Conclusions and recommendations (Objective 4)



## 6 The current state of knowledge and key issues

Evaluation of the current state of knowledge relevant to developing a local-based sport fishing industry in Papua New Guinea is the first crucial step in determining the potential of this initiative to provide a viable alternative to extractive fishing. It is also the necessary underpinning for scoping the key issues involved in ensuring the success of such a venture.

The overall knowledge base across the spectrum of issues relevant to the development of local based sport fisheries, and their livelihood costs and benefits is extremely sparse. The required knowledge includes understanding of the:

- benefits and costs of sport fisheries,
- extent of utilisation of potential sport fish by local people,
- fisheries ecology of Papua New Guinea's key sport fish, particularly black bass and related species,
- ecological interactions of sport fish with the broader ecosystem,
- extent of indigenous knowledge and awareness of key aspects of the fisheries ecology of key sport fish, particularly black bass and related species,
- key attributes of successful sport fisheries from a business-operational point of view,
- key operational features of a tropical sport fishing industry in relation to maximising the resilience of the component fish stocks and sport fishery catches,
- appropriate management and regulatory framework for tropical sport fisheries species.

Extensive literature research and contacts with experts in each of the fields showed a surprising lack of information across any of these topics.

1. The lack of evaluation of livelihood costs and benefits of sport fisheries to local people was a key gap in knowledge needed to understand the potential of the whole project, so was addressed as a key priority through an extensive literature review and theoretical development. This work is detailed below (section 5) and is now published in the international literature (Wood et al. 2013).
2. No studies have specifically addressed the extent of utilisation of potential sport fish by local people. The most relevant information comes from two ACIAR reports (Blaber 2003, Fisher 2010) into the barramundi fisheries of Western Province and the Fly River, and a report on village-based marine resource use and rural livelihoods in Kimbe Bay, West New Britain, commissioned by The Nature Conservancy (Koczberski et al. 2006). Although they are not specific to black bass, they show that large coastal predatory fish can be important sources of food and income for local communities, and that population growth and increasing cash needs of villagers are leading to increasing commercialisation of natural resources.
3. Unlike barramundi, a commercially exploited species, there is almost no formal knowledge base on the fisheries ecology of Black Bass or related species in Papua New Guinea. The exception is a report of the nursery habitat utilisation of black bass and related species in coastal ecosystems of Kimbe Bay in a current ACIAR project (Sheaves & Johnston in review). Additionally, the only published records of black bass occurrence come from compendia of species lists of Papua New Guinea (e.g. Fishes of New Guinea;(Munro 1967)), two reports on the status and health of estuarine ecosystems of the Milne Bay region (Sheaves 2007, 2009), and a miss-

identification of a juvenile black bass as a juvenile mangrove jack (*Lutjanus argentimaculatus*) in a survey from Kimbe Bay (Jenkins 2000).

4. The lack of biological and ecological information from Papua New Guinea's coastal ecosystems, and specifically in relation to black bass and related species, means no information is available on the ecological interactions of sport fish with the broader ecosystem besides minor references in the reports mentioned above (Sheaves 2007, 2009).
5. Again, there is little information on the extent of indigenous knowledge and awareness of key aspects of the fisheries ecology of key sport fish, but the studies that have been conducted (principally along the Fly River and adjacent coasts) indicated little indigenous knowledge of important issues like spawning patterns, nursery ground use or migration for barramundi, the only species investigated (Fisher 2010). Additionally, there was little awareness of the need to manage fish stocks as sustainable resources.
6. Understanding of the key attributes of successful sport fisheries from a business-operational point of view does not exist for the tropical Pacific, with the information available relating mainly to temperate salmon fisheries (e.g. Butler et al. 2009) or Caribbean shallow water sport fish (Bruger & Haddad 1986), so of doubtful relevance.
7. Similarly, key operational features of a tropical sport fishing industry in relation to maximising the resilience of the component fish stocks and sport fishery catches, is only available from overseas (Bruger & Haddad 1986).
8. The only available information on management of Papua New Guinea's coastal fisheries comes from the ACIAR reports on commercial barramundi fisheries (Blaber 2003, Fisher 2010). Although this contains some pertinent information it does not align with the management and regulatory frameworks needed for tropical sport fisheries species. While there is some information from overseas (Bruger & Haddad 1986), most related to very different environments, fish and fisheries and so is of only partial relevance.

The almost total lack of knowledge resources across the key areas of understanding means that each of these requires new research for complete evaluation. As a result, the SRA concentrated on developing preliminary understanding of four key issues; (i) evaluating the overall benefits and costs of sport fisheries to local people in Papua New Guinea, (ii) determining the key attributes of a commercially and environmentally sustainable sport fishing enterprise, (iii) evaluating the likely ecology of the principal species exploited by sport fisheries, and (iv) scoping the capacity building needs and resources required to address those needs.

Each of these was investigated in as much detail as possible given the extent of available knowledge. However, the scarcity of that background information means the results of this SRA should be considered as provisional outcomes aimed at providing the direction for more specific studies, rather than definitive evaluations.

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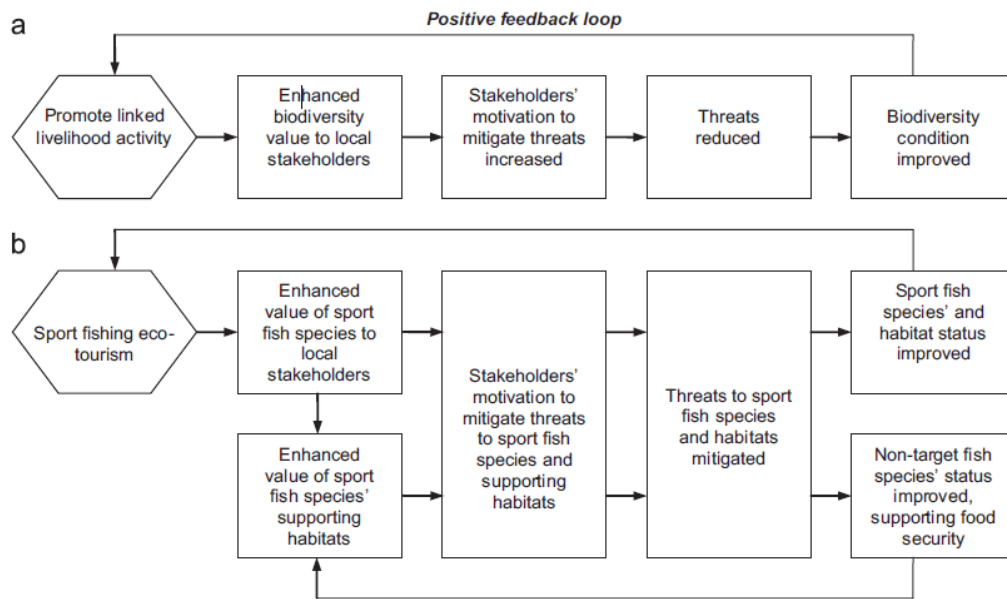
## 7 Livelihood costs and benefits of existing sport fisheries

An overall cost-benefit assessment is the key piece of knowledge integration necessary to provide the basis for evaluation of the potential of a sport fishery development project to deliver a valuable outcome for the people of Papua New Guinea.

The livelihood costs and benefits of an existing sport fishery for local communities were evaluated via extensive literature review and stakeholder interviews. The limited research into sport fisheries in developing countries was augmented with a review of community-based ecotourism, integrated conservation and development projects (ICDPs) and common property management literature to propose design principles.

**Cost and benefits, National Level:** From the perspective of Papua New Guinea's national interests, experience from around the world underlines the critical need for alternative livelihood strategies that can generate income and simultaneously conserve fish stocks and their habitats. This need is acute in Papua New Guinea because high population growth rates and poverty are likely to elevate the vulnerability of many coastal communities in the Pacific region to climate change. However, current sport fishing ventures in Papua New Guinea are at an early stage of development; run by a small number of established operators who employ local on-ground staff and remunerate local resource owners for access to sport fishing resources. Consequently, there is considerable scope for future development to (a) expand the industry by more aggressive promotion into international markets, (b) develop the industry to provide greater involvement by local communities and Papua New Guinea nationals at all levels, and (c) develop an integrated business model that includes multiple sites in a 'sport fishing tour', similar to that of bird watching ventures, to provide assurance of access of customers to fishing regardless of any short-term changes in political, social or weather conditions at particular sites.

**Costs and benefits, Local Level:** From a local-level perspective sport fishing ventures provide additional income to communities and individuals that are based on the non-extractive utilisation of their fisheries resources. These include both direct benefits (river fees, land rent fees, a percentage of income from sport fishing operations) and indirect benefits (support of local village industries and other local ecotourism opportunities such as bird watching). A larger industry with greater local involvement would increase these benefits, and provide a variety of co-benefits. These include (a) the conversion from extractive resource to a resource where financial rewards are based on non-extractive utilisation; meaning no venture-related resource depletion, (b) substantial financial returns that would fund the import of protein so reducing the danger of over-exploitation of the fisheries resources and provide funds for other alternative livelihood benefiting projects, (c) provide local employment opportunities improving social cohesiveness and helping power local commercial development, (d) provide a stream of tourists around which to develop other ecotourism ventures (snorkelling, kayaking, village tours, trekking, bird watching), (e) enhanced motivation to mitigate threats to the resources and supporting habitats, leading to enhanced fisheries resource health and long-term sustainability, and (f) overall co-benefits from participating in an integrated conservation and development enterprise (Fig. 1).



**Figure 1: Conceptual representation of (a) the enterprise approach to integrated conservation and development, and (b) the double linkage between conservation of target sport fish and non-target species and their habitats, and livelihoods development created by a community-based sport fishing ecotourism. Hexagons represent enterprises based on biodiversity, and boxes represent outcomes. (from Wood et al. 2013)**

Although benefits of a well-run sport fishing venture are extensive they are often not fully appreciated by local people, and education is needed to help them understand the nature of benefits and the need to develop resilience in their resource and mitigate external threats to the resource. In addition, development of sport fishing enterprises may see broader impacts of the enterprise emerging, which go beyond those usually evaluated in standard assessment of ecotourism success in financial or biodiversity terms.

Costs are low in terms of the fishery, but there are potential local issues in terms of increased numbers of visitors and the consequent potential for social and health costs. There are also costs in terms of increased local tensions over resource ownership that can range from minor to severe depending largely on the initial development of access and management arrangements.

These results have been published in Wood et al. (2013).

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## 8 Key attributes of commercially and environmentally sustainable sport fishing

Literature review, interviews and case study assessments allowed the key attributes of commercially and environmentally sustainable sport fishing ventures to be scoped in detail.

*Commercial Sustainability:* Five prerequisite principles underpin the success of sport fishery enterprises from business, social and livelihood perspectives that have been developed in a recent peer reviewed international journal article (Wood et al. 2013):

1. **Capacity:** There must be adequate local capacity to effectively manage sport fishery businesses and facilities. This capacity needs to be supported by cross-scale co-management amongst stakeholders and continued upgraded by ongoing up skilling.
2. **Governance:** Appropriate governance arrangements need to be developed and implemented at an early stage to ensure the equitable dispersal of benefits to all members of the local community, and to enable effective conflict resolution.
3. **Resource Ownership:** The clear delineation of resource-ownership boundaries and rights must occur before the enterprise begins in order to minimise the potential for future conflict to lead to business failure.
4. **Benefits and Impacts:** Development of the business plan needs to ensure that there are clear social, biodiversity and ecosystem service co-benefits. In particular it is important that there are real and clearly identifiable improvements in income, health, education and food security for local people. At the same time there should be no net detriment to the status of the target and non-target species, their habitats, as well as non-fishery ecosystem services. If possible the business should be developed in a way that will enhance these attributes.
5. **Evaluation of Co-Management:** Monitoring and evaluation of adherence to these principles is needed within an adaptive co-management framework. This should be founded on clear and well established baselines and take a social–ecological systems approach that includes all stakeholders in social learning and power-sharing.

*Environmental Sustainability:* An environmentally sustainable sport fishing venture relies on healthy, resilient and sustainable fish stocks, and the habitats, environment and resources that sustain them. Key attributes are:

1. **Well Managed Stocks:** Well managed fisheries stocks where the biological and ecological attributes of the target species are well understood so the management can be targeted to maintain harvest from all sources at sustainable levels.
2. **Well Managed and Intact Habitats:** Proactive management of habitats is essential because habitat type and quality are the key determinants of the health and resilience of coastal fisheries stocks.
3. **Viable Connectivities:** Most fish use a range of habitats throughout their lives (spawning, feeding, nursery grounds etc.) so it is critical to ensure that connections among these key habitats are maintained.
4. **Well Managed and Abundant Resources:** Most sport fish are high level predators so they rely on abundant and appropriate prey. As a result it is essential that prey resources as well as the fisheries stocks themselves are managed for sustainability.
5. **Well Managed Fishing Activities:** Considerable effort needs to be expended on the management of sport fishing activities. There are two principal considerations; (i) the management of activities to ensure the health of stocks. For instance, methods of handing fish and hooks used need to be appropriate to minimising unintended

mortality. (ii) Sport fisheries are essentially ecotourism ventures, so the same considerations of managing fishing activities also apply to ensuring that customers and outside observers (e.g. conservation groups) have a clear vision that the sport fishing activities are environmentally sustainable.

6. **Control on the Impact of Outside Factors:** Many outside factors can influence the health of fisheries stocks and through them the success of sport fishing ventures. This includes ensuring that non-sport fishing harvests are managed sustainably, that habitat and water quality are not impacted by other industries such as plantation agriculture, forestry and mining. The few impact studies carried out in Papua New Guinea show complex patterns of impact and limited success in attributing causality for environmental degradation (Brodie & Turak 2012).

These results contributed to Wood et al. (2013) and will also contribute to a stand-alone publication. However, this issue has implications outside PNG, so will require additional fieldwork and interviews outside this study.

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## 9 The mode of sport fishing operations and operational issues

Although not a specific objective of the study, the Baia case study provided the opportunity to investigate the mode of black bass sport fishing operations and important operational issues identified during its development.

The Baia Black Bass and Spot-tail Snapper sport fishing operation on West New Britain was visited during two research trips to the “Baia Sport fishing Lodge” from 23-28 September 2012 and 21-28 May 2013. These trips provided the opportunity to observe the operation of the sport fishery and scope areas of concern identified by operators and staff.

### *The Operation*

Papuan Black Bass, *Lutjanus goldiei* and Spot-tail Snapper, *Lutjanus fuscescens*, are the main attraction to the recreational estuarine sport fishery in Baia. The clientele are mainly Australians and Japanese. Fishing trips only run through the dry season (between May and November), are irregular, and fishing effort is distributed between 4-5 rivers (often with blue water fishing in between). Most fishing is carried out from dinghies operated by a guide and deckhands, with fishing generally conducted using cast or trolled artificial lures. Most fish of target species are released after capture, although incidental catches of non-target species may be retained and consumed by local people. The fish captured range in size up to 20kg, but most fish caught are in the 1-6kg range. The sport fishery operates along similar lines to mangrove jack (*Lutjanus argentimaculatus*) sport fisheries in tropical Australia, so the methods and procedures used are not unusual. However, the Black Bass fishery deals with substantially larger fish (up to 20 kg+ compared to about 5kg maximum) so many of the operational issues (e.g. handling and release of fish) are not directly comparable between the two fisheries.

### *Operational Issues*

Observation of fishing operations and discussions with operators indicated some areas of concern related to the fishery itself; (i) catches seem to be declining over time, (ii) fisheries population sizes are unknown and this has a large bearing on the potential for depletion, (iii) there are mixed signals about the recovery of fish following release, and (iv) the behaviour of the fish when hooked may increase fishing mortality.

**Changes in catches through time:** Despite a catch and release policy, catches at Baia have been decreasing through time (from 2008 to present). This is supported by limited data. (i) There have been venture-based tagging studies but no recaptures have ever been reported. (ii) Catches around Baia are low in comparison to those in the newly developed fishing area of East Kove, to the West of Baia. There catches are similar to initial catches at Baia. For instance, 98 black bass were captured by 5 anglers over the same time period (May 2013) as 20 black bass were captured by 10 anglers at Baia. Although a trip with 98 captures is high even for East Kove, catches of approximately 50 fish per trip are normal. Reasons for the reduction in catches are unclear but it seems to be the major operational issue for the fishery and one requiring detailed investigation.

There is the perception among locals and anglers that bass are still abundant and that reduced catches and a lack of recaptures result from fish learning not to take lures from past experience, and from released fish “telling other fish about the lures, and teaching them to avoid them”. However, the irregular nature of fishing trips (only run through the dry season and then irregularly), the distribution of fishing effort between 4-5 rivers (often with blue water fishing in between), suggests that individual fish are unlikely to be captured often enough to become wary and learn to avoid lures, unless populations sizes are much lower than perceived. Also, fish do not have the cognitive abilities to teach each

other, so the decrease in catches is not likely to be caused by changes in 'learned' fish behaviour.

**Likely population sizes:** The possibility that population sizes may be low is supported by the apparent low productivity of the waters where black bass are fished. The waters are usually very clear, which is typical of pristine tropical rivers which feature low productivity. This would suggest that they are unlikely to support abundant large predator populations. There is no data on the ecology of black bass but it has been suggested anecdotally that they spend their whole life in the same river. If this is the case, and population self-recruitment is high, then populations could easily be reduced by even moderate levels of fishing mortality.

**Handling procedures:** There is the perception that black bass recover well from fishing injuries, based on the observation of the occasional capture of fish with evidence of past injuries (e.g. deformed jaws, scars, etc.). In Baia, black bass fishing is mostly done by casting and trolling artificial lures fitted with barbed treble hooks (one in the front, one in the back of the lure). Barbed hooks are harder to remove than barbless hooks and the treatment of animals during hook removal can affect post-release survival. Upon capture, fish are brought on board, usually with the help of a landing net, the hooks are removed and the angler(s) and fish pose for photos. The handling time while removing hooks and taking photos means that fish are exposed to air for some time, when they are deprived of oxygen and under increased physiological stress, following a period of intense physical exertion (fighting). Hooks often get caught on the gill area and eyes, and inexperienced anglers can take an extended period to land a fish, increasing stress (during both trips, fishing parties included both children and inexperienced anglers). Even large fish (e.g. 20 kg) are removed from the water for photos. Although a landing net is used, fish are then held by the lower jaw while posing for photographs, another potential source of injuries. The use of barbless hooks and modified handling practices may help reduce the problem of declining catches, particularly if population sizes are low.

If the reduction in catches is a function of much smaller populations than usually perceived, the observed injuries may indicate a contributing cause to catch declines over time. For example, an average mortality of 18% (median 11%) was found across catch-and-release sport fisheries in the United States, (Bartholomew & Bohnsack 2005). Even if black bass post-release mortality is lower than this, it can compound at each hooking and release event (cumulative mortality), and this can be especially important for large, long-lived species such as black bass (Bartholomew & Bohnsack 2005).

**Fish behaviour:** The behaviour of black bass also has the potential to increase stress and injury. They often swim into snag jams after being hooked leading to high escape rates. This often results in the loss of the lure, with the potential that it could impede feeding or become tangled with the snag trapping the fish. Released fish are also vulnerable to predation, as injured and stunned fish can attract predators such as sharks and crocodiles, and wounds are susceptible to infections and disease. Stress and injuries from capture can therefore affect feeding, behaviour and condition. Even if post-release mortality is low, the recurrent capture of these predators could lead to undetected mortality and rapid population decrease.

## Conclusions

There is clearly a need for studies aimed at ensuring catchable stocks are maintained and developing best-practice operational protocols. A lack of any fisheries or ecological data is a severe impediment to management of fishing activities. There is no information on basic life-cycle characteristics such as recruitment patterns, juvenile habitats, growth rates, longevity, population sizes, size structure and size at maturity, and movement and connectivity between rivers. This information is essential for the appropriate management of this fishery and these needs are covered in more detail in the following section of the report.



## 10 Ecology of the principal species exploited by sport fisheries

In addition to issues identified relative to the mode of the fishery, extensive review of the literature was conducted to investigate the ecology of the principal species likely to form the basis of sport fisheries in PNG. The key species are the Papuan Black Bass, *Lutjanus goldiei*, and the Spot-tail or Freshwater Snapper, *Lutjanus fuscescens*.

The extensive review of the literature found an almost complete lack of information about *L. goldiei* and *L. fuscescens*, except for many anecdotal references to their prominence as PNG's key endemic estuarine and freshwater sport fish. From a scientific point of view, there have been very few studies of any type for these species and almost no ecological studies (Table 1) that could begin to provide the information necessary to underpin a well-managed sport fishing industry.

**Table 1: Summary of published studies into the ecology of *Lutjanus goldiei* and *Lutjanus fuscescens*.**

|   | REFERENCE  |
|---|--|
| <b>Black Bass, <i>Lutjanus goldiei</i></b>  |  |
| Nursery habitats  | (Sheaves & Johnston in review)   |
| Mention in species occurrence lists   | (Berra et al. 1975, Allen & Boeseman 1982, Jenkins 2000, Sheaves 2007, 2009)                     |
| Mention in impact assessment of Fly River   | (Smith & Morris 1992, Swales et al. 1998, Swales 2001, Storey & Yarrao 2008, Storey et al. 2008) |
| <b>Spot-tail Snapper, <i>Lutjanus fuscescens</i></b>  |  |
| Nursery habitats  | (Sheaves & Johnston in review)   |
| Mention in species occurrence lists   | (de Beaufort & Weber 1912, Alien et al. 2000, Polhemus et al. 2008, Druzhinin 2011)              |
| Other relevant studies(principally by implication of common occurrence with barramundi, <i>Lates calcarifer</i> ) | (Blaber 2003, Fisher 2010)   |

This lack of studies into the ecology of *L. goldiei* and *L. fuscescens* is matched by an absence of literature on related issues such as habitat requirements, food resource needs or threats. As a consequence, preliminary studies were undertaken as part of the current study as a first step to identifying habitat requirements concentrating on juvenile habitats.

### **Summary of preliminary nursery habitat identification of estuarine and freshwater lutjanid fishes from West New Britain.**

Estuarine and freshwater habitats of the Kimbe Bay region of West New Britain were sampled extensively using underwater video arrays, cast nets and seine nets with the aim

of identifying the habitat associations of juvenile lutjanid, particularly black bass, *L. goldiei*, and spot-tail snapper, *L. fuscescens*. Over 50 observations of the two target species were made, with *L. goldiei* the most common. *L. goldiei* juveniles occurred in estuaries and lower freshwaters, where they co-occurred with closely related mangrove Jack, *Lutjanus argentimaculatus*. Both were found in close association with submerged timber, aquatic plant beds and along grassed bank overhangs. *L. fuscescens* was only recorded from small low salinity coastal streams or 'micro-estuaries' where they co-occurred with *L. goldiei*. Not only were these shallow coastal estuaries and freshwater streams important habitats for the target species but they were also the habitats for large numbers of Pygmy Snapper, *Lutjanus maxweberi*, another species with almost no published biological knowledge, as well as juvenile *Lutjanus fulviflamma*, *Lutjanus fulvus*, *Lutjanus rivulatus* and *Lutjanus decussatus*. Thus these habitats appear to be important in supporting the life-histories of a range of tropical snappers likely to form the basis of developing coastal sport fishing ventures in PNG.

These studies form a research paper that is in review (Sheaves & Johnston in review)

The barramundi, *Lates calcarifer*, is also a target for sport fisheries along PNGs southern coasts. There is extensive literature on the ecology of barramundi in PNG (e.g. Moore & Reynold 1982, Milton et al. 1998, Blaber et al. 2008), where it is important commercially particularly in Western Province. This literature parallels an extensive literature from Australia and other parts of the region. This literature provides a sound starting point for management of barramundi as a component of the sport fisheries.

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## 11 Conclusions and recommendations

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### 11.1 Conclusions

There are great opportunities for the development of a local sport fishing industry in Papua New Guinea, with long term benefits to livelihoods, environments and resource sustainability. However, the lack of even the most basic information across all areas means extensive knowledge development will be necessary. While this is a daunting prospect, but one that has an up-side; there is the substantial advantage in the case of PNG because work based on an understanding of specific needs can be explicitly targeted to addressing those needs. In other parts of the world knowledge had been developed piece-meal over many years and needs-identification has never been done, meaning key parameters are often poorly understood. There is the opportunity to short-circuit the process for PNG and to rapidly develop an integrated knowledge base superior to that in other parts of the world.

#### *Particular knowledge and capacity needs include:*

**Fisheries Ecology:** The paucity of knowledge on all aspects of the fisheries ecology of the important sport fish of Papua New Guinea, their habitats and resource requirements, means there is an urgent need for a full spectrum of ecological studies. In particular priority should be given to studies of:

- Life-history patterns including locations of vital life-history events (e.g. spawning and nursery grounds),
- Specific habitat requirements for all life-history stages within the locations used by different life-history stages,
- Patterns of movement and migration pathways between habitats and locations,
- Key fisheries parameters including population sizes, growth rates, size structures, recruitment patterns, site fidelity, age at maturity and mortality rates,
- Trophic resource requirements.

**Fishing Operational Issues:** There is limited knowledge of the specific characteristics of favourable sport fishing areas and appropriate practices for tropical sport fisheries so studies are needed on:

- Identification of prospective sport fishing locations,
- Patterns of mortality relative to different fishing equipment (e.g. heavy vs. light line, barbed vs. barbless hooks),
- The effectiveness of different protocols and gears for handling captured fish (e.g. nets vs. gaffs vs. in-water release).

**Threats and Impacts to Habitats and Water Quality:** The complex nature of threats to habitats and water quality from human activities such as plantation agriculture, forestry and mining, together with limited success in determining sources of impacts, mean that specific studies are needed to:

- Determine the extent of habitat and water quality degradation in areas with the potential for sport fishing development,
- Determine the sources of degradation and options for mitigation and/or remediation of problems.

**Specific Cost-benefit Analysis of different Business Models:** The early stage of development of Papua New Guinea's coastal sport fisheries means there is a diversity of

possible business models that could be employed, so a need to identify and assess the different potential models.

**Social Impacts and Potential Problems:** While there is a good knowledge base of information on social impacts and problems for the few current sport fishing ventures, any expansion needs to scope and extend this to understand location-specific:

- Resource allocation and ownership issues,
- Fair recompense and distribution of wealth and benefits generated by new ventures,
- Impacts of development of sport fishing ventures on social cohesion and cultural values,
- Opportunities and constraints for development of associated ventures (e.g. village industries, ecotourism) that take advantage of increased numbers of sport fishing tourists.

**Capacity Building:** There are many capacity building needs. Principal among these are in the areas of developing the skills needed to:

- Develop and run a sport fishing business,
- Conduct a sport fishing operation,
- Develop new sport fishing locations and new location-specification methodologies,
- Develop and disseminate promotional information,
- Work with international customers,
- Develop and implement local-level management,
- Increase the local capacity for collecting, analysing and reporting the range of information needed to ensure business success and resource sustainability,
- Educate local people about the need to develop ecosystem resilience and ecological sustainability,
- Understand the long term trade-offs implicit in decisions about developing a long-term sport fishing venture versus short term gains from extractive fishing or other extractive uses of the environment (e.g. logging, mining).

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## 11.2 Recommendations

There is clearly great potential for the development of a local-based sport fishing industry in PNG as a key means of providing sustainable alternative livelihood solutions, however there is a paucity of background information of all types needed to support this development. Research is needed in each of the areas of knowledge needs identified above, with the development of socio-economic and biological understanding linked closely to capacity building. There is also a need to scope potential linkages to other initiatives, such as other ecotourism ventures and aquaculture, both as a means of diversifying livelihoods and because of the support each can give for the development of the other initiatives.

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- Wood A, Butler J, Sheaves M, Wani J (2013) Sport fisheries: opportunities and challenges for diversifying coastal livelihoods in the Pacific. *Marine Policy* 42:305-314

## **12.2 List of publications produced by project**

Wood A, Butler J, Sheaves M, Wani J (2013) Sport fisheries: opportunities and challenges for diversifying coastal livelihoods in the Pacific. *Marine Policy* 42:305-314