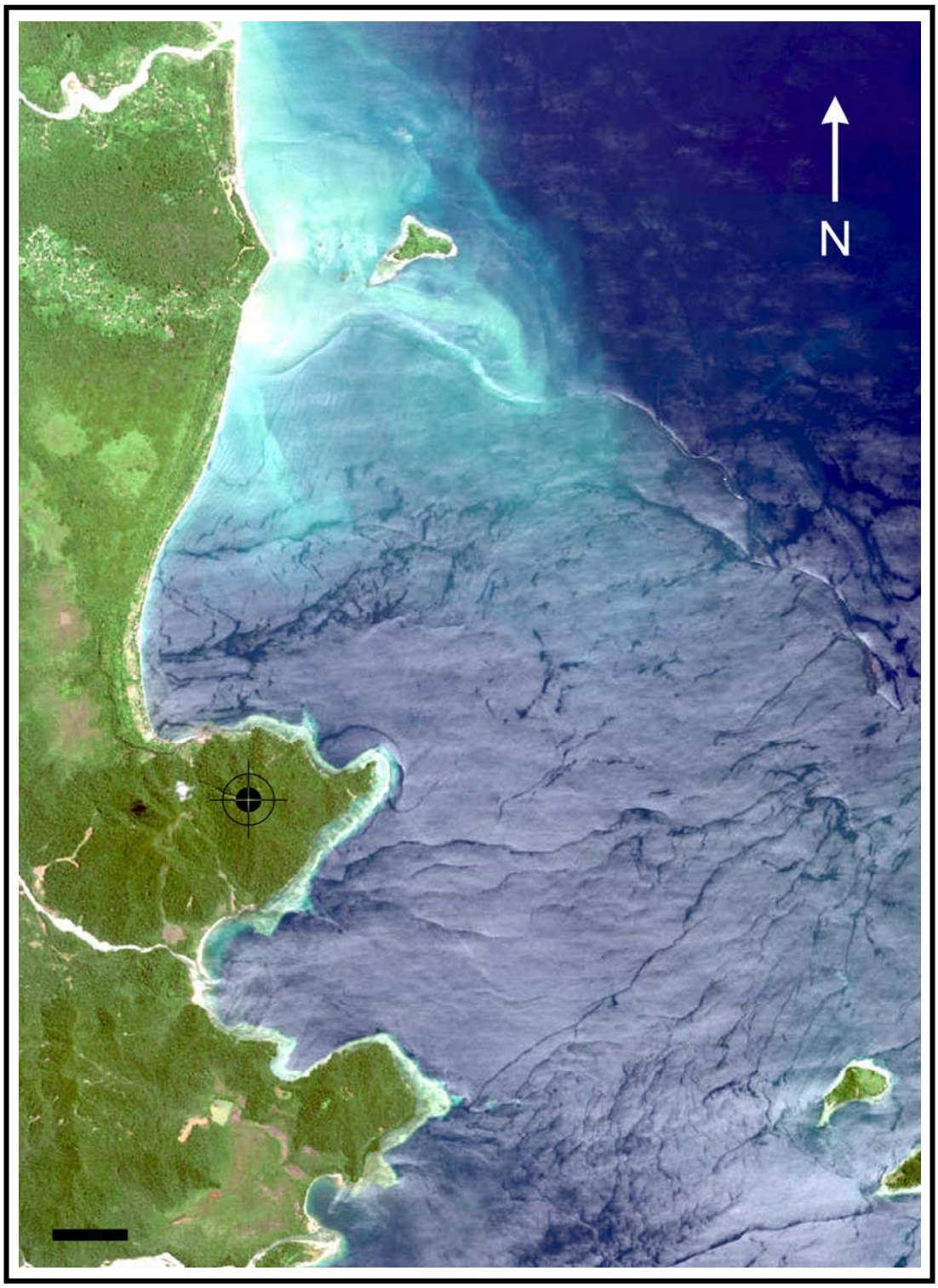
Coral Reef Fish Management Plan for Kamiali Wildlife Management Area, Morobe Province, Papua New Guinea



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Cover: A satellite image of the coral-reef-containing portion of Kamiali Wildlife Management Area. The reference point is located at 7.30905° S, 147.13516° E. The scale bar represents one kilometer. Image courtesy of the GeoEye Foundation.

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for
Kamiali Wildlife Management Area,
Morobe Province, Papua New Guinea

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Preface

One of Bishop Museum's major goals is to guide nature conservation through collaboration with traditional societies and organizations. In Papua New Guinea (PNG), Bishop Museum's strategy is to build upon the culturally based resource management practices of local people, develop on-the-ground knowledge and expertise, and demonstrate to resource owners the tangible benefits of environmental conservation.

Fish is the primary source dietary protein at the village of Kamiali (Morobe Province). This makes Kamiali residents intensely interested in the long-term condition of their marine environment. Conservation strategies that incorporate reasonable levels of exploitation will be readily accepted, advancing both conservation and the sustainable use of the rich marine resources at Kamiali.

This marine management plan was developed in conjunction with the Kamiali Wildlife Management Committee (KWMC) and community members representing Kamiali's clans. Following are the self-described community role and clan of my co-authors.

Name	Role	Clan
Gana Ben	Woman	Tabale
Lucy Edi	Woman	Gala
Endingo Gaip	Woman	Tabale
Tom Jiana	KWMC Member	Gala
Gabong Kawa	Fisher	Gala
Tana Keputong	Magistrate	Tabale
Gwae Muiya	Fisher	Gala
Kissi Nadup	KWMC Secretary	Gala
Takwa Nadup	Teacher	Tabale
Tusi Nandang	KWMC Chairman	Gala
Ben Naru	Community Chairman	Tabale
Simon Naru	KWMC Deputy Chairman	Tabale
June Nero	Fisher	Gala
Gabu Rueben	KWMC Treasurer	Tabale
Yaeng Tana	KWMC Member	Tabale
David Tom	Fisher	Gala
Masila Tusi	Woman	Gala

This management plan is geared toward Kamiali residents. Toward that end, the plan features translations into Kala (Kamiali's vernacular language) and Tok Pisin (PNG's lingua franca). Translations were done in a two-step process with my co-author, Gabu Rueben. First, because Gabu has an easier time thinking in Tok Pisin (relative to English), and because he was not familiar with many of the English words in the plan, he and I collaborated on the Tok Pisin translation. In some places, the Tok Pisin translation is what we considered to be a reasonable approximation of the English text. Gabu then worked independently to translate the Tok Pisin version into Kala. I then sat with Gabu and reviewed both translations to be sure I could read his handwritten manuscripts. I typed the translations after leaving Kamiali (when I had access to electricity). Gabu has not reviewed the typed translations herein. It is likely that I made some errors, and that the translations may need revision. All mistakes in this publication rest solely with me, and should not reflect on my co-authors.

Ken Longenecker
Honolulu, Hawaii
6 November 2014

Acknowledgments

Satellite imagery was provided courtesy of the GeoEye Foundation. All fish images are by John E. Randall, who generously shares his collection of fish photographs. Financial support for this plan came from a private foundation wishing to remain anonymous. The same foundation, plus Hawaiian Airlines, provided support for the marine research on which the plan is based. Holly Bolick reviewed the English version of this plan.

INTRODUCTION

English

About 600 people live in and control the natural resources of the Kamiali Wildlife Management Area (KWMA) on the Huon Coast of Morobe Province, Papua New Guinea (PNG). The KWMA was created in 1996 and includes about 320 square kilometers of land and 150 square kilometers of ocean. Of the 150 square kilometers of ocean, about 2.5 square kilometers are shallow coral reefs (<24 meters)[1], and deeper reefs are found throughout KWMA.

The people living at KWMA get most of their needs from its natural resources. However, they must have cash for modest necessities such as medicine and school fees. In PNG, logging and mining are tempting short-term sources of money for small villages such as Kamiali, but often have disastrous long-term environmental and social consequences.

The KWMA residents took a different approach in the interest of conserving their natural resources, and thus preserving their traditional lifestyle. In 2006, village leaders signed a Memorandum of Understanding with Bishop Museum outlining the development of a world-class, remote, scien-

Tok Pisin

Klostu 600 manmeri stap na lukautim olgeta samting antap long graun, bus, na solwara. Ples bilong bosim na lukautim olgeta samting olsem pis, diwai, bus, graun, na abus em istap long Huon Kost long Morobe Provins, Papua Niugini (PNG). Long dispela ples (KWMA) ol ibin kamapim long 1996 na emi gat 320 skwea kilomita graun na 150 skwea kilomita em long solwara. Long 150 skwea kilomita bilong solwara samting olsem tupela poin faiv (2.5) skwea kilomita em arere bilong rip (twenty-foa mitas) na long dip rip em ol i painim insait long KWMA.

Olgeta manmeri istap long KWMA ikisim olgeta nids bilong ol long dispela hap bilong ol. Igat taim, ol imas igat mani bilong halivim ol long baim malasin na skul fi. Insait long PNG, timba kampani na maining isave kamap sotpela taim long painim mani long liklik ples olsem Kamiali, tasol olgeta taim bagarap isave kamap long graun na givim hevi long manmeri.

KWMA manmeri lukluk long narapela rot bilong lukautim gut graun, bus, na solwara wantaim pasin tumbuna bilong ol. Insait long yia 2006, ol hetman i sainim wanpela wanbel pepa wan-

Kala

Lau gindi tõ gabo nua dene lekene esẽ ko (600) da yomosu Kamiali gi (KWMA). Da soso saĩ putu bilalo magĩ ta. Talu masa yogo gele godotome ŋge duda ila, e, bilalo ma ta magĩ wede da taluta gẽsu Morobe gi, Papua Niugini (PNG). Gẽsu KWMA da yeiti talutosa ndi yala 1996. Ma aŋa puŋa gabo da gindi kopia iŋgu ko (320 skwea kilomita) ma aŋata da ŋa gabo gindi (150 skwea kilomita) kopia iŋgu kobo ŋgu itapi lekene dene 2.5 da kulĩ ŋaisã. Lekene oto ŋgu (24 mita) ma kana mbu yakla da yeitapi gẽ Kamiali.

Lau godotome dene somosu Kamiali gida sesi tapi seĩ somoŋa anda da gẽsu seĩ talugi. Ŋgesu mali nua da wele sesitapi goŋayẽ (mani) ŋgunŋgi salasa ŋgu suli malasĩ magi goŋyẽ lumi kopia ŋa. Ŋgẽ PNG da bombia iĩ kuluku eŋa magĩ kuluku atu goŋayẽ ŋada gẽ teŋgi wele ŋe balitã, da iki ŋapuŋa ndi ambolã kokole duda Kamiali. Teŋgi no yakla da ŋapuŋa puŋa gomosi da iki ŋapuŋa ndi Kala.

KWMA sala lauta da sesilĩ andalawa gwauŋ ŋgu soso saĩ pu magĩ bilalo mata mbulia saĩ abulaĩ andalawa. Ndi yala 2006 da Laubabo ambolã ŋada sosoto kopia nuagĩ Bishop Museum ŋgu

tific-research station at KWMA. This research station has provided the foundation for a self-sustaining environmental conservation and economic development program.

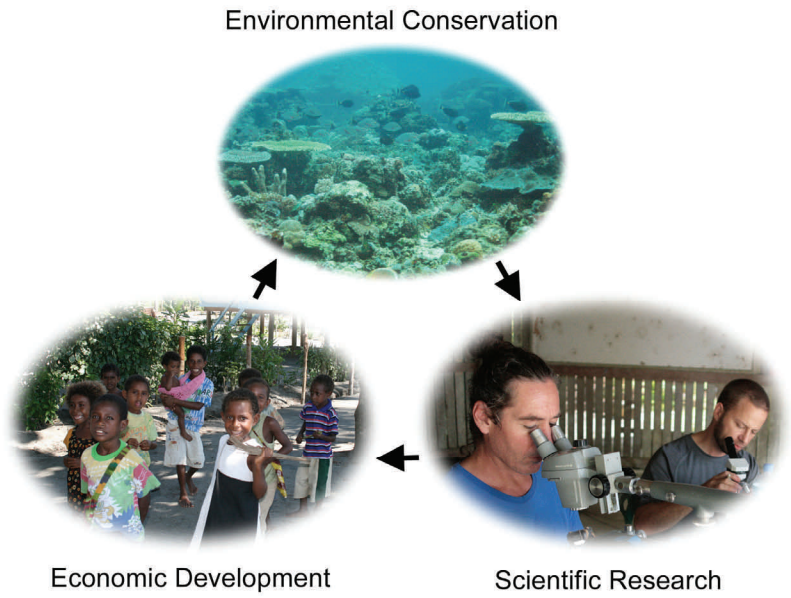
The program concept is simple. Field biologists will be attracted to a well-managed environment. Visiting researchers pay the community for research permits, field support, lodging, and meals. This link between economic growth and environmental conservation provides a strong long-term incentive for villagers to protect their land and water.

taim Bishop Museum long wok bung wantaim long kamapim gutpela risas stesin long olgeta graun. Dispela risas stesin i save givim sapot long gutpela wei o rot long kamapim na lukautim graun, bus, na solwara long kisim mani.

Dispela tingting emi gutpela. Ol saveman bai harim na hamamas long ikam long kain ples olsem. Olgeta saveman i baim kominiti risas fi, sapotim ol wokmanmeri, ples slip wantaim kaikai. Dispela rot kamap namel long ol manmeri long painim mani na gutpela sindaun na strongim ol long lukautim graun, bus, na solawara bilong ol.

sala wele sesinu kuluku pitumeme ŋgu siti da ŋgu koto kana pu, bilalo magĩ ta ŋesu pu gabo dene.

Data dini wele ŋgi kalasa ŋa andalawa yakla ŋgu koto kana pu, bilalo magĩ ta ŋgu wele kata tapi goŋayẽ piŋa. Andalawa ta da anda ŋgu wele bombiala sigu ŋabi ma saĩ tẽ anda ŋgu somo sikano kana ambolã ma wele sesiki goŋa yẽ ukana taluŋa. Ma sesi kalasa ŋgu siki goŋayẽ u talu yoŋgwe ŋa ma u talu bodiŋa. Andalawa ta wele ŋgi tambuli ma yali lasa ŋgu sitapi goŋayẽ ma iki ŋayaŋga (kuŋgawã) ndi sala ŋgu soso saĩ talu (pu, alẽ, ta).



Conceptual model of the environmental conservation and economic development program at Kamiali Wildlife Management Area: A well-managed environment attracts biological research, providing a means of economic development to pay for school and medicine, thus providing incentive for continued environmental conservation.

The biggest threat to the conservation-research-income cycle may be fishing on coral reefs. Coral-reef fish are the primary source of protein in the diet of KWMA residents (there is very little hunting[2]), yet coral reefs represents only about 0.5% of the total area of KWMA. In other words, the village's main source of protein (fish) is collected from a very small portion of KWMA.

For the conservation-research-income cycle to work on KWMA's coral reefs, the village must balance marine conservation with the need for and cultural value of fishing

Bikpela bagarap i kamap long wanem ol manmeri i save kisim pis long rip isap arere long dip. Rip pis emi nambawan abus tru bilong KWMA manmeri (igat wan-wan taim ol isave igo painim abus long bus), igat rip i kamap long kain namba ol-sem 0.5% insait long olgeta hap bilong KWMA. Long arapela, hap bilong ples pi semi abus tru na ol i kisim long liklik hap eria bilong KWMA.

Long pasin bilong wok long KWMA rip ol imas kisim abus inap long kaikai na tu imas lukautim rip na solwara long bihain taim.

Ŋapuŋa gabo gomosi ŋgu tambulila ma yalila siga i ŋgesu kulĩ dene kobo ludũ magĩ mbu. I kulĩ ŋada wede anda solome ŋgẽsu KWMA. Ndi no nuã da sesimia gi silĩ wede ŋgẽ bilalo. Kulĩ dene ipi gẽta daŋa lekene otosa ŋgu 0.5% ŋgẽsu talu godotome dene ŋgẽ KWMA. Ŋgẽ ambolã Kamiali dasaĩ wede da ii sesiga ita mosu saĩ talu walã nua ŋgẽsu KWMA.

Andalawa ŋgu kataga i mosu KWMA ii kulĩŋa wele kataga i gindi ŋgu katiŋa ma koto kana kulĩ magĩ ta u muliaŋa.

To succeed in KWMA's subsistence economy, a marine management plan must balance marine conservation with the need for and cultural value of exploiting the marine habitat.

Some aspects of life at KWMA may already help conserve reef fishes. The area is far from commercial fish markets (64 kilometers), and there are no roads linking KWMA to those markets. In PNG, this distance is enough to reduce the

Sampela wei bilong laip long KWMA emi stap pinis long halivim lukautim rip pis. Dispela eria emi long wei tru long ples bilong salim pis (64 kilomita), na ino gat rot igo long KWMA long maket. Insait long PNG, dispela kilomita emi

Andalawa yakla ŋgu ŋgi KWMA sada agẽ muye ŋgu koto ii kuliŋa. Taluta da agẽ balĩ ŋgu kataga i miapi (64 kilomita) ŋgu taki (maket) ŋgu tatapi goŋayẽ andalawa dene da iki ŋapuŋa ndi KWMA. Ŋgẽ PNG andalawa gitapi KWMA yetã

lihood of overfishing[3]. Further, lack of refrigeration reduces the motivation to catch more fish than can be used within a few days[1].

Additionally, a short list of rules, made under the Fauna (Protection and Control) Act Chapter No. 154 of Papua New Guinea revised laws, governs the use of natural resources within KWMA[4]. Two of these rules offer some protection to reef fishes. First, any person without customary and traditional claim of right to the natural resources within KWMA must have approval from the Kamiali Wildlife Management Committee (KWMC) to injure, kill, or harvest those resources. This rule results, intentionally or not, in a *limited-entry* fishery (whereby fishing pressure is controlled by restricting the number of people that are permitted to fish). Second, the rules prohibit the harvest of natural resources with dynamite, gill nets, and dangerous chemicals (bleach, cyanide).

The existing conditions and rules at KWMC are good ways to protect the area's natural resources. However, a more-active approach to managing fishing on coral reefs may help achieve a better balance between the ability to catch food and the potential for increased income at KWMC.

inap long daunim strong bilong wok pis tumas. Na tu, ino gat masin o ples kol bilong putim pis. Dispela i givim hevi olsem na ol i kisim liklik inap long kaikai tupela o tripela dei.

Igat govman pepa ol i wokim aninit long Pauna (Protekson na Kontrol) namba 154 long Papua Niugini lo insait long KWMA. Dispela tupela lo givim strong lukautim rip pis. Namba wan, wanem man, meri, o pikinini husait i laikim kilim wanpela abus long dispela eria imas tok yesa long KWMA komiti pastaim. Dispela lo i kamap emi inapim tru dispela liklik lain manmeri husait bai usim dispela eria. Namba tu, dispela lo emi tambuim pasin bilong tromoi bom, ol nets, na ol arapela malasin nogut.

Dispela lo nau yet long KWMA emi gutpela tru long lukautim wanem ol samting insait long dispela eria. Igat planti strongpela tingting long lukautim long kisim pis long rip dispela bai halivim ol ples manmeri kisim kaikai na painim mani wantaim.

sudenegi da iki ŋapuŋa ma kuni yeĩ ŋayaŋga mba gu kuluku iŋa. Magĩ masin o da talu ŋagabõ nua itã tã ngu yeiki isu. Gudene ŋada yeiga i gindi ŋgu yeiŋa ŋgesu mali lua o mali tlawa.

Sala lau babo da kopia ŋa (gavman) da sesi Masã Kopia Nua ŋgesu talu ŋgu ŋo gele godotome (Pauna Proteksin Kantrol) #154 ŋgesu Papua Niugini. Ŋgesu KWMA da bilua dene da iki kuŋgawã ŋgu koto kana i kulĩ ŋa. Bi ŋamataŋa iŋgu dudene ŋgu sai tambu nua o iya nua o kole nua aŋa teŋgi ŋgu ailĩ o aiga wede ŋesu talu dini da wele aigu bimu ŋe sala lau babo KWMA ŋa. Bita dene agi saĩ tambuli ma yalila saŋgu soso saĩ talu.

Bigu lua bita da aso yoŋgwe andalawa wasebã bombia (bom) walambo magi malasĩ yayama. Bita deneŋgi da agi KWMA sa anda solome gu soso saĩ gele naŋa masa ŋgesu saĩ talugi. Bita dudene ŋgu kataga iŋe kulĩ ŋgu ŋgi tambulila ma yalila saŋgu sitapi bodi ma sitapi goŋayẽ.

OBJECTIVES

The end goal of this marine management plan is to promote sustainable fishing* on KWMA's coral reefs. The KWMA community will benefit from sustainable fishing practices because well-managed reef-fish populations will:

1) provide current needs (food),

2) attract current income (marine research), and

3) provide future generations with food and income.

Bikpela tingting bilong lukautim solwara em long strongim gutpela pasin bilong kisim pis long nau na bihain taim long KWMA rip. Manmeri bilong KWMA bai kisim gutpela halivim long wei bilong kisim pis long longpela taim. Olsem na:

1) halivim ol manmeri long kisim kaikai long nau,

2) halivim ol manmeri painim mani long nau long saveman bilong wok bilong solwara, na

3) long halivim ol manmeri waintaim kaikai na painim mani long taim bihain.

Lau KWMA ĩ tambuli ma yalila silĩ andalawa ŋgu ŋo sala ma sesiga i iyuto mia.

1) ŋgi kalasa ŋgu taga bodi ndi wele dene,

2) kata tapi goŋayẽ ma lautu lablã kotõ ŋgu sinu kuluku,

3) ŋgi kalasa ubodi ŋa tatapi goŋayẽ ma umbuliã dudene.

APPROACH

This part of the plan is guided by the results of scientific research (at KWMA and elsewhere). Local knowledge of fish and fishing is necessary to put the plan into action.

Dispela hap bilong plen em ol saveman i bosim long KWMA na arapela hap tu. Pasin bilong kisim save long pis na kisim pis long pasin tumbuna ba yumi kamapim gen.

Andalawa deneda lau lablã kotõ (saveman) KWMA ŋada soso geleta magĩ lau amblã yakla. Andalawa ŋgu taga iŋa magĩ abulaĩ andalawa wele ŋamopi waũ. Bita dene wele u andalawa si ŋgu ŋgi Kala tambuli ma sala yalisa ŋe KWMA. Tambu nua o iŋa nua magĩ gulua tatu ŋapuŋa geleyo tã maĩ ŋapuŋa yakla ŋgu koto andalawa dene.

* harvesting fish in a manner that does not result in their long-term decline, thereby maintaining the potential for fish populations to meet the needs of future generations

This reef-fish management plan is a set of guidelines and suggestions for residents of KWMA, who obtain most of the protein in their diet from fish. This plan recognizes that adequate nutrition must be a priority for KWMA residents. No person should go hungry or risk malnutrition in the interest of adhering to the plan.

The plan focuses on one of the most-easily understood concepts in fishery management and conservation: harvest fish only after they have grown large enough to reproduce. This approach allows living fish to "seed" the next generation[5].

Worldwide, the information needed to predict the outcome of changing fishing practices is very rare for reef fishes. However, research at KWMA suggests that a good balance between fishing and conservation can be achieved by small changes in fishing practices. The table below shows the predicted effects of these changes. By taking larger fish (than are currently caught), village residents can catch 30 – 40 % fewer fish but obtain the same amount of food (by weight). Catching fewer fish leaves more alive on the reef. The living fish then have the chance to reproduce, and "seed" the next

Dispela rip pis plen bai kamap olsem lo na bai iken halivim manmeri bilong KWMA, husat kisim planti abus long pis. Dispela plen i luksave olsem igat inap nambawan gutpela kaikai long ol manmeri bilong KWMA. Ino gat man o meri inap igo hangre o painim sik sapos yumi ino bihanim dispela plen.

Dispela plen i sut long wanpela gutpela isipela tingting insait wok pis wantaim solwara: kisim pis inap long bikpela sais we ol i ken karim gen. Dispela tingting i larim ol pis i karim planti nau na bihain tu.

Planti tumas rip pis ol saveman ino save long luksave long wanem samting bai kamap sapos yumi senisim wei bilong kisim pis. Olsem na saveman iwok KWMA iting olsem sapos yumi mekim liklik senis long wei bilong kisim pis bai yumi gat planti pis istap yet. Igat ol namba istap tambolo i soim wanem samting ol saveman i ting bai i kamap sapos yumi mekim senis. Sapos yumi kisim bikpela pis long nau na ol manmeri iken kisim liklik namba bilong pis yumi olgeta i kisim wankain kaikai. Yumi kisim liklik namba bilong pis bai yumi bai igat planti pis moa istap yet long solwara. Ol pis istap long solwara iken kamapim na karim planti liklik pis bihain taim.

Andalawa dene da kialĩ kau nua ŋgesu kuluku iŋa magĩ ta. Kataga masa babo gindi ma yakla masa omo ŋgu iga wauŋ. Andalawa dene gomosi ŋgu katalowe ila ŋgu siga wauŋ ndi wele dene ma su mbuliã. I gongo likĩ da lau taŋga sikano duda guatume gu deneŋa da katalĩ talu wauŋ ŋgu taga imõ.

Lau taŋa masa sinu kuluku mosu KWMA da saĩ teŋgi ŋgu kataga i ma taki mali yakla ŋe mbolame ŋguma kana ila u golikĩ si. Kopia tuŋa lekene negẽ lubula da kialĩ gele masa lautu labla kotõ sotosa ŋgu tambulia kopiata wele gele yakla wele indale. Ŋgu kataga i babo ndi ya dene ma lau tõ nua siga i sawa nua. Kala godotome wele iyata ŋgu katĩ ŋa.

Kataga i gindi ŋgu katiŋa wele kana i goŋgo liki wele omosu taŋa. I dene omota wele siki gulua ma i tatu wele golikĩ ndi wele dene masu mbuliã. Wele kata kano ŋgu ila wele siki ŋakutulu ma kana i wele u goŋgo likĩ. I kulĩ ŋada igaata ndi no nua ŋgesu yala nuagi. Ma ŋgesu yala nua wele kata kano ŋgu igu goŋgo liki.

generation. For instance, a 3 – 37% increase in the number of eggs is expected each time a species reproduces. Because many tropical fishes reproduce several times each year[6], the yearly increase in egg production would be even higher. In other words, small changes in fishing practices should allow the village to meet its current needs (obtain the same amount of food), increase the current economic value of its reefs (attract marine research by leaving more live fish on the reef), and meet the needs and economic aspirations of future generations (more adult fish produce more offspring, helping to insure plentiful fish in the future).

Bai liklik pis iken karim planti gen nau bai yumi save olsem olgeta taim wankain pis bai igat planti kiau inap long karim planti pis. Long wanem planti rip pis isave karim sampela taim long wanwan yia long olgeta yia bai yumi save olsem kiau bilong pis i kamap planti na bai yumi igat planti pis moa. Insait long dispela rot bai igat liklik senis i kamap long pasin bilong kisim pis, dispela bai halivim ol ples manmeri long igat inap kaikai na rot bilong painim mani nau na long bihain taim tu.

The predicted effects of changing fishing practices at KWMA. For each species (column 1), the average length of an individual in recent catches at KWMA is shown in column 2. If KWMA residents harvest slightly larger fish (column 3), they can obtain the same weight from at least 30% fewer fish (column 4). This change would leave more fish on the reef to reproduce and promote a larger fish population in the next generation (column 5). TL = total length; FL = fork length.

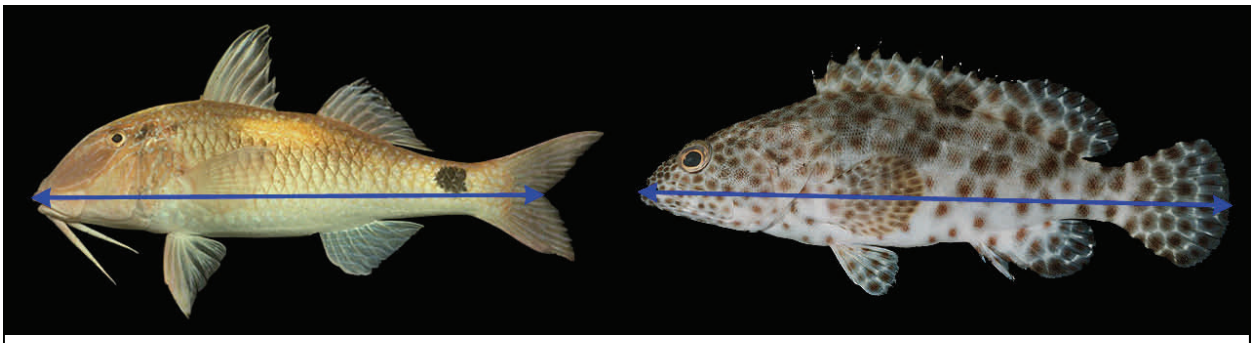
Species	Average Size of Current Catch	Recommended Harvest Size	*Decrease* in # to maintain current catch weight (%)	Increase in # of eggs produced *each* spawning (%)
Cephalopholis cyanostigma (ikula sa)[7]	19.7 cm TL	23-25 cm TL	43	5
Parupeneus barberinus (iwaŋgale)[7]	16.5 cm FL	26-32 cm FL	41	37
Caesio cuning (luduŋ mai)[1]	16.7 cm FL	17-21 cm FL	30	3

RECOMMENDATIONS

Catching adult-sized fish should promote sustainable fishing. The following pages list the adult size of 56 common, exploited reef fishes at KWMA. Each account provides the scientific name of the fish, a picture of the fish, its adult length, and its common names in English and Kala. Lengths are measured from the front of the head (with mouth closed) to the middle of the tail edge .

Kisi mol bikpela pis i halivim yumi long Lukautim pis long nau na bihain taim tu. Dispela hap pepa i soim bikpela sais pis inap long karim long KWMA. Dispela ripot i soim yumi saveman i givim nem bilong ol pis, wantaim piksa bilong pis, na sais bilong karim, waintaim nem bilong Inglis na bilong yumi Kala tok ples. Long makim poret bilong het wantaim passim maus bilong en igo long namel bilong arere bilong tel.

Kataga i babo wele ŋgi kalasa ŋgu koto i ndi wele dene ma mbulianja. Kopia dene kialĩ i masa babo gindi ŋgu iga ŋa ŋgesu KWMA. Kopia dene iŋgu ndi Kala ŋgu Lau-Taŋa sikiŋasẽ (saveman) pi ilagi ma soto ŋakatu magĩ ilaĩ gabo gindi ŋgu kiki gulua wauŋ. Magi ŋasẽ pi bombiaŋa ma Kala kana walo.



Blue arrows show how fish are measured. First, make sure its mouth is closed. Then, measure from the front of the head to the middle of the tail edge.

Fishes on the following pages are grouped by their scientific family name, which appear in alphabetical order. Within each family, species are arranged alphabetically by scientific name. English names are from FishBase[8]. Kala names are by consensus of the plan authors that live at KWMA.

Acanthurus lineatus
(Linnaeus, 1758)

18 cm[9]
lined surgeonfish,
iwiliya

Acanthurus triostegus
(Linnaeus, 1758)

8 cm[10]
convict surgeonfish,
imoŋgolẽ

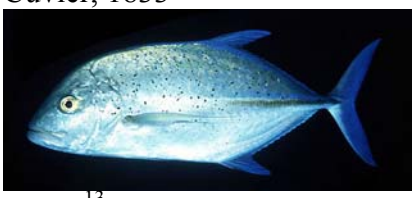
Caesio cuning
(Bloch, 1791)

15 cm[11]
redbelly yellowtail fusilier,
luduŋ mai

Carangoides bajad
(Forsskål, 1775)

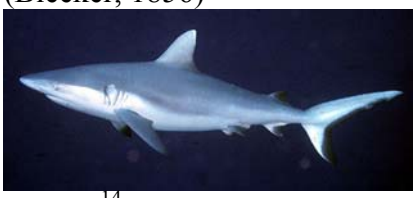
25 cm[12]
orangespotted trevally,
imaŋalẽ babaura

Caranx melampygus
Cuvier, 1833



36 cm[13]
bluefin trevally,
imaŋalẽ talã

Carcharhinus amblyrhynchos
(Bleeker, 1856)

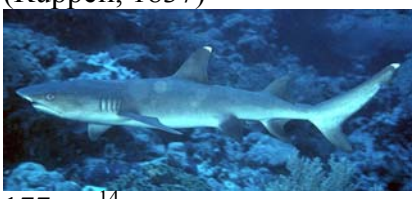


118 cm[14]
blacktail reef shark,
kapa ii

Carcharhinus melanopterus
(Quoy & Gaimard, 1824)

80 cm[15]
blacktip reef shark,
kapa mayumbui

Triaenodon obesus
(Rüppell, 1837)



177 cm[14]
whitetip reef shark,
kapa bage bula

Diagramma pictum
(Thunberg, 1792)

36 cm[16]
painted sweetlips,
godobo manibarã, godobo taro

Plectorhinchus vittatus
(Linnaeus, 1758)

23 cm[17]
Indian Ocean oriental sweetlips,
iyabua kurĩ naba

Myripristis adusta
Bleeker, 1853

17 cm[1]
shadowfin soldierfish,
imbilĩ tombo yeyẽ

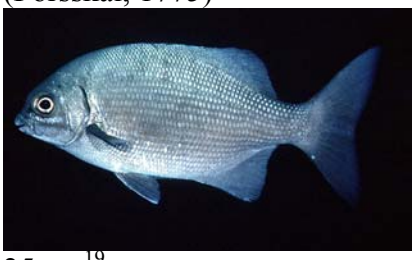
Myripristis berndti
Jordan & Evermann, 1903

20 cm[18]
blotcheye soldierfish,
imbilĩ yakẽ susuwi

Neoniphon sammara
(Forsskål, 1775)

8 cm[17]
Sammara squirrelfish,
imbilĩ sa

Kyphosus cinerascens
(Forsskål, 1775)

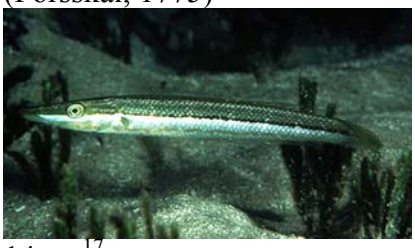


25 cm[19]
blue sea chub,
italawe

Cheilinus fasciatus
(Bloch, 1791)

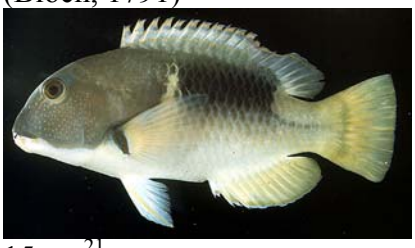
12 cm[20]
redbreasted wrasse,
talulumuã tatalõ

Cheilio inermis
(Forsskål, 1775)



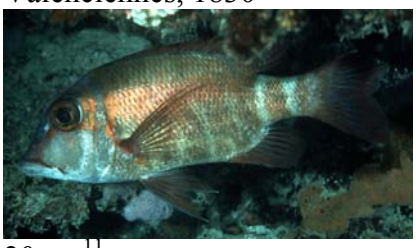
14 cm[17]
cigar wrasse,
tumunduwa

Choerodon anchorago
(Bloch, 1791)



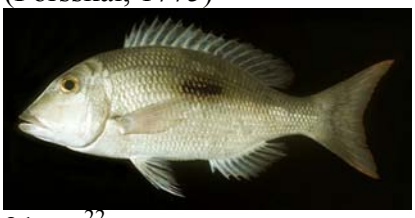
15 cm[21]
orange-dotted tuskfish,
i bubui

Lethrinus erythropterus
Valenciennes, 1830



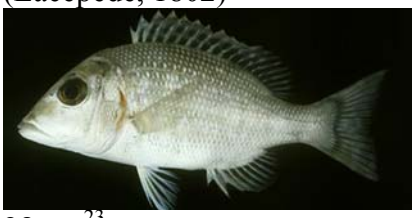
20 cm[11]
longfin emperor,
kada maba

Lethrinus harak
(Forsskål, 1775)



21 cm[22]
thumbprint emperor,
imogõ

Lethrinus lentjan
(Lacepède, 1802)



28 cm[23]
pink ear emperor,
i luwi

Lutjanus argentimaculatus
(Forsskål, 1775)

53 cm[24]
mangrove red snapper,
ilĩ

Lutjanus biguttatus
(Valenciennes, 1830)

17 cm[25]
two-spot banded snapper,
itale

Lutjanus bohar
(Forsskål, 1775)

43 cm[26]
two-spot red snapper,
yame tuaŋ yasai, yame tuaŋ, ilĩ

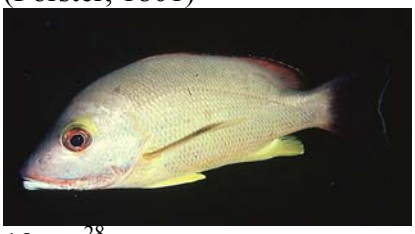
Lutjanus carponotatus
(Richardson, 1842)

19 cm[27]
Spanish flag snapper,
babaura

Lutjanus ehrenbergii
(Peters, 1869)

20 cm[23]
blackspot snapper,
kawasi toŋgwe

Lutjanus fulvus
(Forster, 1801)

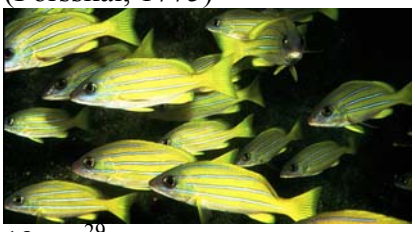


19 cm[28]
blacktail snapper,
iyayaŋ kurĩ naba

Lutjanus gibbus
(Forsskål, 1775)

18 cm[17]
humpback red snapper,
ina suwi

Lutjanus kasmira
(Forsskål, 1775)



12 cm[29]
common bluestripe snapper,
babaura yumi yayã

Lutjanus monostigma
(Cuvier, 1828)

32 cm[30]
one-spot snapper,
baniŋga

Lutjanus russellii
(Bleeker, 1849)

22 cm[31]
Russell's snapper,
kawasi ŋasiŋa

Lutjanus semicinctus
Quoy & Gaimard, 1824

21 cm[7]
black-banded snapper,
imawe

Lutjanus timorensis
(Quoy & Gaimard, 1824)

30 cm[7]
Timor snapper,
iko yaŋgawe, iko

Lutjanus vitta
(Quoy & Gaimard, 1824)

15 cm[32]
brownstripe red snapper,
isale

Mulloidichthys vanicolensis
(Valenciennes, 1831)

17 cm[33]
yellowfin goatfish,
imake

Parupeneus barberinus
(Lacepède, 1801)

12 cm[7]
dash-and-dot goatfish,
iwaŋgale

Parupeneus multifasciatus
(Quoy & Gaimard, 1825)

15 cm[34]
manybar goatfish,
iwaŋgale bote

Parupeneus trifasciatus
(Lacepède, 1801)

11 cm[17]
doublebar goatfish,
walia

Amblyglyphidodon curacao
(Bloch, 1787)

7 cm[35]
staghorn damselfish,
ikĩ

Priacanthus hamrur
(Forsskål, 1775)

20 cm[36]
moontail bullseye,
iko indu

Leptoscarus vaigiensis
(Quoy & Gaimard, 1824)

7 cm[37]
marbled parrotfish,
iŋgi

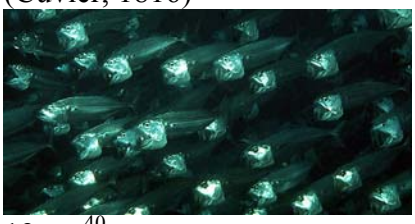
Scarus niger
Forsskål, 1775

17 cm[38]
dusky parrotfish,
iŋga tumi

Gymnosarda unicolor
(Rüppell, 1836)

70 cm[39]
dogtooth tuna,
itaŋgi talalo

Rastrelliger kanagurta
(Cuvier, 1816)



19 cm[40]
Indian mackerel,
indala

Scomberomorus commerson
(Cuvier, 1816)

65 cm[41]
narrow-barred Spanish mackerel,
itaŋgi

Cephalopholis boenak
(Bloch, 1790)

15 cm[42]
chocolate hind,
ikula bobo

Cephalopholis cyanostigma
(Valenciennes, 1828)

23 cm[7]
bluespotted hind,
ikula sa

Cephalopholis sexmaculata
(Rüppell, 1830)

24 cm[43]
sixblotch hind,
ikula talulumua

Epinephelus fasciatus
(Forsskål, 1775)

14 cm[44]
blacktip grouper,
ikula laga

Epinephelus merra
Bloch, 1793

11 cm[10]
honeycomb grouper,
ikula talõ

Epinephelus tauvina
(Forsskål, 1775)

28 cm[45]
greasy grouper,
ikula yula

Plectropomus areolatus
(Rüppell, 1830)

40 cm[46]
squaretail grouper,
ikula su

Plectropomus leopardus
(Lacepède, 1802)

32 cm[47]
leopard grouper,
ikula su

Plectropomus oligacanthus
(Bleeker, 1855)

27 cm[1]
highfin grouper,
ikula su tatalõ

Variola louti
(Forsskål, 1775)

41 cm[48]
yellow-edged lyretail,
ikula talulumua

Siganus doliatus
Guérin-Méneville, 1829-38

18 cm[49]
barred spinefoot,
indaŋa

Siganus lineatus
(Valenciennes, 1835)

24 cm[7]
golden-lined spinefoot,
yulawe

Other Species

The 56 species listed above represent only a small portion of the fish species at KWMA. Papua New Guinea is located in the East Indian region (or Coral Triangle), which is home to about one-third of the world's marine fish species[50]. At least 1184 coastal saltwater fishes are expected to occur at KWMA[51].

A way to estimate reproductive size is needed for the approximately 95% of KWMA fish species for which adult size is unknown. Adult size can be estimated from a fish's maximum size[52], and KWMA residents know how large most species grow.

Research at KWMA shows that the estimated adult size tends to be larger than a fish's actual adult size[1]. However, until detailed reproductive analysis is done, the information presented in the table below is the best available fishing guideline for a given species.

Namba istap antap i makim o soim ol sampela liklik pis grup long KWMA. Papua Niugini emi ples bilong planti tumas pis bilong solwara. Ol saveman iting igat 1184 solwara pis long KWMA.

Ol saveman ino save sais ol pis i karim. Yumi mas painim rot bilong luksave long i klostu olgeta pis bilong KWMA. Yumi bai save long bikpela sais istap na KWMA manmeri tu iken luksave na skulim ol yet long wanem sais bilong pis bai iken karim.

Saveman long KWMA i soim olsem dispela luksave sais emi bikpela long emi luksave bilong saveman. Olsem na igat wok yet long painim dispela sais karim nau mipela igat luksave sais tasol istap.

Uki madĩ pi iŋa labolã ma kawi iŋa walobo ma mia agẽ ŋawala, sududa iŋayumi ŋae ŋaisã. Lekene dini yotosa gẽ baba (56 species) da kialĩ ŋgu kana i dene yeitapi ŋgẽ KWMA. Ŋgesu Papua Niugini da talu masa i goŋgo likĩ omosu tagi. Lautaŋa (saveman) da sesinŋgu i gindi lekene dene (1184) dene omosu tagi ŋge KWMA.

Lautaŋa (saveman) sesitapi i masa iga ŋakole yetaŋ. Ma teŋgu sesiŋgu i godotome dene omosu KWMA. Wele katagu i babo dene omosu KWMA ma tambuli latu yalila sodõ ata ŋgu sigu i masa gindi ŋgu iga ŋakole.

Sala lau taŋa siŋgu saĩ kuluku ŋgu sitapi i masa kobo ŋgu iga ŋakole. Denegi dene da i masa sesi kano da i masa babo agẽta da ita dene omo.

Largest Fish (centimeters)	Estimated Adult Size (centimeters)
5	4
10	7
15	11
20	14
25	17
30	20
35	23
40	26
45	29
50	32
55	35
60	38
65	41
70	44
75	47
80	50
85	53
90	56
95	59
100	62

This table shows the estimated adult size of a fish. To use the table, look down the left column until you find how large the species can grow (distance from the front of the head, with mouth closed, to the middle of the tail edge). Then look to the right to find the estimated adult size.

Example: Imagine that you catch a 20 centimeter fish. If that kind of fish can grow to about 35 centimeters, look for 35 in the left column. Now look right to find its estimated adult size of 23 centimeters. The fish that you caught has probably not yet had the chance to reproduce. It would be best to return it to the ocean. For the kind of fish you caught, it is probably best to keep only those longer than 23 centimeters.

CHALLENGES AND POTENTIAL SOLUTIONS

Fishing in Deep Water

The length-based fishing guidelines above can only work if very few small fish are killed. Length guidelines often assume that short fish can be released, alive, back to the water. However, at KWMA reef fish are often hooked in deep water and die, or are severely injured, from the change in pressure as they are pulled to the surface. There would be little use in returning dead or nearly dead fish to the ocean.

KWMA residents can change fishing methods or location to decrease the chance that short fish will be caught:

1) Larger hooks tend to catch larger fish. If short fish are being caught, a change to a larger hook size should reduce the number of small fish in the catch.

2) In many fish species, large and small fish live in different areas. If short fish are being caught, KWMA residents can use their knowledge of fish habits to choose a new spot where larger fish are more likely to be caught.

Dispela plen o lo istap antap bai ino ken kamap sapos yumi kisim planti tumas ol liklik pis. Dispela lo is skulim yumi sapos yumi kisim liklik pis bai yumi mas putim bek long solwara. KWMA rip pis planti taim ol i pulim long dip solwara eme save dai taim emi kamap. Ino gat narapela wei o rot long larim liklik pis igo long solwara olsem yumi kisim bilong kaikai.

KWMA manmeri iken senisim ples o wei bilong kisim pis long nau ol ino ken tru long kisim ol pis we ino inap karim kiau:

1) Bikpela huk iken kisim bikpela pis. Sapos you pulim o kisim liklik pis yum as senisim huk nay u putim bikpela huk.

2) Insait long planti pis grup igat bikpela na liklik pis istap kainkain eria. Sapos yu pulim o kisim liklik pis, KWMA manmeri igat save long senisim ples we ol bikpela pis isap.

Bi o andalawa dene gẽ baba wele ŋamosi tã ŋgu kataga i tatu goŋgo likĩ. Bi dene sa iŋgu ŋgu katayu o kataga i tatu da kataki ita imia mbuli suta. I tatu KWMA ŋa da nomasa katayu ŋgẽ ta bumayaŋ gomopi baba da ita imbalu. Da andalawa nua getã ŋgu kataki imia yambuli su taŋalolo ta su denegi da wele kataga ŋgu katĩ.

KWMA tambuli latu yalila Kala wele tatapi talu waũ ŋgu kataga iŋe. Ma kata lowe ila somo ŋgu siki ŋakutulu ma siki ŋagulua waũ.

1) Awe gabo da gindi ŋgu katayu i gabo. Ŋgu kaki awe kokole ma kakuyu i kokole da kate awe gabosu aĩya su ŋgu kayu i.

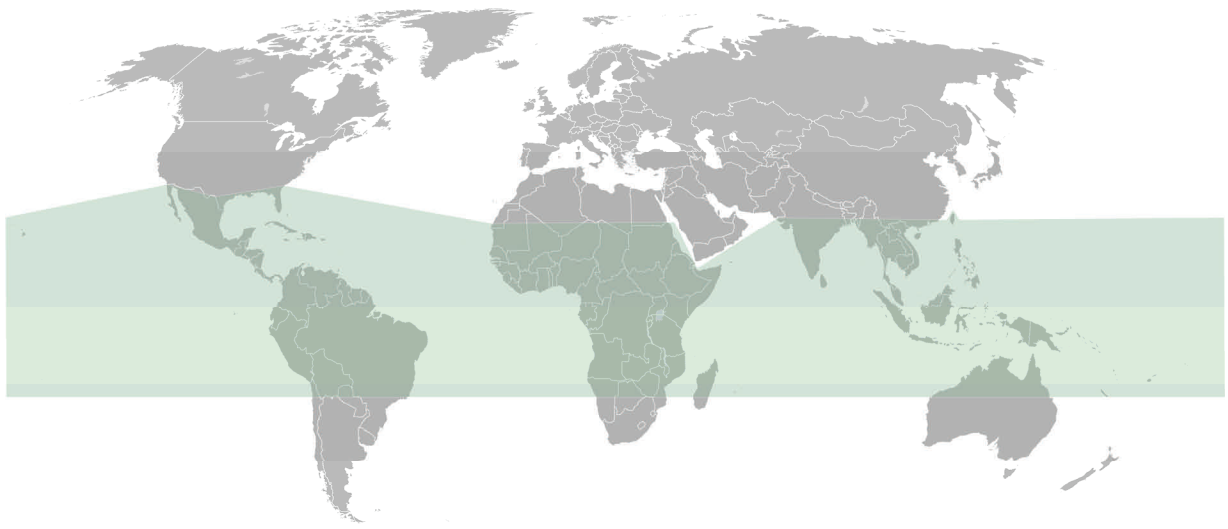
2) Ŋgẽsu ila godotome da i babo ma i tatu da sosoma pilata mosu talu nua. Ŋgu katayu i kokole tutu mali da Kala KWMA ŋa tambuli latu yalila wele kata lowe talu dinie ma tamia du talu waũ ŋgu taga i babo.

Fish Poisoning

Since pre-history, poisoning fish with crushed or ground plant parts has been a traditional fishing method used by native people throughout most of the tropics[53-62]. Fish poisoning will usually result in a large catch, and is useful when preparing for feasts or during periods of starvation.

Long taim bilong ol tumbuna ol manmeri i save yusim poisin rop long kisim pis. Kisim pis bilong poisin rop emi planti tumas inap long halivim ol manmeri wokim pati na tu i ken halivim long taim bilong hangre.

Ndi abulaĩ no da tambulila da sesili wasebã ŋgu siga i. Katali wasebã da kataga goŋgo liki, igu katalisa ŋgu tanu bodi ata ma gu katĩ.



Catching fish by poisoning with plants is a traditional fishing technique throughout most of the tropics (shaded area).

The drawback of fish poisoning is that it is *non-selective*. That is, the poison will kill all fish, large or small, in the area where it is applied. If done too often, KWMA residents risk killing too many small fish.

Wanpela hevi emi olsem, poisin rop i save kilim ol bikpela pis, liklik pis long hap eria we ol yusim. Sapos yumi yusim poisin rop olgeta taim, bai yumi kilim idai olgeta liklik pis.

Ŋapuŋa gabo nua da dudene ŋgu wasebã gili i baba ma i tatu ŋgẽ talu masa kataki wasebã gẽ.

Fish poisoning at KWMA is limited by tidal cycles. The best condition for applying poison and gathering fish is when shallow, isolated, pools of water are present on the reef. These pools are present only in certain areas and only during the lowest of low tides. Unfortunately, these pools are located on the reef flats that are commonly used by immature fish.

To reduce the chance that traditional fish-poisoning will cause major declines in their reef-fish populations KWMA residents chose to do the following:

1) Establish a buffer zone (or no-take zone). All fishing methods are prohibited within the buffer zone. This buffer zone may compensate for the fish harvested elsewhere in KWMA. Also, fish populations within the buffer zone are likely to be of interest to researchers and may increase the income derived from research projects at KWMA. The location of the buffer zone at KWMA is from Aramaua to Puko (7.29861°S, 147.13168°E to 7.29810°S, 147.13942°E)*.

2) Ban fish poisoning on the reef seaward (east) of the buffer zone. The no-poison zone was established to reduce the chance that water currents will sweep poison into the buffer zone. Other

KWMA manmeri i yusim poisin rop long taim bilong drai wara i kamap. Taim wara i drai na raun wara istap long rip. Wanpela hevi emi olsem dispela raun wara istap long rip wantaim ol liklik pis. Dispela kilim olgeta pis ino gat kiau.

Long daunim dispela poisin rop ino ken bagarapim ol rip pis, olsem na KWMA kamapim narapela nupela tingting bai ol manmeri iken bihainim:

1) Kamapim na tambuim eria bilong kisim pis. Olgeta work pis bai ino inap kamap long dispela eria. Dispela eria bai kamapim planti pis na ol saveman bai hamamas tru long ikam lukim na bai KWMA wantaim ol manmeri bai igat mani long dispela wok. Ples we ol i tambuim em long Alẽmaua igo pinis long Puko.

2) Tambu long putim poisin rop long rip klostu long ples we ol i putim tambu. Dispela rot i kamap long tambuim ples klostu nogut solwara i tait na kisim poisin rop ikam bagarapim na kilim ol pis insait long ples ol tambuim. Yu ken kisim pis long spia na string, na noken yusim poisin rop. Bikos yu noken yusim poisin rop long tambu eria bai yumi igat bikpela rip istap long KWMA. Dispela poisin rop i tambu bai i halivim ol yangpela pis

Ŋgu katali wasebã tutumali wele katali i ŋakolela dudu. KWMA tambulila ma yalila sesili wasebã ndi no mandabe ŋa, nota dini da tagegiye ta isamẽmẽ. Ŋapuŋa gabo dudene, ta masa isame kulĩ tu wasebã me da gili itatu magi i ŋakutulu.

Kata lowe wasebã ŋgu gili i kuli dudu da KWMA ilĩ andalawa nua ŋgu ŋgi lau godotome sa me sesi mbulia:

1) Taso yoŋgwe talu nua ma kataga i mosu dini tã. Kala wele kataga i ŋesu taluta tã ma ila wele somo ugoŋgo likisi. Bombia, lautu lablã kotõ (saveman) wele yeimia moŋgu ikano kana talu ma KWMA magĩ lau godotome wele sitapi goŋeye pi kana taluŋa. Talu masa kataso yoŋgwe da Alẽ Maua miagisi Puko.

2) Kataki wasebã su talu masa ŋgẽ kobotã. Yoso yoŋgwe talu masa ŋge kobo, ŋalabolã da ŋgu taisu wele iga wasebã mia ili i dudu. Kataga i ŋa bilĩ, aiŋ awe some ma gele yakla iĩ wasebã da mba. Ŋgu katali wasebã ŋge taluta tã wele kana kulĩ wele ipi gabo ŋge KWMA. Ŋgu wasebã mba da wele ilaĩ ŋakole tatu wele goŋgo likĩ. Katali wasebã su Puko ma imia agẽ si Diŋa tã.

* Geodetic datum: WGS84

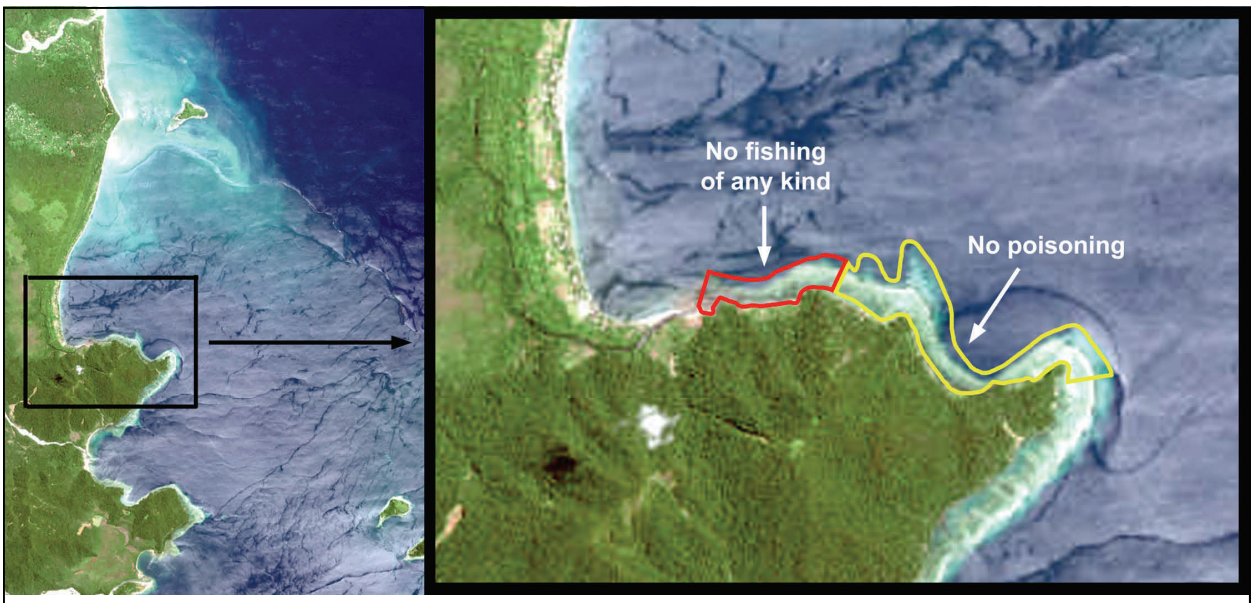
fishing methods may be used in the no-poison zone. Because poisoning is also prohibited within the buffer zone, the total area where traditional fish-poisoning is prohibited covers about 25% of the reef flat at KWMA. This protection should help insure that young fish will have the chance to grow and reproduce. The no-poison zone at KWMA extends from Puko to Dinga (7.29810°S, 147.13942°E to 7.30476°S, 147.15408°E).

3) Poison only when a large number of fish are needed. Because a single fish-poisoning harvest usually yields a large number of fish, this technique is best reserved for events when a large number of people need to be fed. These events include feasts or when food is scarce.

i kamap na karim planti. I noken yusim poisin rop long Puko igo inap long Poin Dinga.

3) Yu ken putim poison rop taim yu lukim bikpela lain pis long kisim na kaikai. Bikos yu yusim poison rop wanpela taim na yu kisim planti pis, orait yum as larim dispela wok istap inap pis i kamap planti bai yu ken kisim long wokim pati o givim long ol manmeri kaikai.

3) Kataki waseba ndi masa kata kano i tõ nua ma kataga ŋgu katĩ. Katali waseba no tumeme me ma kata lowe ŋguma kana i ugoŋgo likisi ma kataga u kuluku baboŋa ma ŋgu katĩ.



No fishing is allowed in the buffer zone (red). No poisoning is allowed in the area (yellow) next to the buffer zone

EVALUATION

If sustainable fishing occurs at KWMA, average fish size should remain the same or increase through time. Stable or increasing average fish length suggests that, because larger fish are generally preferred, fishing activities are not greatly reducing the number of large fish at KWMA. Average size should also be near adult size. This would suggest that there are enough reproductive individuals to "seed" the next generation.

There is now enough baseline information to monitor average fish size relative to adult size for five of the most-abundant, exploited species at KWMA[1] (*Caesio cuning*, *Cephalopholis cyanostigma*, *Lutjanus biguttatus*, *Parupeneus barberinus*, and *Parupeneus multifasciatus*). This information consists of estimates of the average length of free-swimming fish during each of the past five years[1], and published information on adult size[7, 11, 25, 34].

Three-year rolling (or moving) averages suggest that the average length of all five species has been relatively stable in recent years. Further, average lengths for all species are within a few centimeters of female reproductive size. These results suggest that KWMA resi-

Sapos yumi lukautim gut dispela pasin long KWMA, sais bilong ol pis bai istap wankain o bai igo antap gen. Wankain sais o sais igo antap iken tokim yumi, bikos yumi laikim kisim bikpela pis, pasin bilong kisim pis i tokim yumi olsem namba biolong ol bikpela pis istap gut long KWMA. Emi gutpela sapos sais bilong pis i klostu long ol bikpela pis i redi long karim. Dispela luksave emi inap long halivim pis long karim planti pikinini long nau na bihain tu.

Nau igat inap ripot i lukluk long sais bilong pis long painimaut long pis klostu long karim igat faivpela wankain pis long KWMA (luduŋ mai, ikula sa, itale, iwaŋgale, iwaŋgale bote). Dispela ripot i soim sais bilong pis istap long solwara long wanwan yia insait long faivpela yia.

Dispela ripot i tokim yumi olsem sais bilong olgeta faivpela pis emi klostu wankain sais olsem yia igo pinis. Sais bilong faivpela pis klostu bungim mak bilong karim. Dispela toksave i soim olsem KWMA manmeri i lukautim gut pasin bilong kisim rip pis.

Yumi mas painimaut olsem plen emi wok gut o nogat insait long faivpela yia. Gutpela mak i soim

Ŋgu koto andalawa dene ŋesu KWMA wele kana i babo ma wele goŋgo likĩ. Ŋgu iŋa madĩ miapi da geleta iŋalĩ ŋgu Kala wele taga i babo. Sa i babo wele omosu KWMA. Anda ŋgu i masa gi kobo i babo da ita gindi ŋgu iga gulua. Gudene ŋada i wele iga ŋakole goŋgo likĩ ndi wele dene ma sumbuliã. Deneŋgi da kuluku ŋgu takano i masa ŋgu iga ŋagulua. I gindi lita (faivpela) ŋadõ tumeme dene omosu KWMA: luduŋ mai, ilula sa, itale, iwaŋgale, iwaŋgale bote.

Kopia dene kialĩ iŋa gabo dene omosu tagi ndi yala nua ma miagẽ gi itapi yala lita da ita gindi ŋgu iga ŋakole. Kopia iŋgu ko ŋgu i lita ta da giŋgi atame, duda yala masa mialegi. I lita ta dagi itapi madi masa ŋgu iga ata. Andalawa dene da kialĩ ŋgu koto andalawa i kuliŋa anda gẽ KWMA.

Wele kata kano ŋgu andalawa dene kunu kuluku o mba gẽsu yala lita denegi. Iŋa babo kiali ndi Kala ŋgu andalawa ta kunu kuluku. Kala wele kata kano ŋgesu yala lita deneŋa iŋa masalo walã. Ŋgu iŋa masalo walã babo da wele anda ndi KWMA.

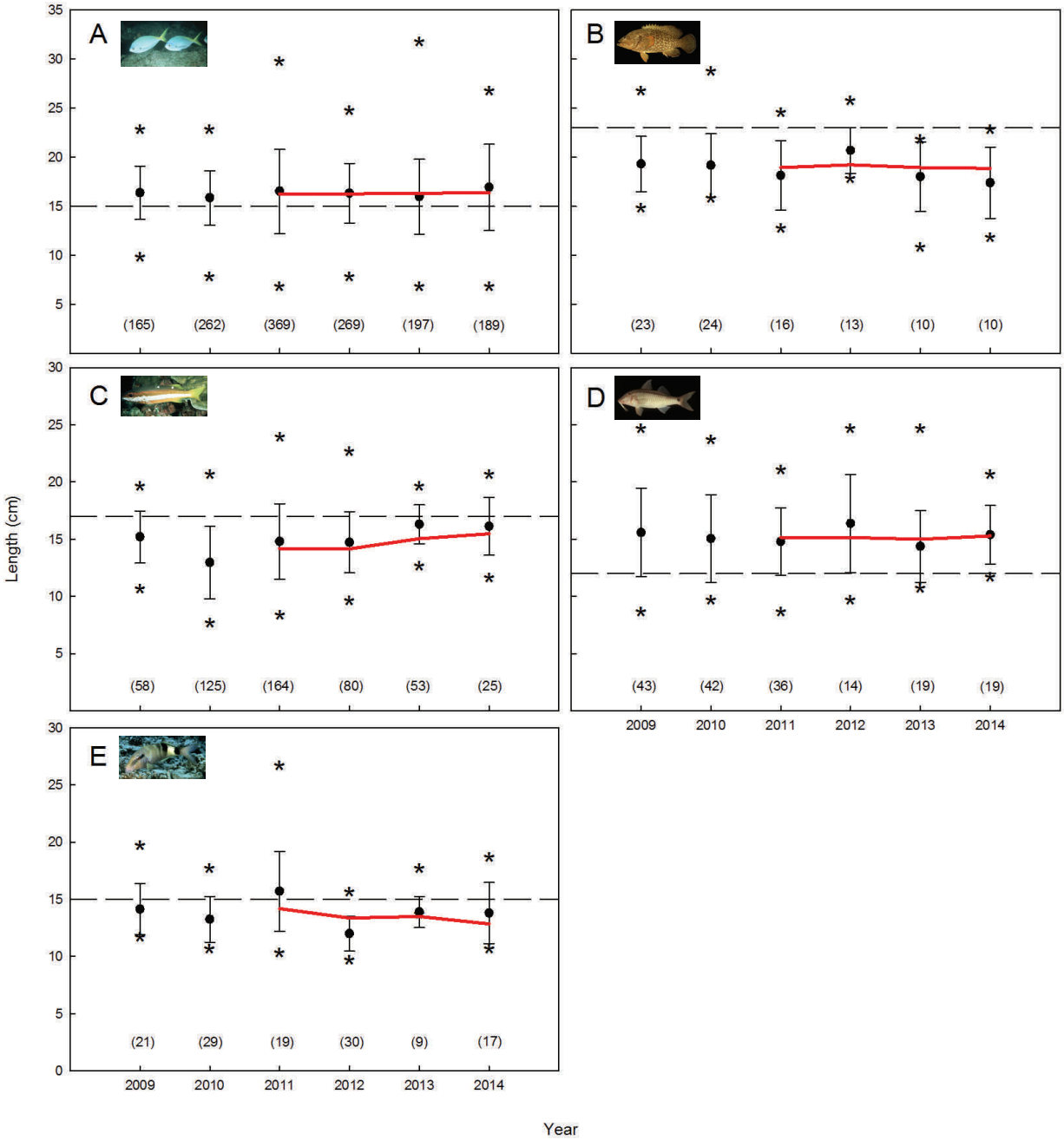
Ŋgu iŋa masalo walã ŋgiata da Kala KWMA koto kana i kulĩ ŋa ma gele nua giama tãŋgesu i kuli ŋa.

dents are practicing sustainable fishing.

The success (or failure) of this management plan should be critically evaluated after five years. An objective measurement of success is average fish length. Established methods[1] should be used to monitor, annually, the lengths of each of the above five reef fishes. Increasing average lengths (as indicated by 3-year rolling averages) would suggest that this management plan had a positive effect on coral-reef-fish populations at KWMA. No change in average lengths would suggest that fishing at KWMA is sustainable, but would also suggest that this plan had no real impact on reef-fish populations. Decreasing average lengths would suggest that fishing is not sustainable and that another approach to managing coral reef fishes is needed at KWMA.

plen emi orait long mak bilong sais bilong pis. Yumi mas sekim long olgeta yia, sais bilong dispela faivpela rip pis. Sais emi kamap long tokim yumi plen emi wok gutpela long rip pis long KWMA. Sapos sais emi wankain i soim yumi KWMA i lukautim gut rip pis, tasol dispela plen ino senisim wanpela samting long rip pis. Sais emi go daun bai iken tokim yumi olsem yumi no lukautim gut rip pis olsem na bai yumi painim narapela rot long lukautim rip pis long KWMA.

Maŋgu iŋa gabo kiambulisu da geleta kialĩ ŋgu koto kana i kulĩ ŋa gindi tã. Ma katalĩ andalawa nua waũ ŋgu koto kana i ŋgesu KWMA.



Average length of some reef-fish species at KWMA. Red lines = 3-year moving average; dashed lines = female adult size, solid circles = yearly average; vertical bars = standard deviation; asterisks = smallest and largest size. Number of specimens in parentheses. A) *Caesio cuning* (luduŋ mai), B) *Cephalopholis cyanostigma* (ikula sa), C) *Lutjanus biguttatus* (itale), D) *Parupeneus barberinus* (iwaŋgale), E) *Parupeneus multifasciatus* (iwaŋgale bote).

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