Six-Year Baseline Information: Size Structure and Reproduction of Exploited Reef Fishes Before Establishing a Management Plan at Kamiali Wildlife Management Area, Papua New Guinea

Ken Longenecker, Ross Langston, Holly Bolick, Utula Kondio, and Mara Mulrooney

Honolulu, Hawai‘i
December 2014

COVER

Hamm Geamsa prepares his gear for hook-and-line fishing just off the fringing reef at Kamiali Wildlife Management Area. Photo: Sarah Rose.

Six-Year Baseline Information: Size Structure and Reproduction of Exploited Reef Fishes Before Establishing a Management Plan at Kamiali Wildlife Management Area, Papua New Guinea

Ken Longenecker[1],
Ross Langston[1],
Holly Bolick[1],
Utula Kondio,[2]
and
Mara Mulrooney[1]

(1) Pacific Biological Survey
Bishop Museum
Honolulu, Hawai‘i 96817, USA

(2) Kamiali Wildlife Management Area
Lababia, Morobe Province, PNG

Bishop Museum Technical Report 63

Honolulu, Hawai‘i
December 2014

Bishop Museum Press
1525 Bernice Street
Honolulu, Hawai‘i

Copyright © 2014 Bishop Museum
All Rights Reserved
Printed in the United States of America

ISSN 1085-455X

Contribution No. 2014-005 to the Pacific Biological Survey

Contents

List of Tables

List of Figures

EXECUTIVE SUMMARY

The Kamiali Initiative is a Bishop-Museum-led project to develop a self-sustaining cycle of environmental conservation, scientific research, and economic development in the coastal community of Kamiali, Papua New Guinea. The area includes approximately 120,000 acres of terrestrial and marine habitat, and is larger than most state parks in California. In fact, Kamiali's territory is larger than that of 16 countries. The success of the Kamiali Initiative is contingent upon ~600 Kamiali residents preserving the natural environment such that biological field researchers are motivated to work in the area. This project is arguably the most successful and is the only fully sustainable large-scale terrestrial/marine biodiversity conservation project in Papua New Guinea.

The most challenging conservation issues at Kamiali center on coral-reef fishes. Fish are the source of the overwhelming majority of dietary protein for this coastal village, and coral-reefs are preferred fishing sites. To be successful, conservation practices must balance the conflicting needs of protecting fish populations against the cultural value of and dietary need for subsistence fishing.

In 2014, Kamiali residents crafted and enacted a reef-fish management plan. The goal of that management plan is to promote sustainable fishing on Kamiali Wildlife Management Area's coral reefs and thus provide residents with current needs (food), to attract current income (derived from marine research), and to prevent the long-term decline in exploited fish populations such that future generations can obtain adequate food and income. The purpose of this report is to provide the baseline data needed to evaluate the effectiveness of the management plan.

Here we describe the pre-plan status of Kamiali's exploited reef-fish populations. We used a combination of advanced diving technology and laser videogrammetry to augment our 2009 – 2013 descriptions of the size structure of exploited species (a total of 100 species are covered in this report), expanded a literature review of reproductive parameters, estimated the percentage of reproductive individuals in each population (when sufficient information existed), and plotted a time series of average length for the most consistently abundant species to examine long-term trends in fish size.

A total of 772 individuals were captured on video during 2014, yielding a combined total of 4,716 individuals representing 100 reef-associated species from 19 families (inclusive of 2009 – 2013 data). An exploited reef fish swimming in the Kamiali Wildlife Management Area (KWMA) is likely to be about 3/5 of its potential maximum length, and 10% shorter than the length at which maximum yield can theoretically be obtained. Size-at-maturity is known for 54% of the species surveyed. Of these, mean individual length was 101% of female L_{50}. Sex-ratios are known for 30 species. Considering only those 30 species, an average 32% of individuals are mature females.

For the five most consistently abundant species, 3-year moving averages of length suggest that size is relatively stable. Average length for all species is near female L_{50}.

With continued monitoring of fish populations, the above information will allow for an objective assessment of the new reef-fish management plan. Increasing average fish lengths would suggest that the 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 the 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.

INTRODUCTION

This report presents the results of research focused on exploited reef fishes at Kamiali Wildlife Management Area (KWMA), Morobe Province, Papua New Guinea in 2014. Those results are combined with previous, related work in the area (Longenecker *et al*. 2009, 2010, 2011, 2012, 2013c) to describe the size structure and reproductive status of fish populations. Combined, the results represent baseline data needed to evaluate a reef-fish management plan crafted and enacted by KWMA residents in 2014. The plan is an important milestone in the Kamiali Initiative, a project to develop a self-sustaining cycle of environmental conservation, economic development, and scientific research.

General Background

Kamiali residents, who hold title to their territory and traditional tenure over their natural resources, established the KWMA in 1996. It contains 32,000 hectares of terrestrial habitat and 15,000 hectares of adjacent marine habitat. KWMA is remote, located about 65 kilometers south of the port town of Lae. There are no roads to (or in) the village. Its approximately 600 residents obtain most of life's needs from the surrounding environment.

Gardening and subsistence fishing are the economic basis throughout much of Papua New Guinea (PNG) and are a focus of life in many villages; however, residents need money for basic supplies and services (*e.g.*, medicine, education, and clothing). These needs, combined with a lack of income, have made exploitation of natural resources (*e.g.*, logging, mining) a tempting short-term source of money elsewhere in PNG. However, logging and mining in PNG often result in disastrous long-term environmental and social impacts. In the interest of conserving their natural resources, and thus preserving their traditional lifestyle, Kamiali leaders signed, in 2006, a Memorandum of Understanding with Bishop Museum outlining the development of a world-class remote scientific research station at KWMA. Visiting researchers pay fees for research permits, field assistance, lodging, and meals. This revenue helps fund educational costs and community-development projects. The Kamiali Initiative thus creates a link between economic benefit and environmental conservation, and provides a strong incentive for villagers to protect their land and water in perpetuity (Figure 1).

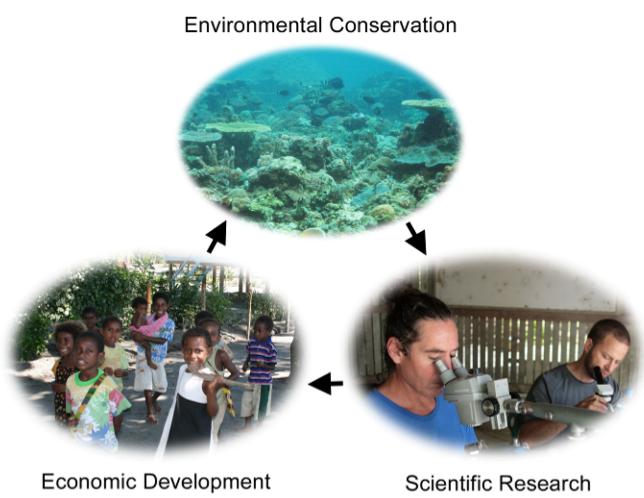


Figure 1. Conceptual model of the Kamiali Initiative: A well-managed environment attracts biological research, providing a means of economic development to pay for school and medicine, thus providing incentive for continued environmental conservation.

Fishing for coral-reef species may be the biggest challenge to the Kamiali Initiative; marine fishes provide the vast majority of dietary protein for this coastal village, and coral reefs are preferred fishing sites. For the conservation-research-income cycle to work in Kamiali waters, the village must balance marine conservation with the need for and cultural value of exploiting the marine habitat.

Reef-Fish Management Plan

In an effort to balance conservation and exploitation, Kamiali residents crafted and enacted a reef-fish management plan in 2014 (Longenecker et al 2014b). The end goal of this marine management plan is to promote sustainable fishing, defined here as 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.

The KWMA community should benefit from sustainable fishing practices because well-managed reef-fish populations will allow the village to meet its current needs (obtain food), increase the current economic value of its reefs (attract marine research by leaving more live fish on the reef), and meet the food needs and economic aspirations of future generations.

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 (Froese 2004). To promote an increase the percentage of adult-sized fish in the catch at KWMA, the plan: 1) encourages the release of viable undersized fish, 2) encourages residents to use their knowledge of fish and fishing to choose techniques and locations likely to yield adult-sized fish, 3) bans *Derris*-fishing on 25% of the reef flat at KWMA, and 4) establishes a no-take zone.

It is our hope that KWMA's reef fish management plan will serve as a model for other subsistence communities in the Indo-Pacific region. However, before promoting the plan elsewhere, and to avoid perpetuating an ineffectual plan at KWMA, it must be critically evaluated.

Purpose

The purpose of this report is to provide baseline information on the size-structure and reproductive status of Kamiali's exploited reef fish populations. We present a synopsis of data collected during the six-year period prior to establishing the reef-fish management plan. We compiled length-frequency information and compared it to estimated length at optimum yield and life-history parameters such as maximum length, reproductive size, and sex ratios. For five of the most abundant species at KWMA (as indicated by our fishery surveys), we present a time-series of average fish length. With additional monitoring, it will be possible to detect whether desirable changes in reef-fish populations occurred after the plan was established.

Kala Pronunciation Guide

To help our target audience (coastal residents of the Huon Coast, Papua New Guinea) better understand the information presented in this report, we present the Kala fish names used by residents of the Kamiali Wildlife Management Area. Kala is the vernacular (or native) language of approximately 2,000 people from six villages along the Huon Coast.

English speakers will recognize most Kala letters. Shared consonants are pronounced the same in both languages; however English speakers may hear the Kala "l" as an English "r". The Kala language has ten vowels. It also has a consonant not used in English. The following pronunciation guide is paraphrased from DeVolder *et al*. 2012:

- a is pronounced "a" as in apple.
- e is pronounced "ay" as in way.
- i is pronounced "ee" as in see.
- o is pronounced "oa" as in boat.
- u is pronounced "oo" as in boot.
- The diacritical mark ~, called a *titi* (meaning wave) in Kala, may appear with any vowel (ã, ẽ, ĩ, õ, ũ) and indicates the vowel is nasalized. That is, air is let into the nasal cavity during pronunciation.
- ŋ is pronounced "ng" as in song.

METHODS

Study Area

Kamiali is one of six Kala-speaking villages in Papua New Guinea and is located on the Huon Coast, approximately 64 km SSE of the port city, Lae. Approximately 600 residents hold title to and control the use of land, adjacent marine water, and the resources contained therein. The northern boundary of the Kamiali Wildlife Management Area (KWMA) is the mouth of the Bitoi River, whereas the Sela River is the southern limit. Nassau and Saschen Bays are wholly contained within the management area, as are Lababia and Jawani Islands and Capes Dinga and Roon. The northern part of Hessen Bay is also contained within the management area.

The terrestrial portion of the KWMA is remarkably undeveloped and characterized by lush vegetation. Kamiali Village is concentrated along the northern portion, where the shoreline is exclusively sandy beach. South of the village, the shoreline is dominated by fringing reefs on Capes Dinga and Roon. Fringing reefs also surround the islands of Lababia and Jawani. These reef flats transition abruptly to a fore reef which is steep, typically descending 20 to 30 meters. At their bases, the reefs give way to sandy sediment that is believed to occupy the majority of the marine area. Some coral outcroppings, patch reefs and pinnacles are interspersed throughout this presumably sedimentary area. The combined horizontal and vertical area (on reef flats and fore reefs, respectively) occupied by coral is approximately 248 ha.

Fishery Surveys

From 25 May – 7 June 2014, we conducted 13 laser-videogrammetry surveys to describe the size distribution of exploited reef fishes in Kamiali Wildlife Management Area. We used closed-circuit rebreathers with 10/50 trimix diluent as life support to reach depths to 91 m. Due to the lengthy decompression obligations incurred while working at these depths (*e.g.*, 3 hours for a 20-minute dive to 91 m), the work was performed in areas with bathymetric profiles that permitted work to continue while ascending. Thus, surveys are concentrated at offshore pinnacles and near fringing reefs (Table 1, Figure 2). Five surveys were conducted at previously established sites for coral growth monitoring experiments (surveys 1 - 4) or a temperature monitoring transect (survey 9). The remaining survey sites were randomly selected. Here we superimposed a grid onto a satellite image of KWMA, with each square of the grid representing one hectare. We then numbered each square that included reef crest. We used randomly generated numbers to select a series of squares, and determined the latitude and longitude at the center of each. In the field, we used a global positioning system (GPS) receiver to navigate to the coordinates, and then began our surveys on the nearest reef crest.

A high-definition video camera fitted with parallel laser pointers was used to capture images of individual fish when they were oriented perpendicular to the laser beam axes. We used editing software to review the video and capture still frames where both lasers appeared on the fish. Because the beams are parallel, the lasers superimpose a reference scale on the side of the fish, allowing length estimates by solving for equivalent ratios. Our length estimates were calculated using ImageJ software (Rasband 2009). Longenecker & Langston (2008) have demonstrated a nearly 1:1 relationship between estimated and actual fish lengths. Further, a prediction interval suggested that 95% of estimates will be within 0.5 cm of the actual fish length (Longenecker & Langston 2008).

The species included in the fishery survey met the following four criteria: 1) they are reef fishes; 2) they are exploited by local fishers; 3) they are common enough to have been captured at least several times on video; and 4) they can be reliably identified from still images. A total of 100 species representing 19 families (Acanthuridae, Balistidae, Caesionidae, Carangidae, Carcharhinidae, Ephippidae, Haemulidae, Holocentridae, Kyphosidae, Labridae, Lethrinidae, Lutjanidae, Mullidae, Nemipteridae, Priacanthidae, Scaridae, Scombridae, Serranidae, and Siganidae) met these criteria.

A systematic literature review was conducted using the methods of Longenecker *et al.* (2008a) to obtain estimates of maximum length (L_{max}), size-at-maturity, size-specific sex ratios, spawning season, and reproductive mode. Briefly, we: 1) searched electronic resources (*e.g.*, Google Scholar, FishBase) using keyword combinations of species names plus "reproduction" or "maturity"; 2) upon obtaining these publications, we identified and obtained additional relevant literature listed in their reference section; 3) we then searched these publications and obtained any additional references.

In summarizing life-history information, preference was given to studies specific to Papua New Guinea (*e.g.*, the maximum-length information of Allen & Swainston 1993). Preference was also given to length at 50% maturity (L_{50}) over other estimates of size-at-maturity (*e.g.*, minimum size-at-maturity or L_m). Results from studies outside the southern hemisphere were included only when data for southern populations were not available (*e.g.*, reproductive size for *imaŋalẽ talã* or *Caranx melampygus*). Conversely, information on spawning seasonality was included only for southern hemisphere populations.

We applied the empirically derived equations of Froese & Binohlan (2000) to estimate fishery and, when necessary, reproductive parameters. Published maximum lengths (L_{max}, see Results) were used to generate estimates of L_∞ (the length a fish would attain if it were to grow indefinitely, or asymptotic length). The latter were then used to generate estimates of L_{opt} (theoretical length at which maximum yield can be obtained). If published values of L_{50} were not available, we also used L_∞ estimates to generate ♀L_m estimates.

Table 1. List of marine sites surveyed at Kamiali Wildlife Management Area during 2014. Latitude and longitude were estimated by GPS using the WGS84 datum. FR = Fringing Reef, OP = Offshore Pinnacle, PR = Patch Reef.

Survey	Date	Latitude (ºS)	Longitude (ºE)	Habitat	Max Depth (m)
1	25-May-14	7.29849	147.13194	FR	19
2	26-May-14	7.24776	147.14786	PR	6
3	27-May-14	7.32414	147.13902	FR	9
4	28-May-14	7.35343	147.15063	FR	15
5	29-May-14	7.32928	147.20532	OP	49
6	30-May-14	7.33971	147.14227	FR	40
7	31-May-14	7.29838	147.13963	FR	34
8	02-Jun-14	7.32938	147.20720	OP	63
9	03-Jun-14	7.30425	147.15440	FR	91
10	04-Jun-14	7.34844	147.15512	FR	48
11	05-Jun-14	7.30760	147.16638	OP	48
12	06-Jun-14	7.33007	147.20633	OP	62
13	07-Jun-14	7.32909	147.20520	OP	62

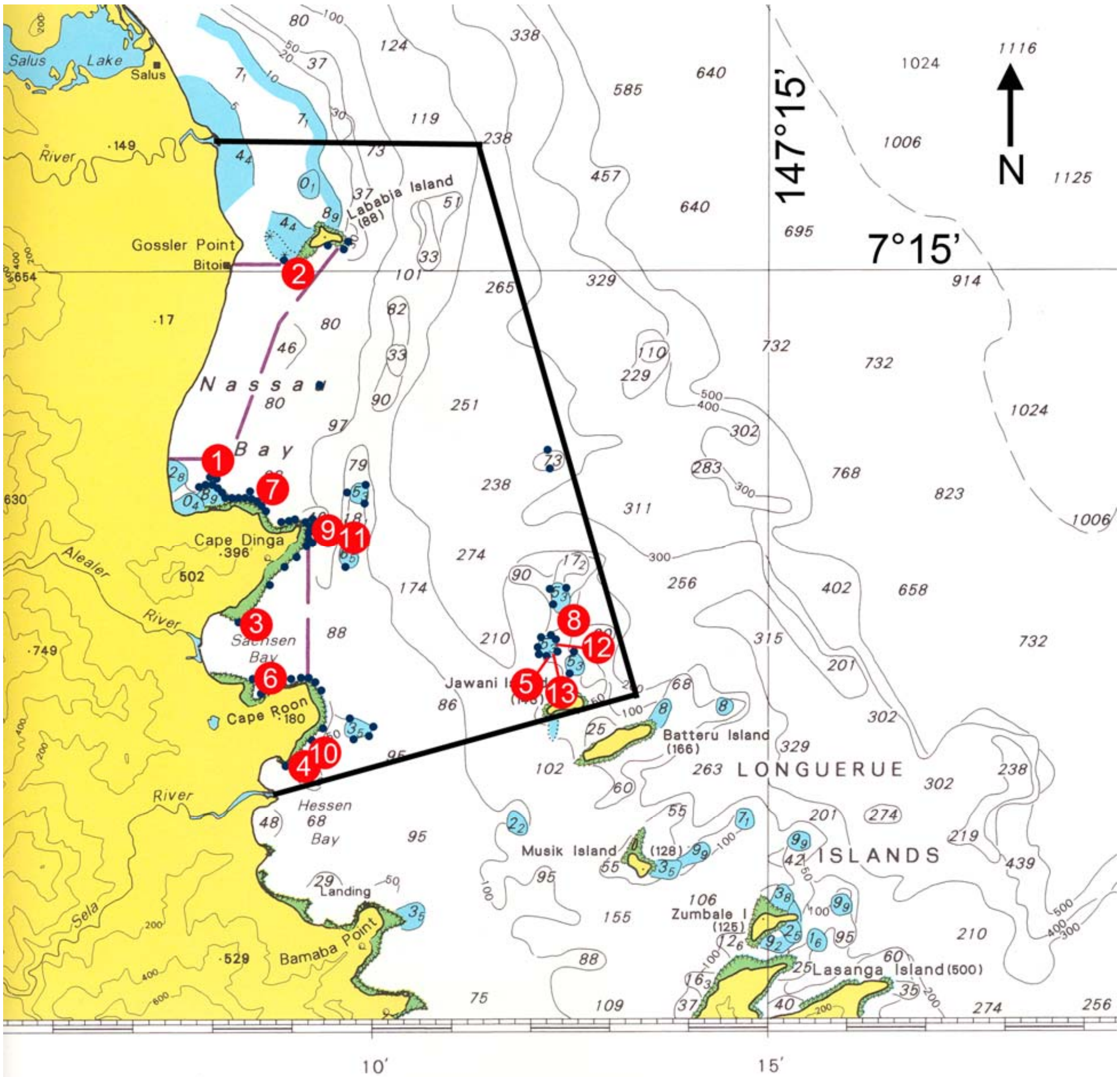


Figure 2. The marine portion of Kamiali Wildlife Management Area (outlined in black). Red circles indicate locations of 2014 survey sites (coordinates are given in Table 1). Smaller blue circles indicate 2009 - 2013 survey sites (coordinates in Longenecker *et al*. 2009, 2010, 2011, 2012, 2013c). Adapted from chart Aus 523, published by the Australian Hydrographic Service. Depths are in meters.

We constructed length-frequency histograms for each species for which at least 15 individuals were captured on video from 2009 – 2014. To be included in the count of total number of individuals, a still image captured from video must have been of suitable quality for length estimation. Mean length was compared to L_{max}, L_{opt}, and female L_m or L_{50}. When sex ratios were available, we estimated the percentage of reproductive females in each population. The length information presented below is the distance between the front of the head and the end of the middle caudal ray.

Time Series

We plotted a time-series of average length by year for species that were most-frequently and consistently captured on video. To smooth interannual fluctuation and highlight longer-term trends, we also plotted 3-year moving averages. Species we analyzed were represented by at least ~10 specimens each of the last five years. Five species met this criterion: *luduŋ mai* (the caesionid, or fusilier, *Caesio cuning*), *ikula sa* (the serranid, or grouper, *Cephalopholis cyanostigma*), *itale* (the lutjanid, or snapper, *Lutjanus biguttatus*), *iwaŋgale* (the mullid, or goatfish, *Parupeneus barberinus*), and *iwaŋgale bote* (another goatfish, *P. multifasciatus*). Images of each are presented in Figure 3.

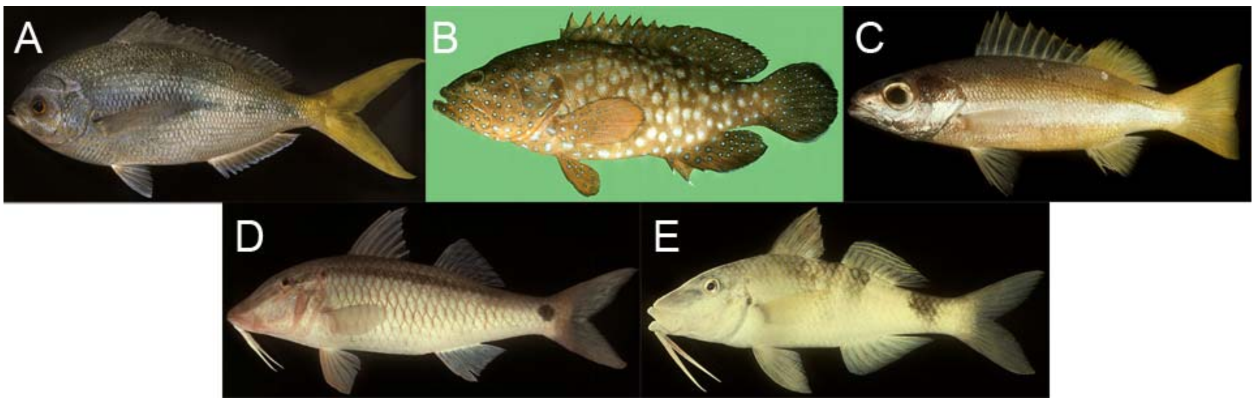


Figure 3. Species used for time-series plots. A) *luduŋ mai* (*Caesio cuning*), B) *ikula sa* (*Cephalopholis cyanostigma*), C) *itale* (*Lutjanus biguttatus*), D) *iwaŋgale* (*Parupeneus barberinus*), E) *iwaŋgale bote* (*P. multifasciatus*). Images courtesy of J. Randall.

RESULTS

Fishery Surveys

In 2014, we captured an additional 772 specimens on video suitable for length estimation, yielding a combined total of 4,716 individuals from 2009 to 2014. These specimens include 16 species not analyzed in the 2009 - 2013 surveys (Longenecker *et al*. 2013c). Mean length, along with known information on maximum length, size-at-maturity, size-specific sex ratios, spawning season, and reproductive mode is presented for each of the 100 species in Table 3. Species and family names follow the taxonomy of FishBase (Froese and Pauly 2012). A tilde (~) preceding values in Table 3 indicates uncertainty. These typically occur before maximum length and size-at-maturity values. For maximum length, a lack of published total length (TL) to fork length (FL) equations prevented accurate determination of fork length. For size-at-maturity values, only minimum size-at-maturity (L_m) values were available. These would be expected to be smaller than the preferred size at 50% maturity (L_{50}).

Weighted percent maximum length of all individuals captured on video was 57% (unchanged since 2013). That is, an exploited reef fish swimming in the KWMA is likely to be about 3/5 its potential maximum length.

Weighted percent estimated optimum length of all individuals captured on video was 90%. In other words, an exploited fish is likely to be about 10% shorter than the length at which the empirical equation of Froese & Binohlan (2000) suggests maximum yield per recruit can be obtained.

Information about reproduction in these species is scant. Size-at-maturity is known for about half (54%) of the species studied. Of this subset, an average free-swimming individual of nearly 3/5 (59%) of species is likely to be mature (Table 2). Of the remaining 41% of species, an average individual is most likely to be immature, Further, no individual *godobo manibarã* /*tarõ* (*Diagramma pictum*), or *ikula su mani balã* (*Plectropomus areolatus*) captured on video had reached maturity.

Table 2. Reef fish species at Kamiali Wildlife Management Area for which an average, free-swimming individual is likely to be at least (Mature column) or shorter than (Immature column) reproductive size.

Family	Mature	Immature
Acanthuridae	*Ctenochaetus striatus*	*Acanthurus lineatus* (iwiliya)
	Naso lituratus	*Naso hexacanthus* (*biaŋgawe suwi*)
Caesionidae	*Caesio cuning* (*luduŋ mai*)	
Carangidae	*Carangoides bajad* (*imaŋalẽ babaura*)	*Caranx melampygus*(*imaŋalẽ talã*)
Carcharhinidae	*Carcharhinus melanopterus* (*kapa mayumbui*)	*Carcharhinus amblyrhynchos* (*kapa ii*)
		Triaenodon obesus (*kapa bage bula*)
Haemulidae	*Plectorhinchus vittatus* (*iyabua kurĩ naba*)	*Diagramma pictum* (*godobo manibarã* & *tarõ*)
Holocentridae	*Myripristis adusta* (*imbilĩ tombo yeyẽ*)	
	Neoniphon sammara (*imbilĩ sa*)	
Kyphosidae	*Kyphosus cinerascens* (*italawe*)	
Labridae	*Cheilinus fasciatus* (*talulumuã tatalõ*)	
Lethrinidae	*Lethrinus erythropterus* (*kada maba*)	
Lutjanidae	*Lutjanus carponotatus* (*babaura*)	*Lutjanus argentimaculatus* (*ilĩ*)
	Lutjanus gibbus (*ina suwi*)	*Lutjanus biguttatus* (*itale*)
	Lutjanus kasmira (*babaura yumi yayã*)	*Lutjanus bohar* (*yame tuaŋ yasai, yame tuaŋ,* & *ilĩ*)
	Lutjanus vitta (*isale*)	*Lutjanus fulvus* (*iyayaŋ kurĩ naba*)
		Lutjanus monostigma (*baniŋga*)
		Lutjanus russellii (*kawasi ŋasiŋa*)
		Lutjanus semicinctus (*imawe*)
		Lutjanus timorensis (*iko yaŋgawe* & *iko*)
Mullidae	*Mulloidichthys vanicolensis* (*imake*)	*Parupeneus multifasciatus* (*iwaŋgale bote*)
	Parupeneus barberinus (*iwaŋgale*)	
	Parupeneus trifasciatus (*walia*)	
Nemipteridae	*Scolopsis bilineata* (*buamea*)	
Priacanthidae	*Priacanthus hamrur* (*iko indu*)	
Scaridae	*Scarus ghobban*	*Cetoscarus bicolor*
	Scarus niger (*iŋga tumi*)	*Chlorurus microrhinos*
	Scarus oviceps	*Scarus rubroviolaceus*
Scombridae	*Rastrelliger kanagurta* (*indala*)	*Gymnosarda unicolor* (*itaŋgi talalo*)
	Scomberomorus commerson (*itaŋgi*)	
Serranidae	*Cephalopholis boenak* (*ikula bobo*)	*Cephalopholis cyanostigma* (*ikula sa*)
	Cephalopholis sexmaculata (*ikula talulumua*)	*Plectropomus areolatus* (*ikula su*)
	Epinephelus fasciatus (*ikula laga*)	
	Epinephelus merra (*ikula talõ*)	
	Plectropomus leopardus (*ikula su*)	
	Plectropomus oligacanthus (*ikula su talalõ*)	
Siganidae	*Siganus lineatus* (*yulawe*)	*Siganus doliatus* (*indaŋa*)

Given the scarcity of reproductive information, we compared average length relative to minimum size at female maturity (♀L_m), and observed size at which 50% of females are mature

(♀L_{50}). For all ♀L_m values combined (observed and estimated), the weighted mean length of 66 species suggests an exploited fish was 101% of minimum size-at-maturity. Published ♀L_{50} values were available for 33 species. For these, average length was 101% of female L_{50}.

Published descriptions of sex ratios are limited to 35 of the species examined in this report. When these sex ratios are considered, the size-structure data generated from laser-videogrammetry surveys study suggest that, on average, 32% of the exploited reef-fish population is composed of mature females.

Demographic information for each of 100 species is presented below. When at least 15 individuals were captured on video suitable for length estimates, we generated size-frequency histograms, with arrows indicating maximum length (L_{max}), optimum length (L_{opt}) and female reproductive length. The reader is cautioned that, depending on the information available, reproductive length may be minimum size-at-maturity (L_m) or size at 50% maturity (L_{50}). Also, note that arrows are solid for published values and dashed for estimated values.

In an effort to reduce the size of this report and to make information more easily accessible, species accounts are presented in a telegraphic style. For each species account, the first line indicates the number of specimens captured on video in 2014 and the total number of specimens analyzed from 2009 – 2014. If a species is covered for the first time, the first line begins with "First report", and indicates the total number of specimens analyzed in 2014. The second line indicates average length. If a length comparison was possible between 2013 and 2014 (*i.e.*, the species was covered previously *and* specimens were captured on video during 2014) the relative change is indicated in parentheses: ↑ = increase, ↓ = decrease, or no change. The following three lines compare average length to maximum length (L_{max}), optimum length (L_{opt}) and female size-at-maturity (L_m or L_{50}), respectively. We also indicate whether the length parameters were estimated, reported (published values converted to fork length), or published. When sex ratio information was available, a sixth line indicates the estimated percentage of mature females in the population. Finally, a note may describe any caveats to the information listed in lines 1 – 6.

This page is intentionally blank.

Table 3. Size and reproductive information for common, exploited fishes in Kamiali Wildlife Management Area (updated from Longenecker *et al.* 2013c). Values bridging female and male L_{50} columns (*Naso hexacanthus, Neoniphon sammara*, *Lutjanus monostigma*, *Scarus oviceps*, *Gymnosarda unicolor*, and *Scomberomorus commerson*) indicate no sex-specific size-at-maturity values were provided.

Taxon (Kala name, if recorded)	N	Mean length (cm)	L_{max} (cm)	Female L_{50} (cm)	Male L_{50} (cm)	Sex ratio	Spawning season	Sex change?
ACANTHURIDAE								
Acanthurus lineatus (*iwiliya*)	15	17	31[1,2,3]	18[3]	~17[3]	1♂:1.1♀[3]	Sep-Feb[4]	
Acanthurus pyroferus	40	17	23[1,2]					
Ctenochaetus striatus	18	13	23[1,2]	~14[2,5]	~16[2,5]			No[6]
Ctenochaetus tominiensis (*aloweya yayã*)	21	14	19[1,2]					No[7]
Naso hexacanthus (*biaŋgawe suwi*)	88	43	71[1,2]	~50[2,8]				No[7]
Naso lituratus	4	21	38[1,2]	15[9]	18[9]		Year round[9]	No[6]
Naso lopezi (*biaŋgawe talõ*)	3	59	48[1,2]					No[7]
Naso vlamingii (*biaŋgawe tumi*)	10	36	51[1,2]					No[7]

BALISTIDAE								
Balistoides conspicillum	3	24	50[1]					No[10]
Canthidermis maculata (*labaikã suwi*)	13	33	35[1]					No[7]
Odonus niger	10	19	32[1,2]					No[7]
Sufflamen bursa	10	13	24[1]					No[7]
CAESIONIDAE								
Caesio cuning (*luduŋ mai*)	1451	16	31[11]	15[11]	13[11]	♀ biased 17-20 cm, otherwise ♂ biased[11]		No[11]
CARANGIDAE								
Carangoides bajad (*imaŋalẽ babaura*)	50	25	51[1,2]	~25[12]		~1:1[12]	Jun-Sep[12]	
Carangoides plagiotaenia (*imaŋalẽ tombo gabo*)	36	27	38[1,2]					
Caranx melampygus (*imaŋalẽ talã*)	41	27	72[1,2]	36[13]		1♂:1.48♀[13]		No[13]
Caranx papuensis (*imaŋalẽ labrã kulĩ*)	16	57	66[2,14]					
CARCHARHINIDAE								
Carcharhinus amblyrhynchos (*kapa ii*)	11	76	217[1,2]	118[2,15]	114[2,15]		May-Oct (biennial)[15]	

Taxon (Kala name, if recorded)	N	Mean length (cm)	L_{max} (cm)	Female L_{50} (cm)	Male L_{50} (cm)	Sex ratio	Spawning season	Sex change?
Carcharhinus melanopterus (*kapa mayumbui*)	5	82	150[1,16]	80[16]	78[16]	1:1[16]	Jan-Feb[16]	
Triaenodon obesus (*kapa bage bula*)	12	70	177[1,2]	97[2,15]	94[2,15]		May-Oct (biennial)[15]	
EPHIPPIDAE								
Platax orbicularis	9	37	50[1]					
Platax pinnatus (*ibuŋgi tarõ*)	29	25	30[1]					
Platax teira (*ibuŋgi*)	5	33	60[1]					
HAEMULIDAE								
Diagramma pictum (*godobo manibarã* & *godobo tarõ*)	8	25	90[1]	36[17]	27[17]	~1:1[17]	Apr-May & Nov[17]	No[17]
Plectorhinchus chaetodonoides	7	41	~60[1,18] (TL)					
Plectorhinchus gibbosus	4	38	60[1]					
Plectorhinchus lineatus (*iyabua sa*)	50	36	50[1]					
Plectorhinchus vittatus (*iyabua kurĩ naba*)	4	28	50[1]	~23[2,19]	~29[2,19]	1♂:1.75♀[19]	Dec-May[19]	

HOLOCENTRIDAE								
Myripristis adusta (*imbilĩ tombo yeyẽ*)	19	19	28[1,20]	17[21]	15[21]	Increasingly male-biased with length[21,22]		No[21]
Myripristis berndti (*imbilĩ yakẽ susuwi*)	8	14	26[1,23]					No[7]
Myripristis kuntee (*imbilĩ godõ nambĩ*)	79	12	16[1,24]					No[7]
Myripristis pralinia (*imbilĩ yakẽ susuwi*)	4	13	17[1,23]					No[7]
Myripristis violacea (*imbilĩ yakẽ bumbu*)	98	13	17[1,23]					No[7]
Myripristis vittata (*imbilĩ yakẽ suwi*)	20	11	17[1,20]					No[7]
Neoniphon sammara (*imbilĩ sa*)	19	13	~27[1,20]	~8[18,19] (SL)		1♂:2.56♀[19]	Nov-May[19]	No[7]
Sargocentron caudimaculatum (*imbilĩ yasai*)	9	15	19[1,2]					No[7]
Sargocentron melanospilos	4	15	23[1,2]					
KYPHOSIDAE								
Kyphosus cinerascens (*italawe*)	75	30	41[2,14]	~25[25]	~18[25]			
Kyphosus vaigiensis (*italawe talabopia*)	8	35	56[2,14]					

Taxon (Kala name, if recorded)	N	Mean length (cm)	L_{max} (cm)	Female L_{50} (cm)	Male L_{50} (cm)	Sex ratio	Spawning season	Sex change?
LABRIDAE								
Bodianus mesothorax	7	12	20[1]					♀→♂[26]
Cheilinus fasciatus (*talulumuã tatalõ*)	51	16	~36[1,18] (TL)	~12[18,26]	~20[18,26]			♀→♂[26]
Choerodon anchorago (*i bubui*)	5	24	38[1]					
Oxycheilinus celebicus (*talulumuã bobo*)	29	13	20[1]					
Oxycheilinus digramma (*ikula talulumuã*)	12	17	30[1]					
LETHRINIDAE								
Lethrinus erythropterus (*kada maba*)	5	22	48[1,2]	20[11]	~19[11]	Increasingly male-biased with length[11]	Mar-May[27]	♀→♂[11]
Monotaxis grandoculis (*labaikã taloŋ* & *labaikã*)	76	24	~56[1,20]					
LUTJANIDAE								
Lutjanus argentimaculatus (*ilĩ*)	5	47	118[1,2]	53[28]	47[28]	1♂:1.18♀[28]	Oct-Nov[29], Dec[28]	No[30]
Lutjanus biguttatus (*itale*)	505	15	19[1,31]	17[31]	13[31]	1:1[31]		No[31]

Lutjanus bohar (*yame tuaŋ yasai, yame tuaŋ,* & *ilĩ*)	4	17	71[1,2]	43[32]	<30[32]		Aug-Apr[32]	No[32]
Lutjanus boutton (*iyayaŋ*)	271	14	28[1,2]					No[30]
Lutjanus carponotatus (*babaura*)	38	21	38[1,2]	19[33]		Increasingly male-biased with length[34]	Oct-Dec[33]	No[35]
Lutjanus fulvus (*iyayaŋ kurĩ naba*)	47	18	39[1,2]	19[36]	14[36]	1:1[36]	Year round[30,37]	No[36]
Lutjanus gibbus (*ina suwi*)	24	21	42[1,2]	~18[2,19]-23[38]	~14[2,19]	Increasingly male-biased with length[39]	Jan-Apr[19]	No[30]
Lutjanus kasmira (*babaura yumi yayã*)	4	16	33[1,40]	~12[19,40]	~14[19,40]	1♂:1.33♀[19]	Year round[30]	No[30]
Lutjanus monostigma (*baniŋga*)	5	24	48[1,2]	~32[41]			Feb & Nov[30]	No[30]
Lutjanus rivulatus (*isina*)	4	31	63[1,2]					No[30]
Lutjanus russellii (*kawasi ŋasiŋa*)	82	21	43[1,2]	22[42]			Aug-Feb[43]	No[30]
Lutjanus semicinctus (*imawe*)	53	20	34[1,2]	21[44]	18[44]	Varies unpredictably with length (~1:1)[44]		No[44]
Lutjanus timorensis (*iko yaŋgawe* & *iko*)	7	23	50[1]	~30[44]	23[44]			No[44]
Lutjanus vitta (*isale*)	24	16	37[1,2]	15[45]		Increasingly male-biased > 29 cm[46]	Sep-Apr[46,47]	No[30]

Taxon (Kala name, if recorded)	N	Mean length (cm)	L_{max} (cm)	Female L_{50} (cm)	Male L_{50} (cm)	Sex ratio	Spawning season	Sex change?
Macolor macularis (*labaikã tewe yayã*)	21	30	55[1,2]					
Macolor niger (*labaikã yasai*)	5	28	~60[1,18] (TL)					
MULLIDAE								
Mulloidichthys vanicolensis (*imake*)	7	21	34[1,2]	17[48]			Oct-Nov[49]	
Parupeneus barberinus (*iwaŋgale*)	173	15	44[1,20]	~12[44]	~14[44]	Increasingly male-biased with length[44]	Oct-May[19]	No[44]
Parupeneus cyclostomus (*iwaŋgale bokole*)	40	19	44[1,50]					
Parupeneus multifasciatus (*iwaŋgale bote*)	125	14	26[1,51]	15[51]	15[51]	Increasingly male-biased with length[51]		No[51]
Parupeneus trifasciatus (*walia*)	64	18	30[1,52]	~11[19,52]	~16[19,52]	1♂:1.67♀[19]	Sep-Apr[19]	
NEMIPTERIDAE								
Scolopsis bilineata (*buamea*)	10	13	~23[1,18] (TL)	~12[53]	~16[53]	Exclusively male >16 cm TL[53]		♀→♂[53]
Scolopsis ciliata	9	13	~22[1,18] (TL)					

Scolopsis margaritifera	3	15	~30[1,18] (TL)					
PRIACANTHIDAE								
Priacanthus hamrur (*iko indu*)	4	23	~40[1,18] (TL)	20[54]	18[54]	1♂:1.77♀[54]	Apr-Jul[54]	
SCARIDAE								
Cetoscarus bicolor	4	33	74[1,2]	35[55]	37[55]			♀→♂[55]
Chlorurus bleekeri (*iŋga bobo* & *iŋga talã*)	41	19	30[1]					
Chlorurus bowersi (*guniau*)	9	22	31[56]					
Chlorurus japanensis	7	18	30[1]					
Chlorurus microrhinos	3	25	42[1,2]	31[57]		Increasingly male-biased with length[58]		♀→♂[57]
Scarus flavipectoralis (*iŋga talaŋ* & *iŋga tali lau*)	90	18	29[1,2]					♀→♂[59]
Scarus ghobban	7	33	91[1,2]	~26[60]	~29[60]	Increasingly male-biased with length[61]		♀→♂[57]
Scarus niger (*iŋga tumi*)	16	21	~35[1,18]	17[55]	28[55]	Increasingly male-biased with length[59]		♀→♂[59]

Taxon (Kala name, if recorded)	N	Mean length (cm)	L_{max} (cm)	Female L_{50} (cm)	Male L_{50} (cm)	Sex ratio	Spawning season	Sex change?
Scarus oviceps	3	26	~35[1] (TL)	21[62]				♀→♂[59]
Scarus rubroviolaceus	3	24	64[1,2]	27[57]		1♂:4.5♀[63]		♀→♂[57]
SCOMBRIDAE								
Gymnosarda unicolor (*itaŋgi talalo*)	18	59	137[1,2]	~70[64]			Dec-Feb[65]	No[65]
Rastrelliger kanagurta (*indala*)	17	22	33[1,2]	19[66]	18[66]		Oct-Jul[66]	No[65]
Scomberomorus commerson (*itaŋgi*)	11	66	218[1,67]	~65[68]		Female biased >90 cm[68]	Jul-Dec[65]	No[65]
SERRANIDAE								
Anyperodon leucogrammicus (*ikula damasã*)	19	25	52[1]					♀→♂[69]
Cephalopholis boenak (*ikula bobo*)	10	16	24[1]	15[70]	16[70]	1♂:5.30♀[71]	Apr-Oct[70]	♀→♂[70]
Cephalopholis cyanostigma (*ikula sa*)	96	19	35[1]	23[44]	20[44]	Increasingly male-biased with length[44]		♀→♂[44]
Cephalopholis microprion (*ikula yuyeŋ*)	30	13	23[1]					♀→♂[69]
Cephalopholis sexmaculata (*ikula talulumua*)	4	24	47[1]	~24[72]			Mar-May[72]	♀→♂[69]

Cephalopholis urodeta (*ikula karu guŋ-guŋ*)	6	18	27[1]			1♂:28.50♀[71]		♀→♂[69]
Epinephelus fasciatus (*ikula laga*)	3	16	40[1]	~14[73]	~18[73]	Increasingly male-biased with length[73]		♀→♂[73]
Epinephelus merra (*ikula talõ*)	3	22	28[1]	11[74]				♀→♂[69]
Plectropomus areolatus (*ikula su*)	15	18	70[1]	40[2,75]	48[2,75]	Increasingly male-biased with length[76]	Jan-May[75]	♀→♂[69]
Plectropomus leopardus (*ikula su*)	10	32	68[1,2]	32[77]	37[70]	Increasingly male-biased > 44 cm[77]	Sep-Dec[78]	♀→♂[78]
Plectropomus oligacanthus (*ikula su tatalõ*)	77	32	65[1]	~27[21]	~41[21]		Apr-Jun[21]	♀→♂[21]
SIGANIDAE								
Siganus doliatus (*indaŋa*)	6	17	~30[1,18]	~18[79]	~18[79]			No[79]
Siganus javus (*yulawe kokoranawa*)	41	26	~53[14,18] (TL)					
Siganus lineatus (*yulawe*)	76	26	41[1,2]	24[44]	~19[44]	~1:1[44]	Year round[27]	No[44]
Siganus puellus (*indaŋa malũ*)	4	25	~38[1,18] (TL)					
Siganus vulpinus (*indaŋa*)	20	17	30[1]					

[1] Allen & Swainston 1993; **[2]** estimated using length-length relationship from Froese & Pauly 2012; **[3]** Craig *et al*. 1997; **[4]** however, spawning occurs year round, Craig 1998; **[5]** Montgomery & Galzin 1993; **[6]** Breder & Rosen 1966; **[7]** Thresher 1984; **[8]** Choat & Robertson 2002 (authors do not describe how estimate was obtained); **[9]** Taylor *et al*. 2014; **[10]** Myers 1999; **[11]** Longenecker *et al*. 2014a **[12]** Grandcourt *et al*. 2003; **[13]** Sudekum *et al*. 1991; **[14]** Randall *et al*. 1990; **[15]** Robbins 2006; **[16]** Lyle 1987; **[17]** Grandcourt *et al*. 2011; **[18]** no relationship available to estimate fork length; **[19]** Anand & Pillai 2002 (authors report minimum size-at-maturity based on a combination of gross and histological examination of individuals in variable size classes, above lengths are the mean of minimum and maximum class limits); **[20]** Longenecker *et al*. 2010; **[21]** Longenecker *et al*. 2013c; **[22]** %F = 369.91 – 15.84(FL); **[23]** FL estimated from a general *Myripristis* length relationship (C.J. Bradley, unpublished data) based on Hawaiian specimens of at least three species: *M. berndti*, *M. chryseres*, *M. kuntee*: FL = -0.4139 + 0.8919(TL); r^2 = 0.993; n = 50; **[24]** FL estimated from Hawaiian specimens (Longenecker 2008 and C.J. Bradley, unpublished data) FL = 0.4314 + 0.8288(TL), r^2 = 0.993, n = 13; **[25]** Longenecker *et al.* 2012; **[26]** Hubble 2003; **[27]** Hamilton *et al*. 2004; **[28]** Russell & McDougall 2008; **[29]** Pakoa 1998; **[30]** Allen 1985; **[31]** Longenecker *et al*. 2013a; **[32]** Marriott *et al* 2007; **[33]** Kritzer 2004; **[34]** authors' interpretation of data in Heupel *et al*. 2010: %♀ = 146.986 – 3.735(FL); **[35]** Evans *et al*. 2008; **[36]** Longenecker *et al*. 2013b; **[37]** Caillart *et al*. 1994; **[38]** Heupel *et al*. 2009 (all females > 23 cm FL were mature); **[39]** results from Heupel *et al*. 2009 suggest the proportion of females is inversely related to size; **[40]** Friedlander *et al*. 2002; **[41]** Munro & Williams 1985 (length at first maturity); **[42]** Kritzer in Williams *et al*. 2002; **[43]** authors' interpretation of GSI and developmental stages in Sheaves 1995; **[44]** Longenecker *et al*. 2011; **[45]** Davis & West 1993; **[46]** authors' interpretation of data in Davis & West 1992: sex ratio is 1:1 to 29 cm, then %♀ = 1.986 – 0.00534(FL); **[47]** Loubens 1980; **[48]** Cole 2008; **[49]** Jehangeer 2003; **[50]** FL estimated from Hawaiian specimens (Longenecker 2008): FL = 0.3132 + 0.8657(TL), r^2 = 0.998, n = 14; **[51]** Longenecker & Langston 2008, %♀ = 141.3 – 0.6167(FL in mm) with all individuals male above 225 mm; **[52]** FL estimated from relationships for Hawaiian specimens: FL = 0.827 + 0.840(TL), r^2 = 0.99, n = 3; FL = 1.029 + 1.044(SL), r^2 = 0.97, n = 3; **[53]** Boaden & Kingsford 2013; **[54]** Sivakami *et al*. 2001; **[55]** Barba 2010; **[56]** Bellwood 2001; **[57]** Taylor & Choat 2014; **[58]** authors' interpretation of data in Sabetian 2010: %♀ = 148.866 – 2.266(FL); **[59]** Choat & Robertson 1975; **[60]** Sabetian 2010; **[61]** authors' interpretation of data in Sabetian 2010: %♀ = 311.971 – 7.836(FL); **[62]** Page 1998; **[63]** Grandcourt 2002; **[64]** Sivadas & Anasukoya 2005 report that all individuals < 70 cm were immature; **[65]** Collette & Nauen 1983; **[66]** Abdussamad *et al*. 2010; **[67]** Mackie *et al.* 2003; **[68]** Lewis *et al*. 1974 (length at first maturity, sex ratio was ~1:1 in specimens <90 cm, but larger size classes were female biased, 4♂:38♀); **[69]** Heemstra & Randall 1993; **[70]** Chan & Sadovy 2002; **[71]** Were 2009; **[72]** Shakeel & Ahmed 1996 report the smallest mature female was 24 cm; **[73]** Mishina *et al*. 2006; **[74]** Murty 2002; **[75]** Rhodes & Tupper 2007; **[76]** authors' interpretation of data in Williams *et al*. 2008: %♀ = 285.0 – 4.346(FL); **[77]** authors' interpretation of data in Ferreira 1995: sex ratio is ~1♂:4♀ to 44 cm, then %♀ = 333 – 5.6(FL), maximum female size is 56 cm; **[78]** Ferreira 1995; **[79]** Brandl & Bellwood 2013.

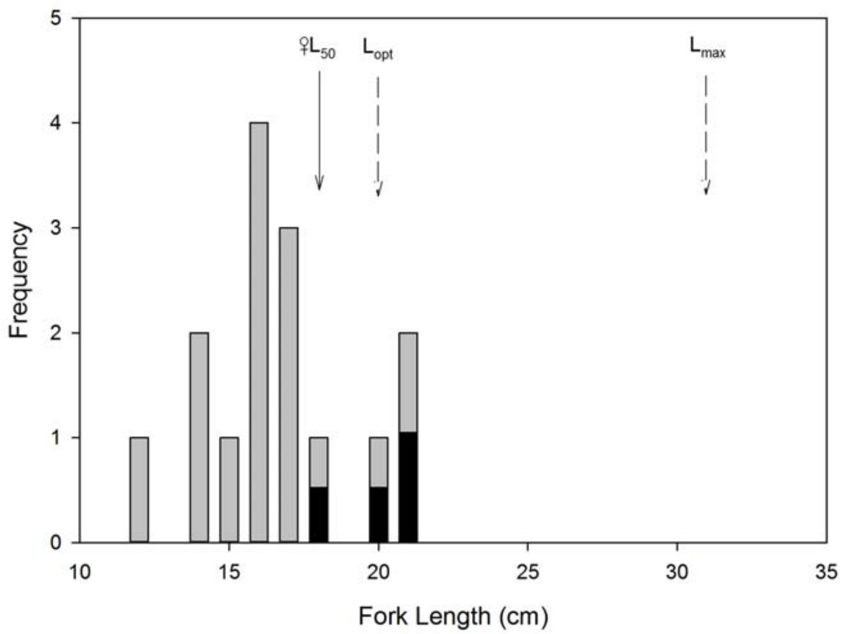
Species Accounts

<u>Acanthuridae</u>

Acanthurus lineatus **(Linnaeus, 1758)** or ***iwiliya***. Figure 4.

4 new specimens; 15 total (Figure 5)
Mean FL = 17 cm (no change)
57% of reported L_{max} (31 cm)
85% of estimated L_{opt} (20 cm)
94% of published ♀L_{50} (18 cm)
14% mature ♀

← Figure 4. *Iwiliya* (*Acanthurs lineatus*). Inter-laser distance 32 mm.

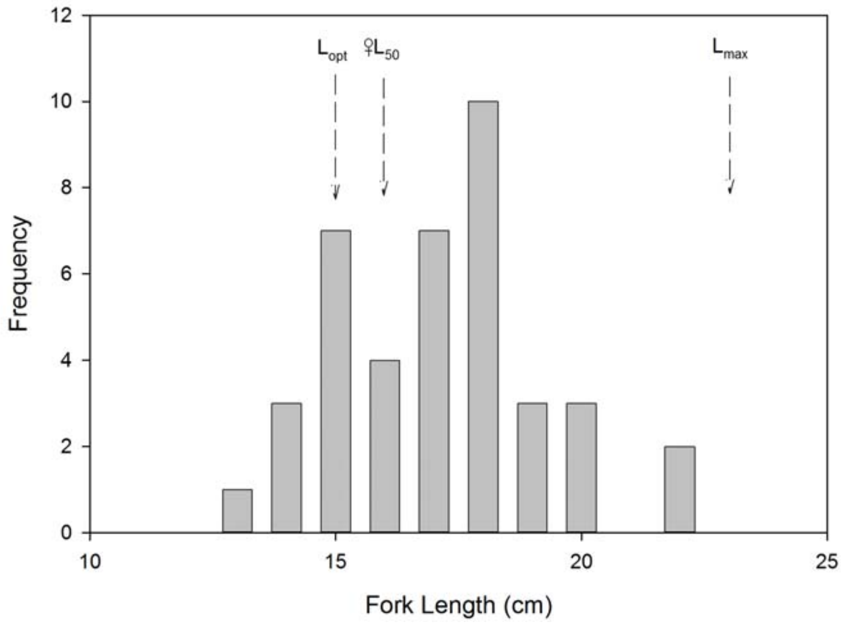


← Figure 5. Size structure of *Acanthurus lineatus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Acanthurus pyroferus **(Kittlitz, 1834)**; Kala name not yet recorded. Figure 6.

First report; 40 specimens (Figure 7)
Mean FL = 17 cm
74% of estimated L_{max} (23 cm)
113% estimated L_{opt} (15 cm)
106% of estimated ♀L_m (16 cm)

← Figure 6. *Acanthurus pyroferus*. Inter-laser distance 32 mm.

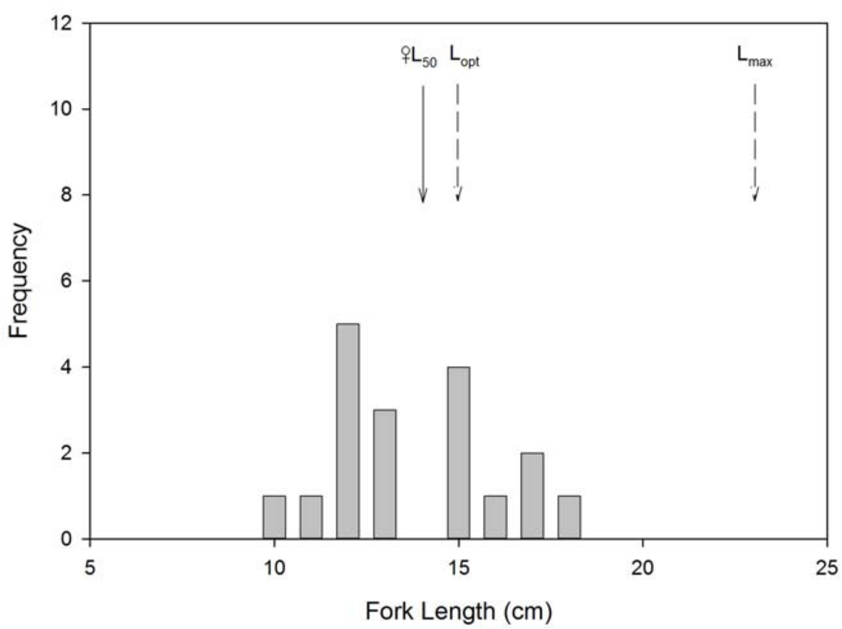


← **Figure 7. Size structure of *Acanthurus pyroferus*.**

***Ctenochaetus striatus* (Quoy & Gaimard, 1825)**; Kala name not yet recorded. Figure 8.

First report; 40 specimens (Figure 9)
Mean FL = 17 cm
74% of estimated L_{max} (23 cm)
113% estimated L_{opt} (15 cm)
121% of published ♀L_m (14 cm)

← **Figure 8. *Ctenochaetus striatus*. Inter-laser distance 31 mm.**

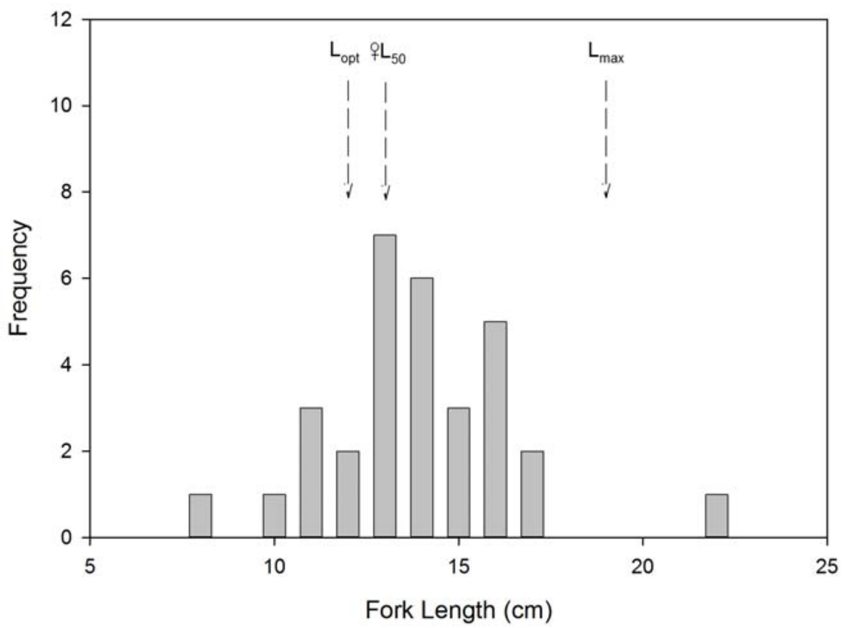


← **Figure 9. Size structure of *Ctenochaetus striatus*.**

Ctenochaetus tominiensis* Randall, 1955** or ***aloweya yayã. Figure 10.

21 new specimens; 31 total (Figure 11)
Mean FL = 14 cm (no change)
74% of estimated L_{max} (19 cm)
117% of estimated L_{opt} (12 cm)
108% of estimated ♀L_m (13 cm)

← Figure 10. *Aloweya yayã* (*Ctenochaetus tominiensis*). Inter-laser distance 31.5 mm.



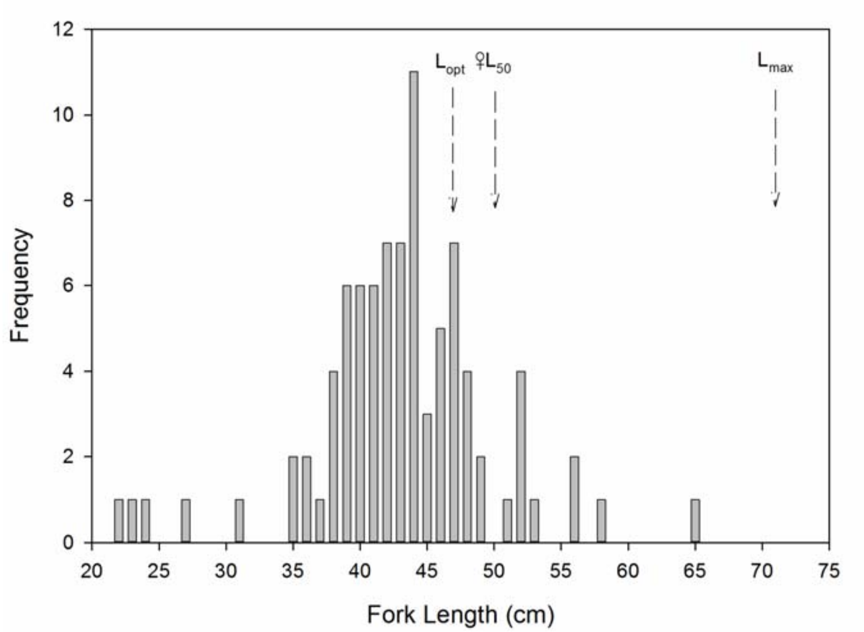
← Figure 11. Size structure of *Ctenochaetus tomeniensis.*

Naso hexacanthus* (Bleeker, 1855)** or ***biaŋgawe suwi. Figure 12.

Figure 12. *Biaŋgawe suwi* (*Naso hexacanthus*). Inter-laser distance 36 mm.

0 new specimens; 88 total (Figure 13)
Mean "FL" = 43 cm
61% of estimated L_{max} (71 cm)
91% of estimated L_{opt} (47 cm)
86% of estimated ♀L_{50} (50 cm)

Note: We were not able to evaluate the reliability of the size-at-maturity estimate from Choat & Robertson (2002).



← **Figure 13. Size structure of *Naso hexacanthus*.**

***Naso lituratus* (Forster, 1801);** Kala name not yet recorded. Figure 14.

First report; 4 specimens
Mean FL = 21 cm
55% of estimated L_{max} (38 cm)
84% estimated L_{opt} (25 cm)
140% of published ♀L_m (15 cm)

← **Figure 14. *Naso lituratus*. Inter-laser distance 31.5 mm.**

Naso lopezi* Herre, 1927** or ***biaŋgawe talõ. Figure 15.

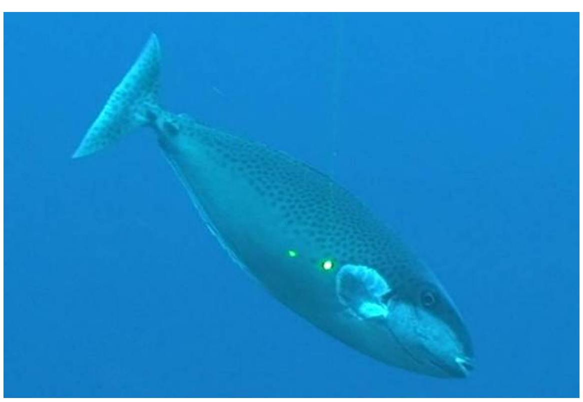


Figure 15. *Biaŋgawe talõ* (*Naso lopezi*). Inter-laser distance 36 mm.

0 new specimens; 3 total
Mean FL = 59 cm
123% of estimated L_{max} (48 cm)
190% of estimated of L_{opt} (31 cm)
190% of estimated ♀L_m (31 cm)

Note: L_{max} reported by Allen & Swainston (1993) may be an underestimate. Estimated length of the largest specimen captured on video was 85 cm, or 177% of published L_{max}.

Naso vlamingii* (Valenciennes, 1835)** or ***biaŋgawe tumi. Figure 16.

0 new specimens; 10 total
Mean FL = 36 cm
71% of estimated L_{max} (51 cm)
109% of estimated of L_{opt} (33 cm)
109% of estimated ♀L_m (33 cm)

← Figure 16. *Biaŋgawe tumi* (*Naso vlamingii*).

<u>Balistidae</u>

***Balistoides conspicillum* (Bloch & Schneider, 1801);** Kala name not yet recorded. Figure 17.

First report; 3 specimens
Mean TL = 24 cm
48% of reported L_{max} (50 cm)
73% estimated L_{opt} (33 cm)
75% of estimated ♀L_m (32 cm)

← Figure 17. *Balistoides conspicillum*. Inter-laser distance 31 mm.

Canthidermis maculata* (Bloch, 1786)** or ***labaikã suwi. Figure 18.

0 new specimens; 13 total
Mean TL = 33 cm
94% of reported L_{max} (35 cm)
143% of estimated L_{opt} (23 cm)
143% of estimated ♀L_m (23 cm)

← Figure 18. *Labaikã suwi* (*Canthidermis maculata*). Inter-laser distance 36 mm.

***Odonus niger* (Rüppell, 1836);** Kala name not yet recorded. Figure 19.

First report; 10 specimens
Mean FL = 19 cm
63% of estimated L_{max} (32 cm)
90% estimated L_{opt} (21 cm)
90% of estimated ♀L_m (21 cm)

Figure 19. *Odonus niger*. Inter-laser distance 31 mm.

***Sufflamen bursa* (Bloch & Schneider, 1801);** Kala name not yet recorded. Figure 20.

First report; 10 specimens
Mean TL = 13 cm
54% of reported L_{max} (24 cm)
87% estimated L_{opt} (15 cm)
81% of estimated ♀L_m (16 cm)

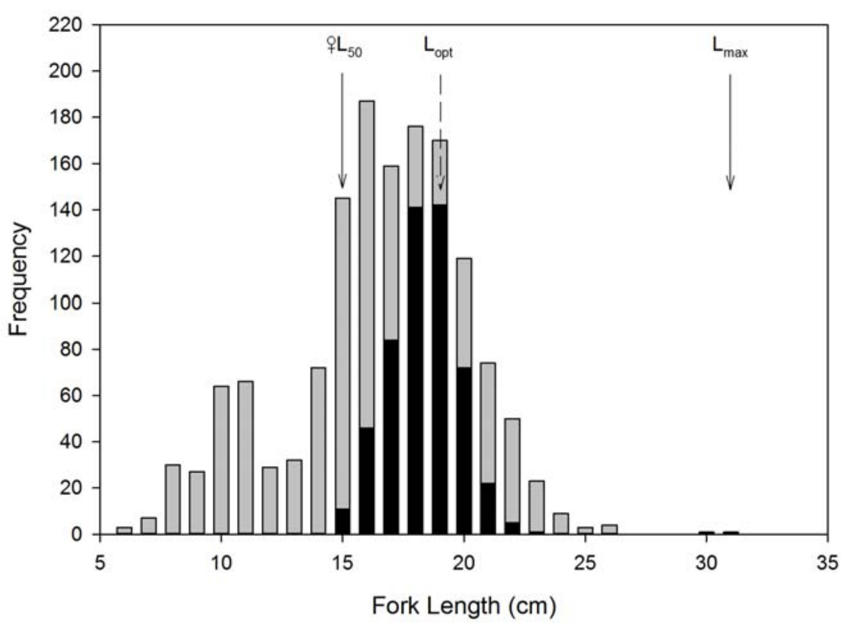
Figure 20. *Sufflamen bursa*. Inter-laser distance 31 mm.

Caesionidae

Caesio cuning* (Bloch, 1791)** or ***luduŋ mai. Figure 21.

189 new specimens; 1451 total (Figure 22)
Mean FL = 16 cm (no change)
52% of published L_{max} (31 cm)
84% of estimated L_{opt} (19 cm)
107% of published ♀L_{50} (15 cm)
36% mature ♀

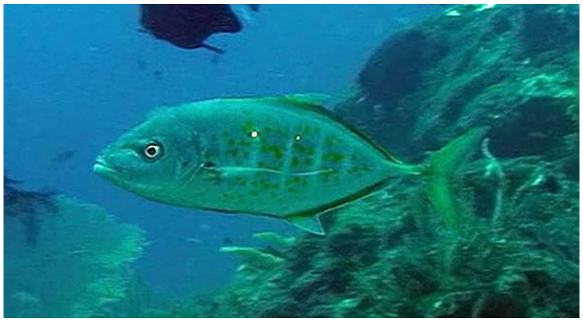
← Figure 21. *Luduŋ mai* (*Caesio cuning*). Inter-laser distance 31.5 mm.



← Figure 22. Size structure of *Caesio cuning*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

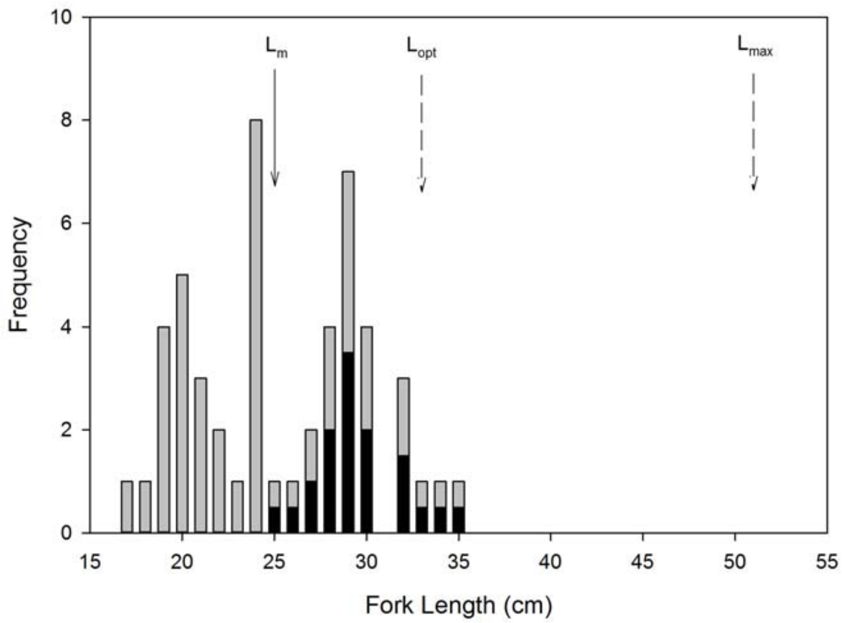
Carangidae

Carangoides bajad* (Forsskål, 1775)** or ***imaŋalẽ babaura. Figure 23.



8 new specimens; 50 total (Figure 24)
Mean FL = 25 cm (↓)
49% of estimated L_{max} (51 cm)
76% of estimated L_{opt} (33 cm)
100% of published ♀L_m (25 cm)
33% mature ♀

← Figure 23. *Imaŋalẽ babaura* (*Carangoides bajad*). Inter-laser distance 39 mm.

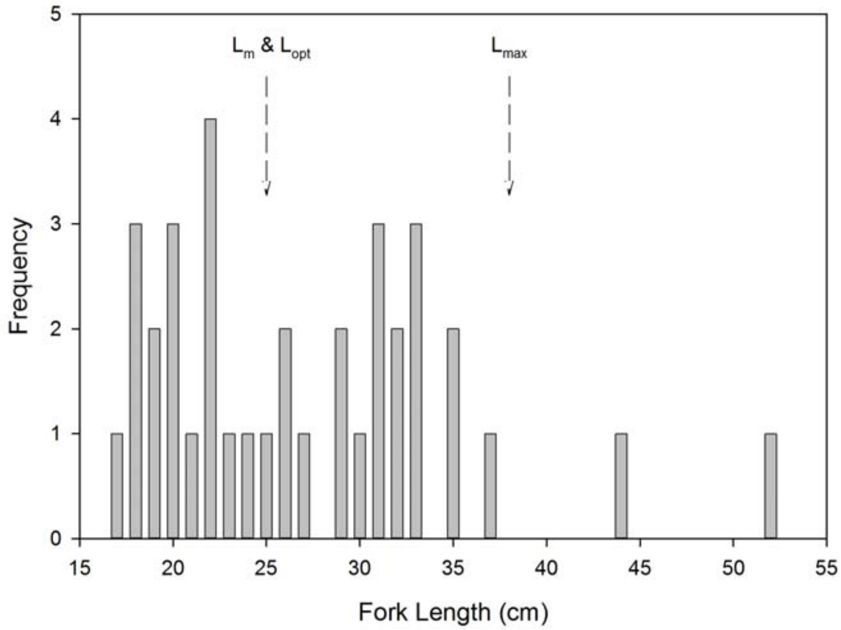


← Figure 24. Size structure of *Carangoides bajad*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Carangoides plagiotaenia* Bleeker, 1857** or ***imaŋalẽ tombo gabo. Figure 25.

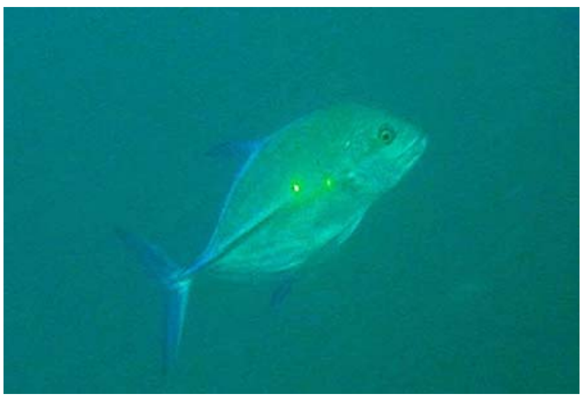
1 new specimen; 36 total (Figure 26)
Mean FL = 27 cm (no change)
71% of estimated L_{max} (38 cm)
108% of estimated L_{opt} (25 cm)
108% of estimated ♀L_m (25 cm)

← Figure 25. *Imaŋalẽ tombo gabo* (*Carangoides plagiotaenia*). Inter-laser distance 36 mm.



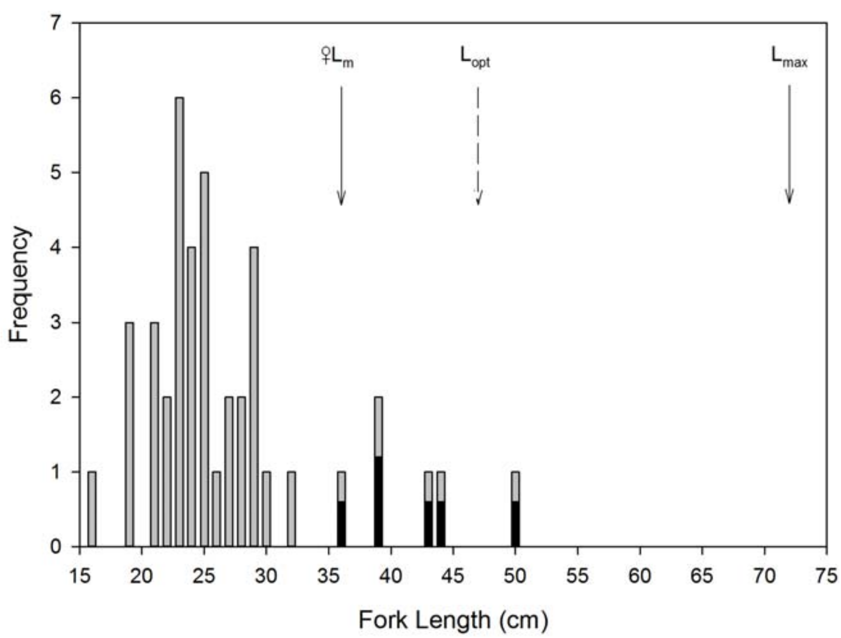
← **Figure 26. Size structure of *Carangoides plagiotaenia*.**

Caranx melampygus* Cuvier, 1833** or ***imaŋalẽ talã. Figure 27.



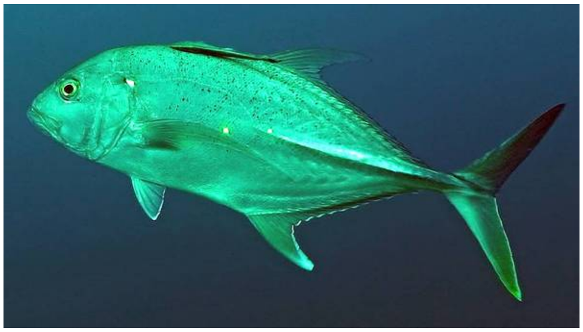
3 new specimens; 41 total (Figure 28)
Mean FL = 27 cm (↑)
38% of reported L_{max} (72 cm)
57% of estimated L_{opt} (47 cm)
75% of published ♀L_m (36 cm)
9% mature ♀

← **Figure 27. *Imaŋalẽ talã* (*Caranx melampygus*). Inter-laser distance 32 mm.**



← **Figure 28. Size structure of *Caranx melampygus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.**

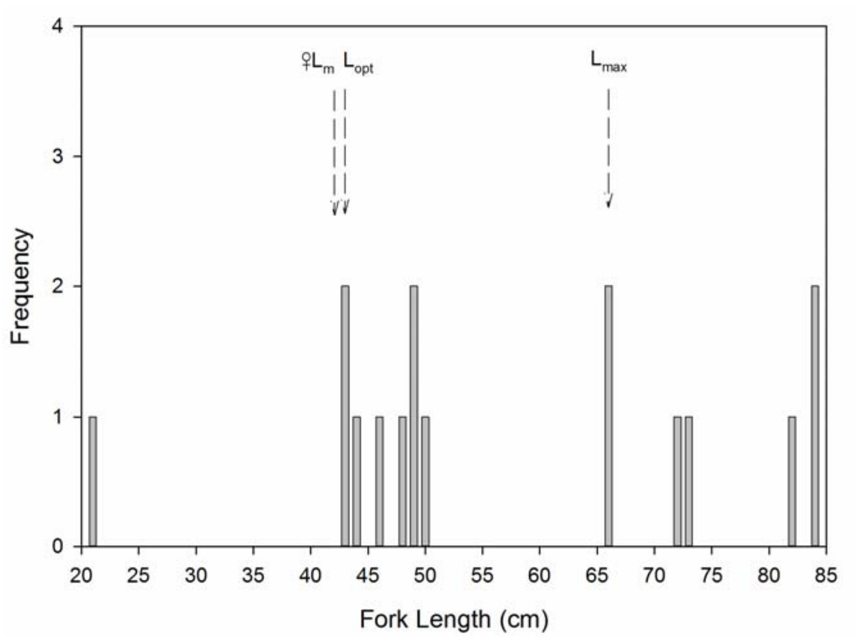
Caranx papuensis* Alleyne & MacLeay, 1877** or ***imaŋalẽ labrã kulĩ. Figure 29.



← **Figure 29. *Imaŋalẽ labrã kulĩ* or *Caranx papuensis* (with a remora attached near the origin of the first dorsal fin). Inter-laser distance 39 mm.**

0 new specimens; 16 total (Figure 30)
Mean FL = 57 cm
86% of estimated L_{max} (66 cm)
133% of estimated L_{opt} (43 cm)
136 % of estimated ♀L_m (42 cm)

Note: L_{max}, estimated from Allen & Swainston (1993) may be an underestimate. The estimated lengths of 31% of the individuals captured on video was greater than L_{max}.



← **Figure 30. Size structure of *Caranx papuensis*.**

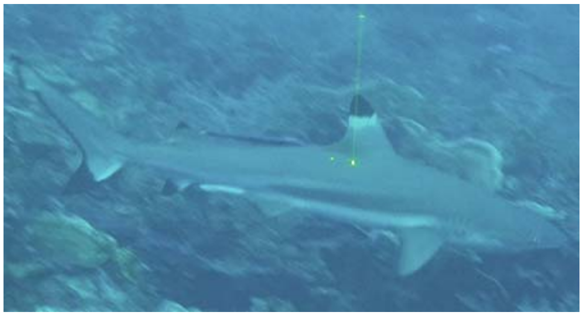
Carcharhinidae

Carcharhinus amblyrhynchos* (Bleeker, 1856)** or ***kapa ii. Figure 31.

2 new specimens;11 total
Mean FL = 76 cm (↓)
35% of estimated L_{max} (217 cm)
52% of estimated L_{opt} (147 cm)
64% of published ♀L_{50} (118 cm)

← **Figure 31. *Kapa ii* (*Carcharhinus amblyrhynchos*).**

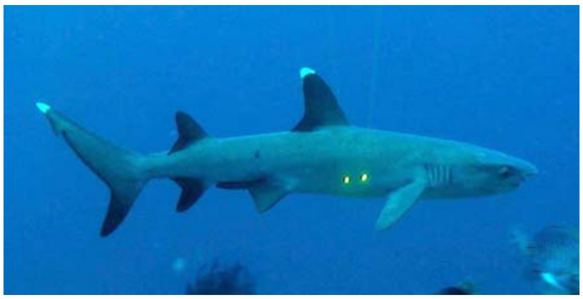
Carcharhinus melanopterus* (Quoy & Gaimard, 1824)** or ***kapa mayumbui. Figure 32.



1 new specimen; 5 total
Mean FL = 82 cm (↑)
55% of reported L_{max} (150 cm)
81% of estimated L_{opt} (101 cm)
103% of published 100% L_m (80 cm)

← Figure 32. *Carcharhinus melanopterus*. Inter-laser distance 36 mm.

Triaenodon obesus* (Rüppell, 1837)** or ***kapa bage bula. Figure 33.



4 new specimens; 12 total
Mean FL = 70 cm (↓)
40% of reported L_{max} (177 cm)
59% of estimated L_{opt} (119 cm)
72% of published ♀L_{50} (97 cm)

← Figure 33. *Kapa bage bula* (*Triaenodon obesus*). Inter-laser distance 31 mm.

Ephippidae

***Platax orbicularis* (Forsskål, 1775)**; Kala name not yet recorded. Figure 34.

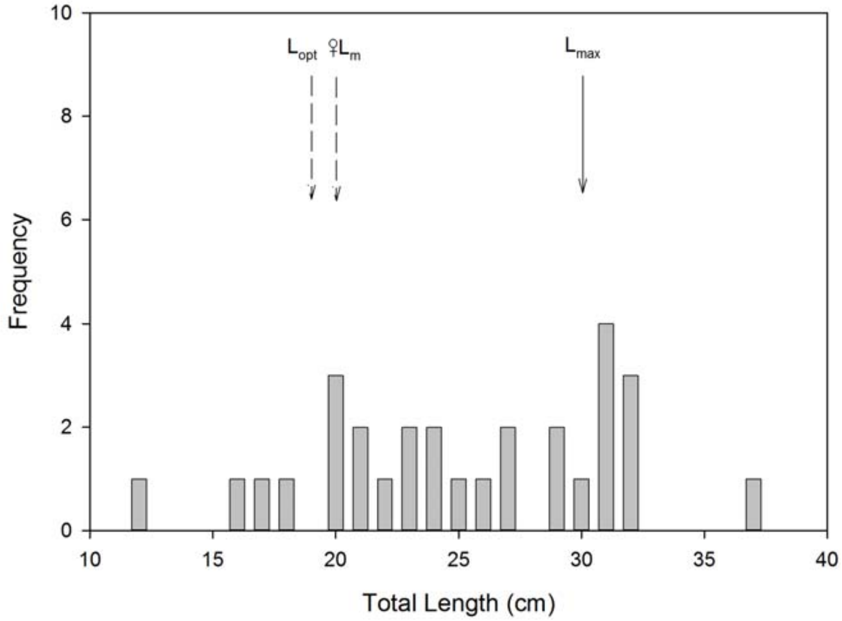
4 new specimens; 9 total
Mean FL = 37 cm (↑)
74% of reported L_{max} (50 cm)
112% of estimated L_{opt} (33 cm)
116% of estimated ♀L_m (32 cm)

← Figure 34. *Platax orbicularis*. Inter-laser distance 32 mm.

Platax pinnatus* (Linneaus, 1758)** or ***ibuŋgi tarõ. Figure 35.

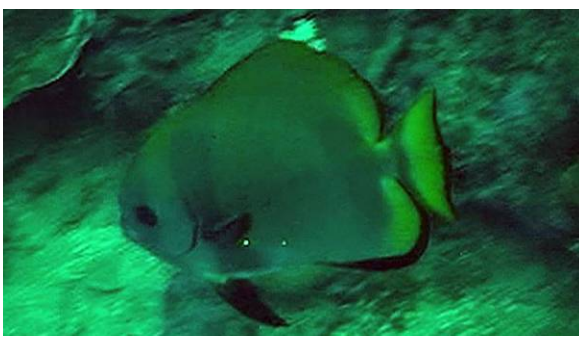
16 new specimens; 29 total (Figure 36)
Mean TL = 25 cm (no change)
83% of reported L_{max} (30 cm)
132% of estimated L_{opt} (19 cm)
125% of estimated ♀L_m (20 cm)

← Figure 35. *Ibuŋgi tarõ* (*Platax pinnatus*). Inter-laser distance 36 mm.



← **Figure 36. Size structure of *Platax pinnatus*.**

Platax teira* (Forsskål, 1775)** or ***ibuŋgi. Figure 37.



0 new specimens; 5 total
Mean TL = 33 cm
55% of reported L_{max} (60 cm)
85% of estimated L_{opt} (39 cm)
89% of estimated ♀L_m (38 cm)

← **Figure 37. *Ibuŋgi* (*Platax teira*). Inter-laser distance 39 mm.**

Haemulidae

Diagramma pictum* (Thunberg, 1792)** or ***godobo manibarã (juvenile) and ***godobo tarõ*** (adult). Figure 38.

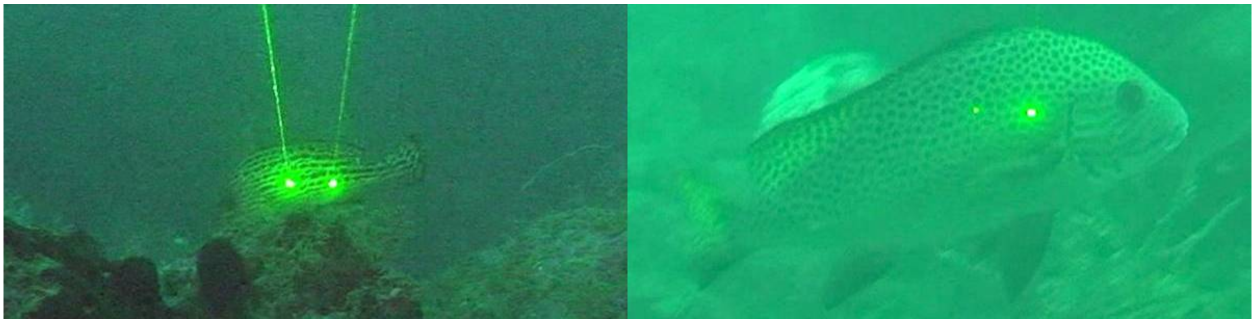


Figure 38. *Godobo manibarã* (left) and *godobo tarõ* (right) or *Diagramma pictum* juvenile (left) and adult (right). Inter-laser distance 31 and 36 mm, respectively.

0 new specimens; 8 total
Mean TL = 25 cm
28% of reported L_{max} (90 cm)
57% of the published L_{opt} (44 cm)
69% of the published ♀L_{50} (36 cm)

Note: None of the individuals captured on video had reached female L_{50}.

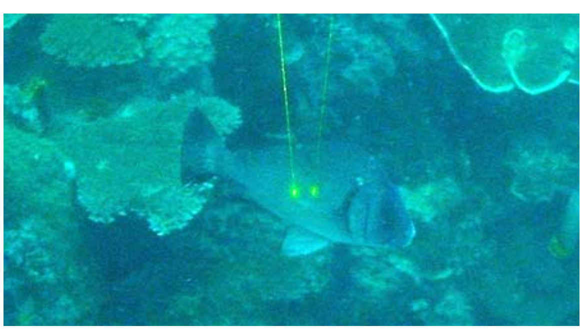
***Plectorhinchus chaetodonoides* Lacepède, 1801;** Kala name not yet recorded. Figure 39.

Figure 39. *Plectorhinchus chaetodonoides*. Inter-laser distance 36 mm.

2 new specimens; 7 total
Mean FL = 41 cm (↓)
68% of reported L_{max} (60 cm TL)
105% of estimated L_{opt} (39 cm TL)
108% of estimated ♀L_m (38 cm TL)

Note: L_{max}, L_{opt}, & ♀L_{50} values are presented as total length because the relationship between total and fork lengths is unknown. The above percentages are likely underestimates.

***Plectorhinchus gibbosus* (Lacepède, 1802);** Kala name not yet recorded. Figure 40.



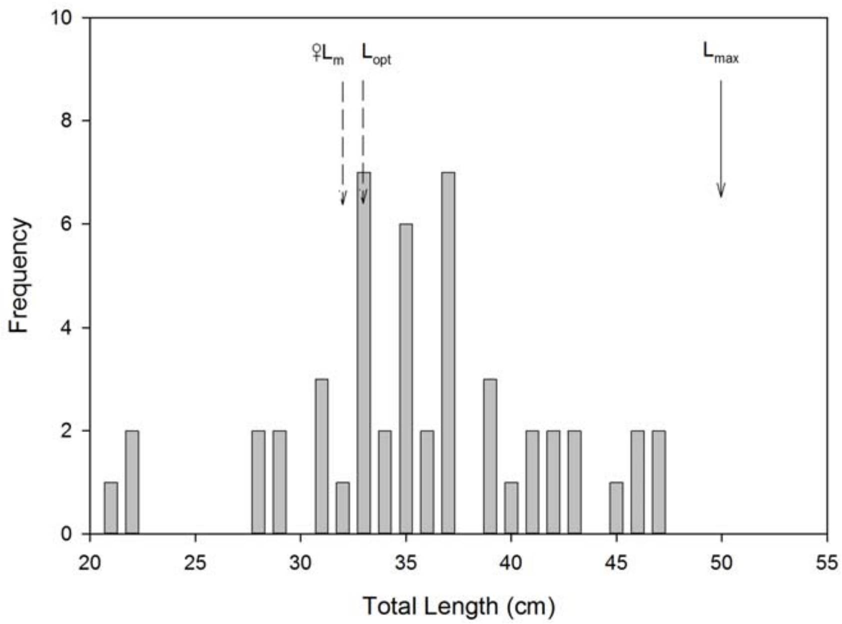
First report; 4 specimens
Mean TL = 38 cm
63% of reported L_{max} (60 cm TL)
97% of estimated L_{opt} (39 cm TL)
100% of estimated ♀L_m (38 cm TL)

← Figure 40. *Plectorhinchus gibbosus*. Inter-laser distance 31.5 mm.

Plectorhinchus lineatus* (Linnaeus, 1758)** or ***iyabua sa. Figure 41.

4 new specimens; 50 total (Figure 42)
Mean TL = 36 cm (no change)
72% of reported L_{max} (50 cm)
109% of estimated L_{opt} (33 cm)
113% of estimated ♀L_m (32 cm)

← Figure 41. *Iyabua sa* (*Plectorhinchus lineatus*). Inter-laser distance 39 mm.



← Figure 42. Size structure of *Plectorhinchus lineatus*.

Plectorhinchus vittatus* (Linnaeus, 1758)** or ***iyabua kurĩ naba. Figure 43.

0 new specimens; 4 total
Mean TL = 28 cm
56% of reported L_{max} (50 cm)
85% of estimated L_{opt} (33 cm)
122% of published ♀L_m of (23 cm)
64% mature ♀

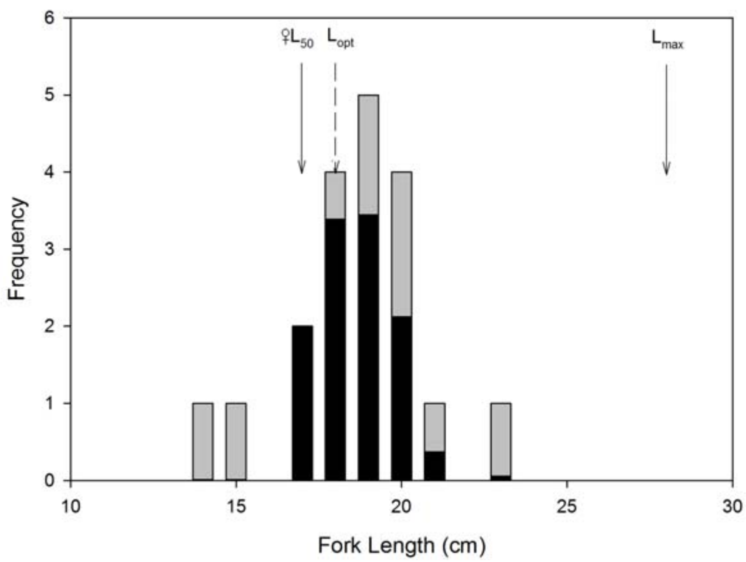
← Figure 43. *Iyabua kurĩ naba* (*Plectorhinchus vittatus*). Inter-laser distance 31.5 mm.

Holocentridae

Myripristis adusta **Bleeker, 1853** or ***imbilĩ tombo yeyẽ*** (previously reported as ***imbilĩ tombo gabo***). Figure 44.

2 new specimens; 19 total (Figure 45)
Mean FL = 19 cm (no change)
68% of reported L_{max} (28 cm)
106% of estimated L_{opt} (18 cm)
112% of observed ♀L_{50} (17 cm)
60% mature ♀

← Figure 44. *Imbilĩ tombo yeyẽ* (*Myripristis adusta*).



← Figure 45. Size structure of *Myripristis adusta*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Myripristis berndti*) (Jordan & Evermann, 1903)** or ***imbilĩ yakẽ susuwi (previously reported as ***imbilĩ yakẽ yayã***). Figure 46.

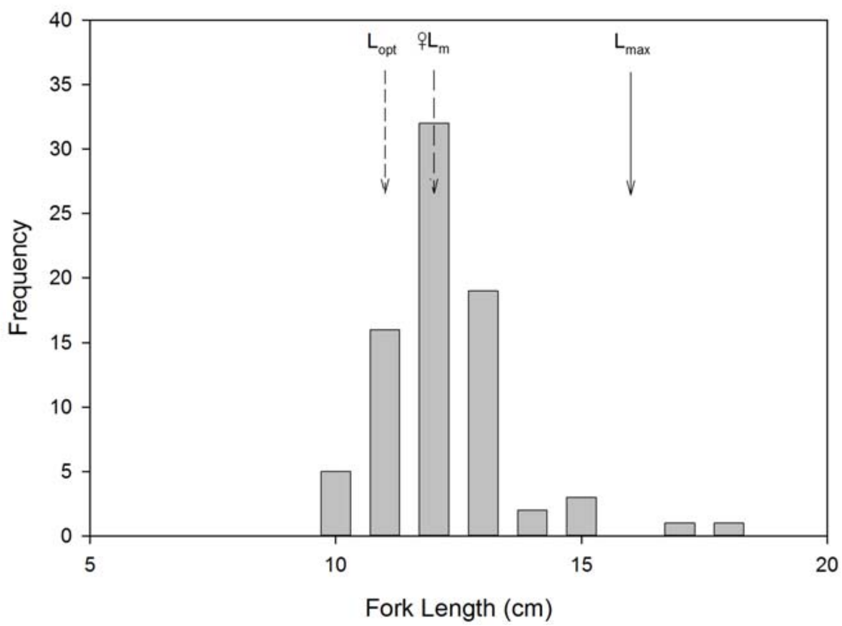
3 new specimens; 8 total
Mean FL = 14 cm (↑)
54% of reported L_{max} (26 cm)
82% of estimated L_{opt} (17 cm)
78% of estimated ♀L_m (18 cm)

← Figure 46. *Imbilĩ yakẽ susuwi* (*Myripristis berndti*).

Myripristis kuntee* Valenciennes, 1831** or ***imbilĩ godõ nambĩ. Figure 47.

3 new specimens; 79 total (Figure 48)
Mean FL = 12 cm (no change)
75% of reported L_{max} (16 cm)
109% of estimated L_{opt} (11 cm)
100% of estimated ♀L_m (12 cm)

← Figure 47. *Imbilĩ godõ nambĩ* (*Myripristis kuntee*). Inter-laser distance 39 mm.



← Figure 48. Size structure of *Myripristis kuntee*.

Myripristis pralinia* Cuvier, 1829** or ***imbilĩ yakẽ susuwi (previously reported as ***imbilĩ yakẽ suwi***). Figure 49.

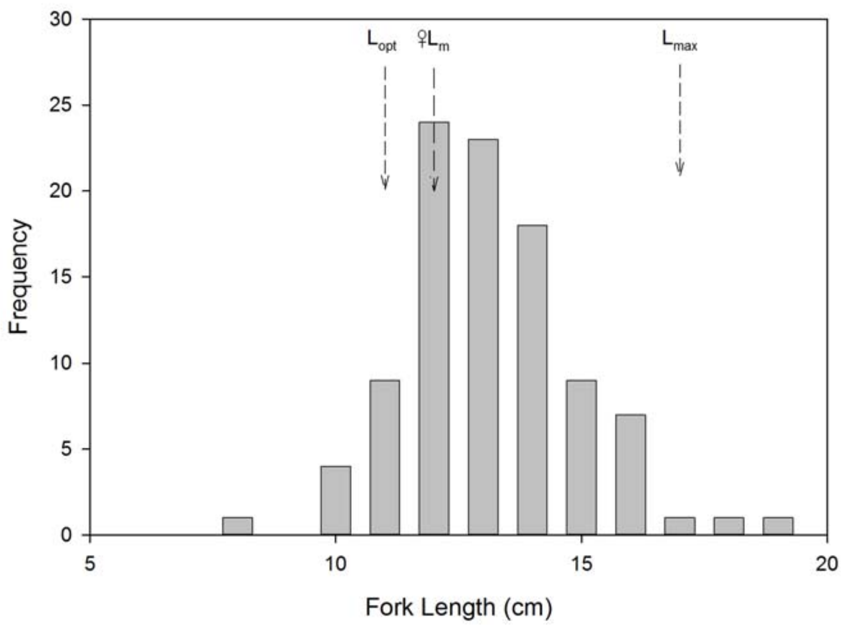
1 new specimen; 4 total
Mean FL = 13 cm (↑)
76% of reported L_{max} (17 cm)
118% of estimated L_{opt} (11 cm)
108% of estimated ♀L_m (12 cm)

← Figure 49. *Imbilĩ yakẽ susuwi* (*Myripristis pralinia*).

Myripristis violacea* Bleeker, 1851** or ***imbilĩ yakẽ bumbu. Figure 50.

9 new specimens; 98 total (Figure 51)
Mean FL = 13 cm (no change)
76% of estimated L_{max} (17 cm)
118% of estimated L_{opt} (11 cm)
108% of estimated ♀L_m (12 cm)

← Figure 50. *Imbilĩ yakẽ bumbu* (*Myripristis violacea*).

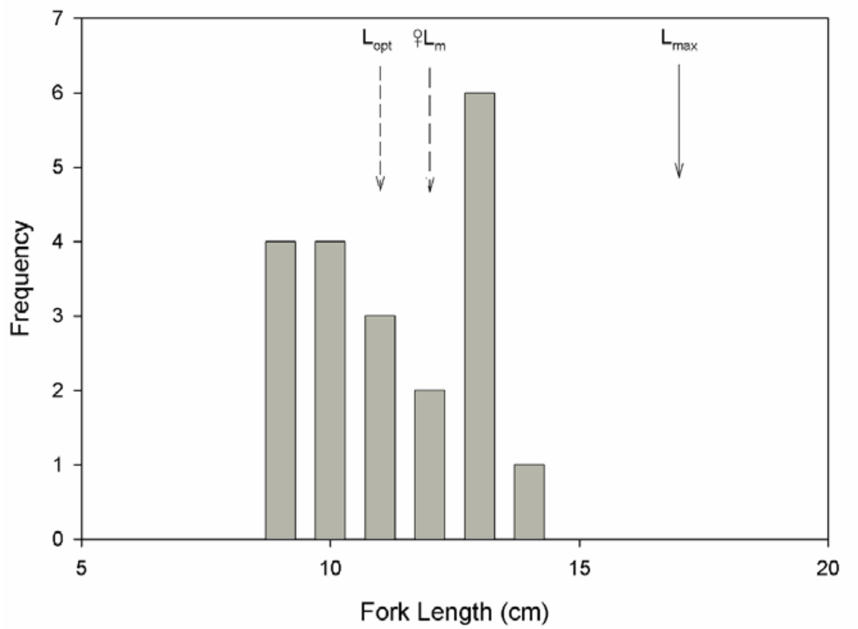


← Figure 51. Size structure of *Myripristis violacea*.

Myripristis vittata* Valenciennes, 1831** or ***imbilĩ yakẽ suwi. Figure 52.

0 new specimens; 20 total (Figure 53)
Mean FL = 11 cm
65% of reported L_{max} (17 cm)
100% of estimated L_{opt} (11 cm)
92% of the estimated ♀L_m (12 cm)

← Figure 52. *Imbilĩ yakẽ suwi* (*Myripristis vittata*). Inter-laser distance 36 mm.

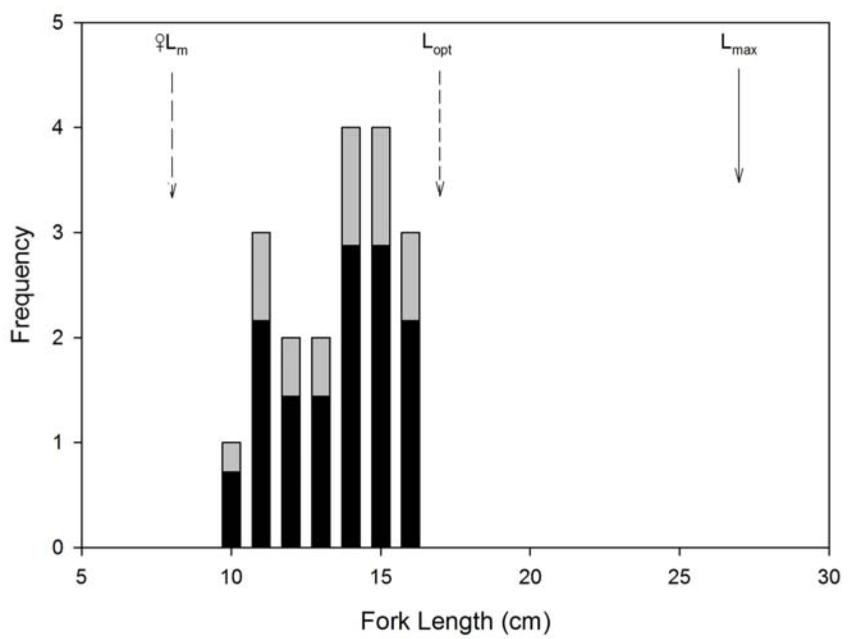


← **Figure 53. Size structure of *Myripristis vittata*.**

Neoniphon sammara* (Forsskål, 1775)** or ***imbilĩ sa. Figure 54.

1 new specimen; 19 total (Figure 55)
Mean FL = 13 cm (↓)
48% of estimated L_{max} (27 cm)
76% of estimated L_{opt} (17 cm)
163% of published ♀L_m (8 cm)
61% mature ♀

← **Figure 54. *Imbilĩ sa* (*Neoniphon sammara*). Inter-laser distance 39 mm.**



← **Figure 55. Size structure of *Neoniphon sammara*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.**

Sargocentron caudimaculatum* (Rüppell, 1838)** or ***imbilĩ yasai. Figure 56.

1 new specimen; 9 total
Mean FL = 15 cm (no change)
79% of reported L_{max} (19 cm)
125% of estimated L_{opt} (12 cm)
115% of estimated ♀L_m (13 cm)

← Figure 56. *Imbilĩ yasai* (*Sargocentron caudimaculatum*). Inter-laser distance 31 mm.

***Sargocentron melanospilos* (Bleeker, 1858);** Kala name not yet recorded. Figure 57.

1 new specimen; 4 total
Mean FL = 15 cm (no change)
65% of reported L_{max} (23 cm)
100% of estimated L_{opt} (15 cm)
94% of estimated ♀L_m (16 cm)

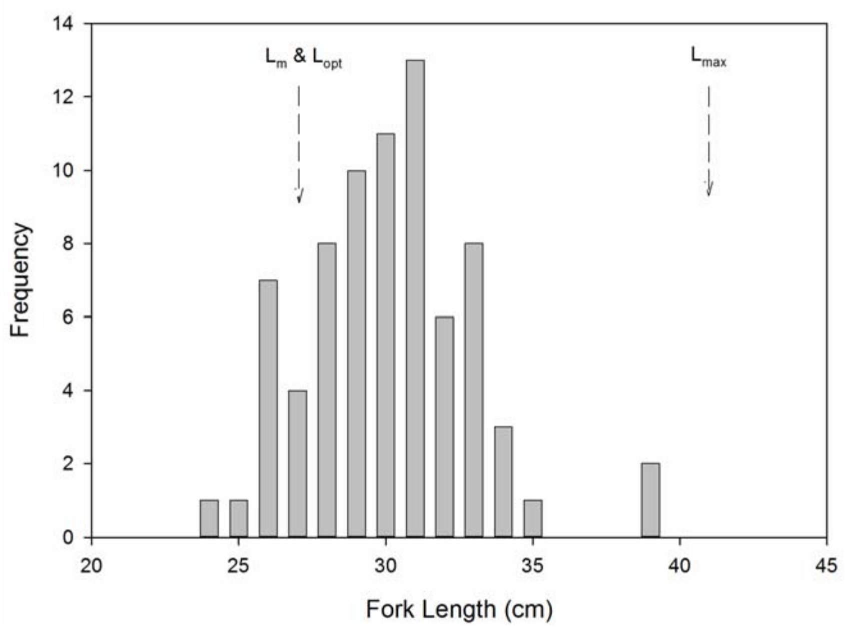
← Figure 57. *Sargocentron melanospilos*. Inter-laser distance 32 mm.

<u>Kyphosidae</u>

Kyphosus cinerascens* (Forsskål, 1775)** or ***italawe. Figure 58.

0 new specimens; 75 total (Figure 59)
Mean FL = 30 cm
73% of estimated L_{max} (41 cm)
111% of estimated L_{opt} (27 cm)
120% of published ♀L_m (25 cm)

← Figure 58. *Italawe* (*Kyphosus cinerascens*). Inter-laser distance 39 mm.



← **Figure 59. Size structure of *Kyphosus cinerascens*.**

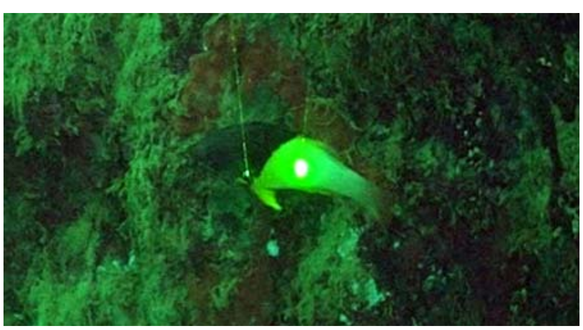
Kyphosus vaigiensis* (Quoy & Gaimard, 1825)** or ***italawe talabopia. Figure 60.

1 new specimen; 8 total
Mean FL = 35 cm (no change)
63% of estimated L_{max} (56 cm)
95% of estimated L_{opt} (37 cm)
97% of estimated ♀L_m (36 cm)

← Figure 60. *Italawe talabopia* (*Kyphosus vaigiensis*). Inter-laser distance 39 mm.

Labridae

***Bodianus mesothorax* (Bloch & Schneider, 1801)**; Kala name not yet recorded. Figure 61.



First report; 7 specimens
Mean TL = 12 cm
60% of reported L_{max} (20 cm)
92% of estimated L_{opt} (13 cm)
86% of estimated ♀L_m (14 cm)

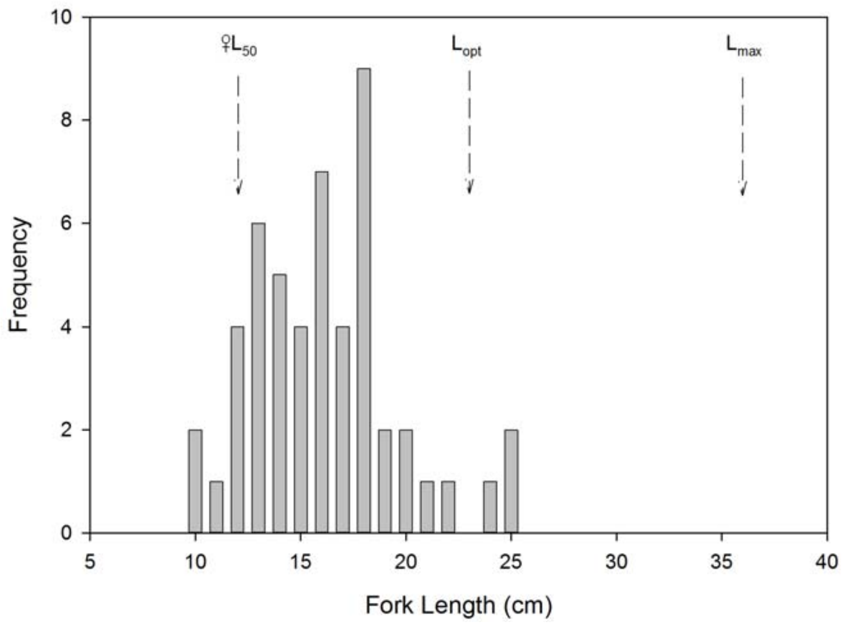
← Figure 61. *Bodianus mesothorax*. Inter-laser distance 32 mm.

Cheilinus fasciatus* (Bloch, 1791)** or ***talulumuã tatalõ. Figure 62.

Figure 62. *Talulumuã tatalõ* (*Cheilinus fasciatus*). Inter-laser distance 39 mm.

16 new specimens; 51 total (Figure 63)
Mean FL = 16 cm (no change)
44% of estimated L_{max} (36 cm TL)
70% of estimated L_{opt} (23 cm TL)
133% of published ♀L_{50} (12 cm TL)

Note: L_{max}, L_{opt}, & ♀L_{50} values are presented as total length because the relationship between total and fork lengths is unknown. The above percentages are likely underestimates.



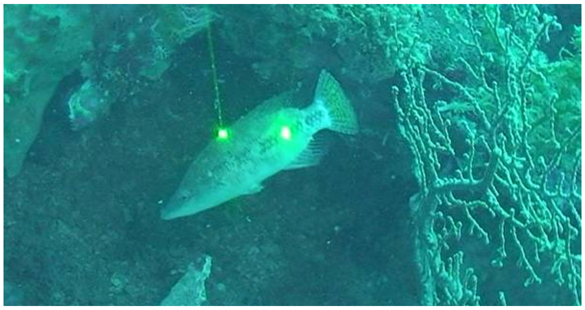
← Figure 63. Size structure of *Cheilinus fasciatus.* Estimates of female L_{50}, L_{opt}, and L_{max} are total lengths.

Choerodon anchorago* (Bloch, 1791)** or ***i bubui. Figure 64.

0 new specimens; 5 total
Mean TL = 24 cm
63% of published L_{max} (38 cm)
96% of estimated L_{opt} (25 cm)
96% of estimated ♀L_m (25 cm)

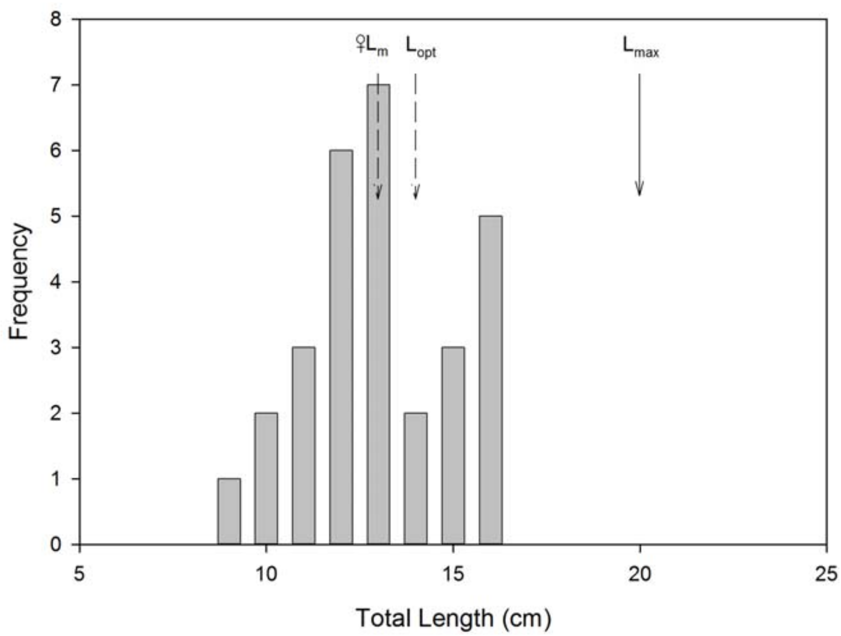
← Figure 64. *I bubui* (*Choerodon anchorago*). Inter-laser distance 36 mm.

Oxycheilinus celebicus* (Bleeker, 1853)** or ***talulumuã bobo. Figure 65.



5 new specimens; 29 total (Figure 66)
Mean TL = 13 cm (no change)
65% of published L_{max} (20 cm)
93% of estimated L_{opt} (14 cm)
100% of estimated ♀L_m (13 cm)

← Figure 65. *Talulumuã bobo* (*Oxycheilinus celebicus*). Inter-laser distance 31 mm.



← Figure 66. Size structure of *Oxycheilinus celebicus.*

Oxycheilinus digramma* (Lacepède, 1801)** or ***ikula talulumuã. Figure 67.

7 new specimens; 12 total
Mean TL = 17 cm (no change)
57% of estimated L_{max} (30 cm)
89% of estimated L_{opt} (19 cm)
85% of estimated ♀L_m (20 cm)

← Figure 67. *Ikula talulumuã* (*Oxycheilinus digramma*). Inter-laser distance 36.5 mm.

Lethrinidae

Lethrinus erythropterus* Valenciennes, 1830** or ***kada maba. Figure 68.

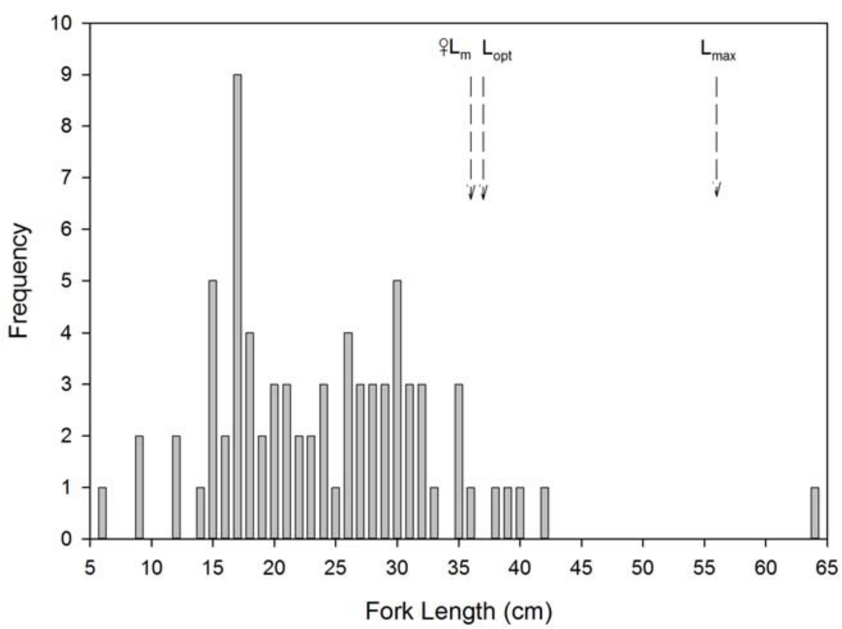
0 new specimens; 5 total
Mean FL = 22 cm
46% of estimated L_{max} (48 cm)
71% of estimated L_{opt} (31 cm)
110% of observed ♀L_{50} (20 cm)
22% mature ♀

← Figure 68. *Kada maba* (*Lethrinus erythropterus*). Inter-laser distance 31 mm.

Monotaxis grandoculis* (Forsskål, 1775)** or ***labaikã taloŋ (juvenile) and ***labaikã*** (adult). Figure 69.

Figure 69. *Labaikã taloŋ* (left) and *labaikã* (right) or *Monotaxis grandoculis* juvenile (left) and adult (right).

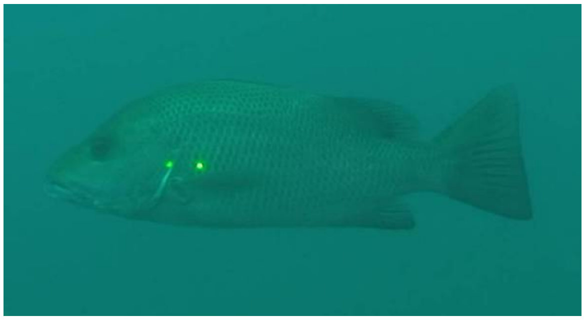
6 new specimens; 76 total (Figure 70)
Mean FL = 24 cm (↓)
43% of estimated L_{max} (56 cm)
65% of estimated L_{opt} (37 cm)
67% of estimated ♀L_m (36 cm)



← Figure 70. Size structure of *Monotaxis grandoculis*.

Lutjanidae

Lutjanus argentimaculatus* (Forsskål, 1775)** or ***ilĩ. Figure 71.



1 new specimen; 5 total
Mean FL = 47 cm (↓)
40% of reported L_{max} (118 cm)
59% of estimated L_{opt} (79 cm)
89% of published ♀L_{50} (53 cm)
22% mature ♀

← Figure 71. *Ilĩ* (*Lutjanus argentimaculatus*). Inter-laser distance 36 mm.

Lutjanus biguttatus* (Valenciennes, 1830)** or ***itale. Figure 72.

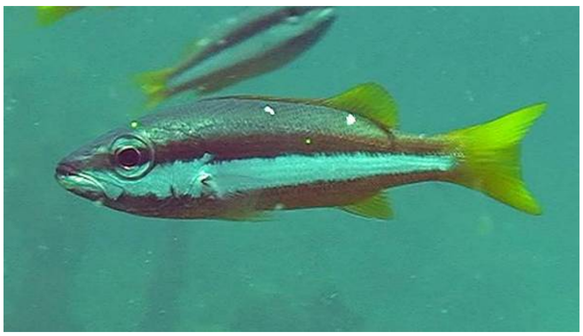
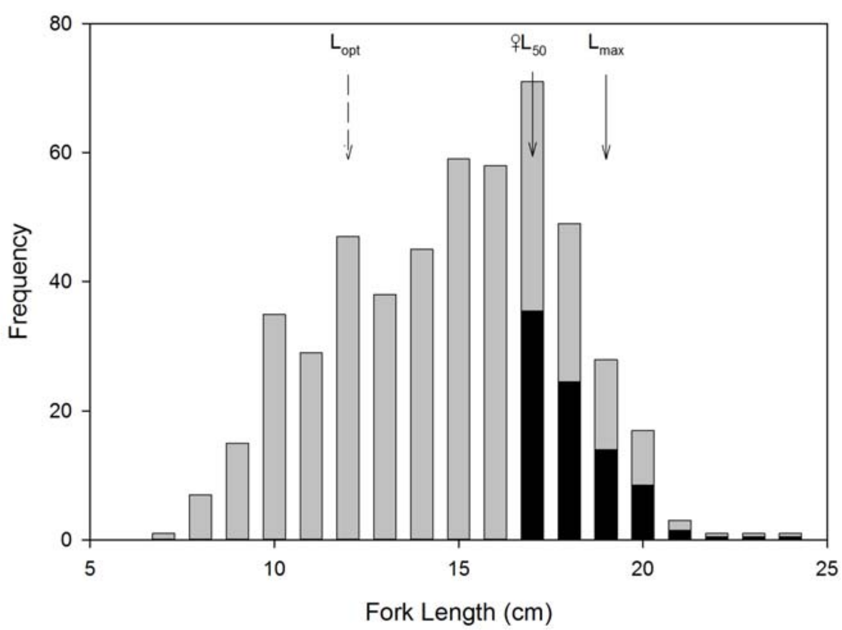


Figure 72. *Itale* (*Lutjanus biguttatus*). Inter-laser distance 39 mm.

25 new specimens; 505 total (Figure 73)
Mean FL = 15 cm (no change)
79% of published L_{max} (19 cm)
125% of estimated L_{opt} (12 cm)
88% of published ♀L_{50} (17 cm)
17% mature ♀

Note: L_{max} of Allen & Swainston (1993) may be an underestimate for the region; 5% of the individuals captured on video are larger. The largest individual observed at KWMA was 23 cm FL.



← Figure 73. Size structure of *Lutjanus biguttatus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Lutjanus bohar **(Forsskål, 1775)** or ***yame tuaŋ yasai***, ***yame tuaŋ***, and ***ilĩ*** (juvenile through adult stages). Figure 74.

Figure 74. ***Yame tuaŋ yasai*, *yame tuaŋ*, & *ilĩ* (*Lutjanus bohar*). Inter-laser distance 31 mm.**

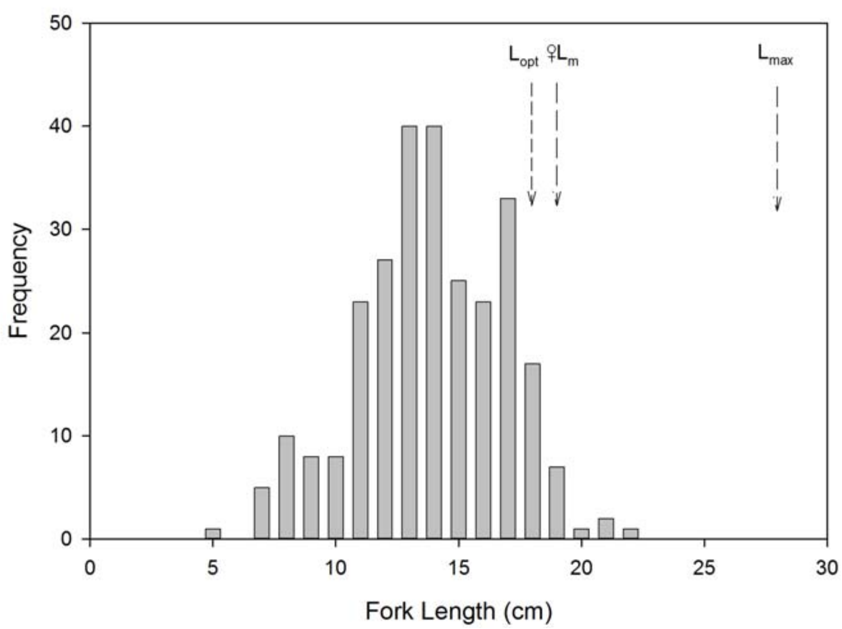
0 new specimens; 4 total
Mean FL = 17 cm
24% of reported L_{max} (71 cm)
36% of estimated L_{opt} (47 cm)
40% of published ♀L_{50} (43 cm)

Note: The low percentages above may be an artifact of our methods. Color patterns allow accurate identification of juveniles; however, adults are difficult to distinguish from *L. argentimaculatus* (note the same Kala name for both species) and may have been classified as unidentified individuals.

Lutjanus boutton **(Lacepède, 1802)** or ***iyayaŋ***. Figure 75.

56 new specimens; 271 total (Figure 76)
Mean FL = 14 cm (no change)
50% of estimated L_{max} (28 cm)
78% of estimated L_{opt} (18 cm)
74% of estimated ♀L_m of (19 cm)

← Figure 75. *Iyayaŋ* (*Lutjanus boutton*). Inter-laser distance 39 mm.

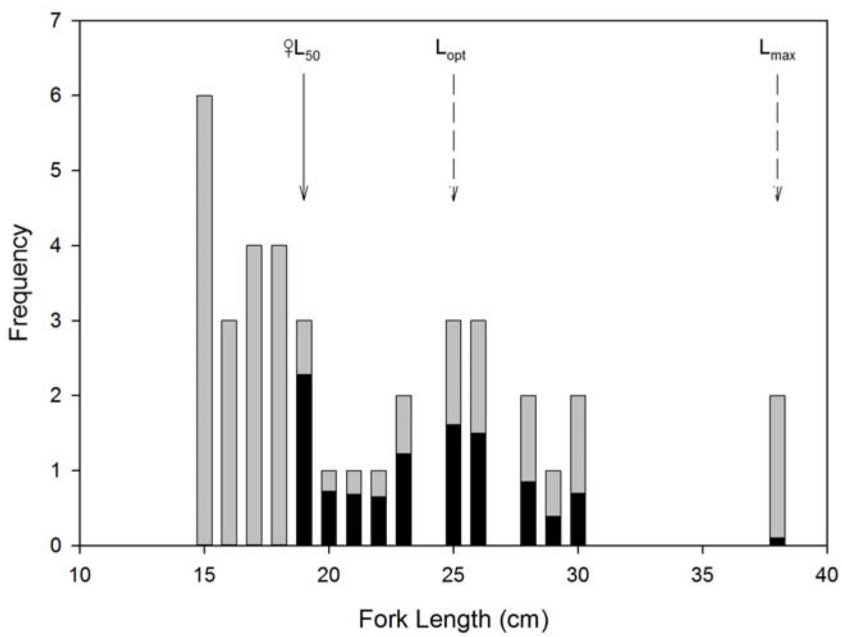


← Figure 76. Size structure of *Lutjanus boutton*.

Lutjanus carponotatus* (Richardson, 1842)** or ***babaura. Figure 77.

2 new specimens; 38 total (Figure 78)
Mean FL = 21 cm (no change)
55% of reported L_{max} (38 cm)
84% of estimated L_{opt} (25 cm)
111% of published ♀L_{50} (19 cm)
28% mature ♀

← Figure 77. *Babaura* (*Lutjanus carponotatus*). Inter-laser distance 32 mm.

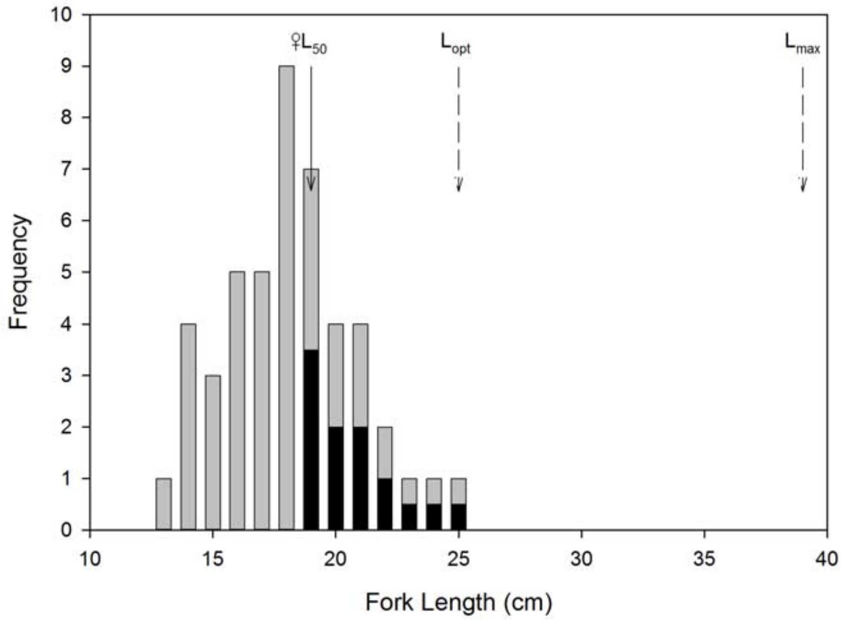


← Figure 78. Size structure of *Lutjanus carponotatus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Lutjanus fulvus* (Forster, 1801)** or ***iyayaŋ kurĩ naba. Figure 79.

2 new specimens; 47 total (Figure 80)
Mean FL = 18 cm (no change)
46% of reported L_{max} (39 cm)
72% of estimated L_{opt} (25 cm)
95% of published ♀L_{50} (19 cm)
21% mature ♀

← Figure 79. *Iyayaŋ kurĩ naba* (*Lutjanus fulvus*). Inter-laser distance 31 mm.

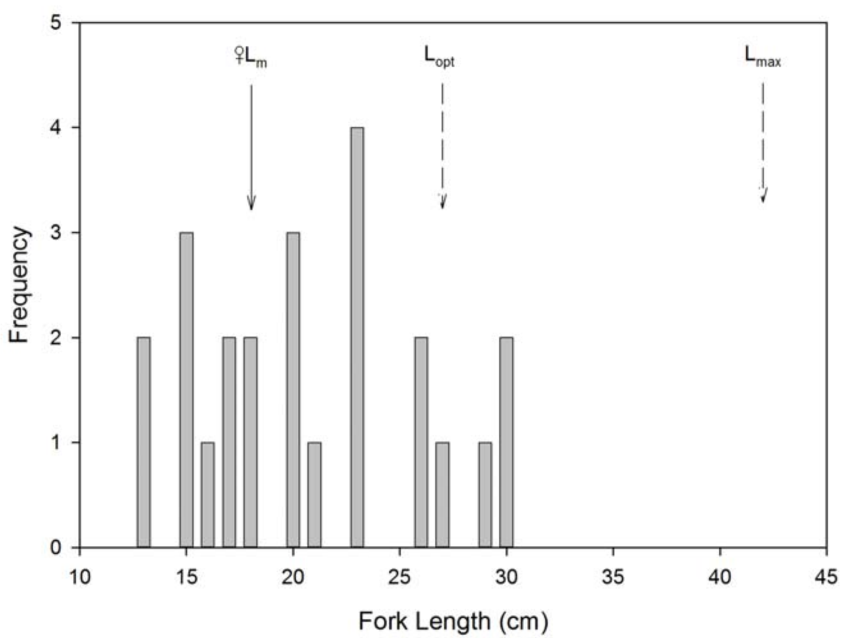


← **Figure 80. Size structure of *Lutjanus fulvus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.**

Lutjanus gibbus* (Forsskål, 1775)** or ***ina suwi. Figure 81.

2 new specimens; 24 total (Figure 82)
Mean FL = 21 cm (↑)
50% of estimated L_{max} (42 cm)
78% of estimated L_{opt} (27 cm)
117% of published ♀L_m (18 cm)

← **Figure 81. *Ina suwi* (*Lutjanus gibbus*). Inter-laser distance 39 mm.**



← **Figure 82. Size structure of *Lutjanus gibbus*.**

Lutjanus kasmira* (Forsskål, 1775)** or ***babaura yumi yayã. Figure 83.

0 new specimens; 4 total
Mean FL = 16 cm
48% of published L_{max} (33 cm)
76% of estimated L_{opt} (21 cm)
133% of published ♀L_m (12 cm)
43% mature ♀

← Figure 83. *Babaura yumi yayã* (*Lutjanus kasmira*). Inter-laser distance 36 mm.

Lutjanus monostigma* (Cuvier, 1828)** or ***baniŋga. Figure 84.

1 new specimen; 5 total
Mean FL = 24 cm (↑)
50% of estimated L_{max} (48 cm)
77% of estimated L_{opt} (31 cm)
75% of published ♀L_m (32 cm)

← Figure 84. *Baniŋga* (*Lutjanus monostigma*). Inter-laser distance 31 mm.

Lutjanus rivulatus* (Cuvier, 1828)** or ***isina. Figure 85.

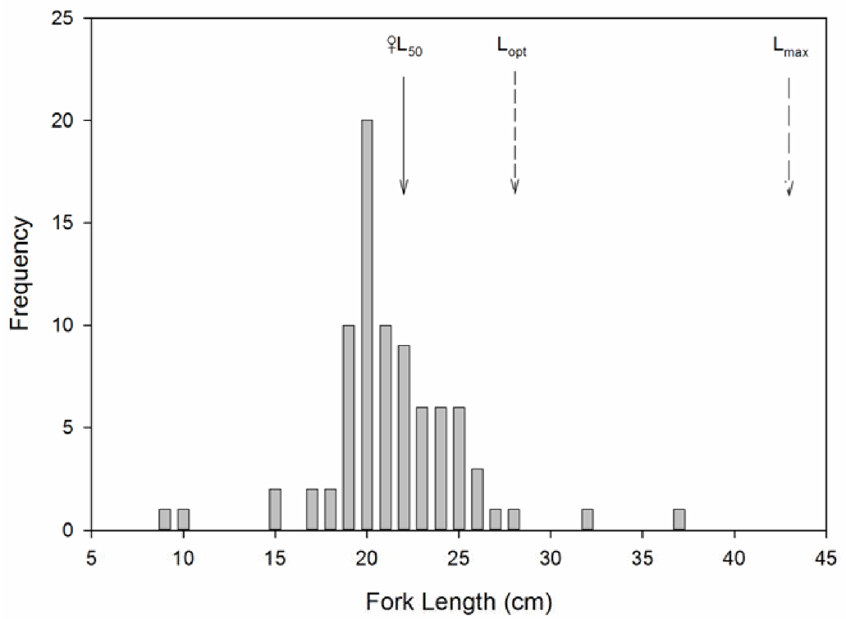
0 new specimens; 4 total
Mean FL = 31 cm
49% of estimated L_{max} (63 cm)
76% of estimated L_{opt} (41 cm)
78% of estimated ♀L_m (40 cm)

← Figure 85. *Isina* (*Lutjanus rivulatus*). Inter-laser distance 39 mm.

Lutjanus russellii* (Bleeker, 1849)** or ***kawasi ŋasiŋa. Figure 86.

0 new specimens; 82 total (Figure 87)
Mean FL = 21 cm
49% of estimated L_{max} (43 cm)
75% of estimated L_{opt} (28 cm)
95% of published ♀L_{50} (22 cm)

← Figure 86. *Kawasi ŋasiŋa* (*Lutjanus russellii*). Inter-laser distance 39 mm.



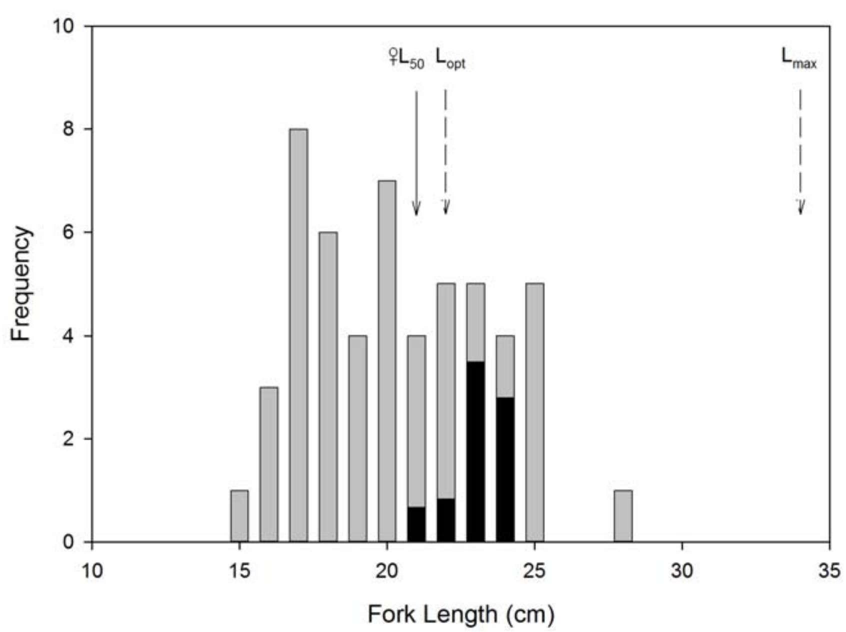
← **Figure 87. Size structure of *Lutjanus russellii*.**

Lutjanus semicinctus **Quoy & Gaimard, 1824** or ***imawe***. Figure 88.

Figure 88. *Imawe* (*Lutjanus semicinctus*). Inter-laser distance 39 mm.

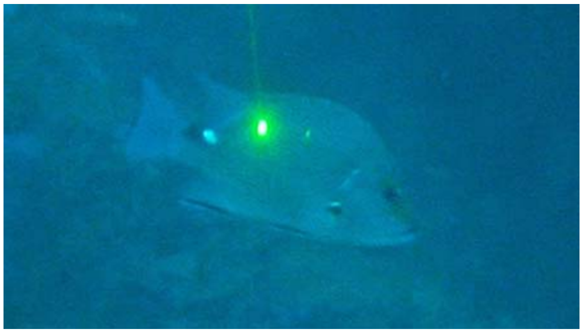
1 new specimen; 53 total (Figure 89)
Mean FL = 20 cm (no change)
59% of estimated L_{max} (34 cm)
91% of estimated L_{opt} (22 cm)
95% of published ♀L_{50} (21 cm)
15% mature ♀

Note: Information on size-specific sex ratios (Longenecker *et al*. 2011) is limited and may underestimate of the number of mature females in large size classes.



← **Figure 89. Size structure of *Lutjanus semicinctus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.**

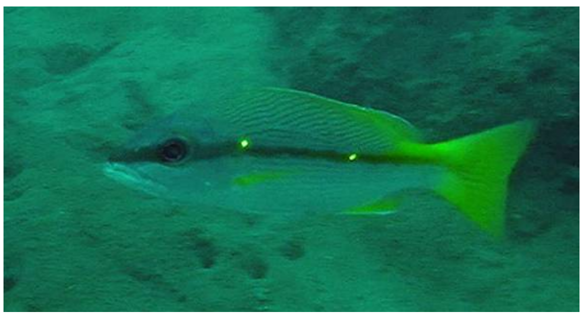
Lutjanus timorensis* (Quoy & Gaimard, 1824)** or ***iko yaŋgawe and ***iko*** (juvenile and adult). Figure 90.



First report; 7 specimens
Mean TL = 23 cm
46% of reported L_{max} (50 cm)
70% of estimated L_{opt} (33 cm)
77% of published ♀L_m (30 cm)

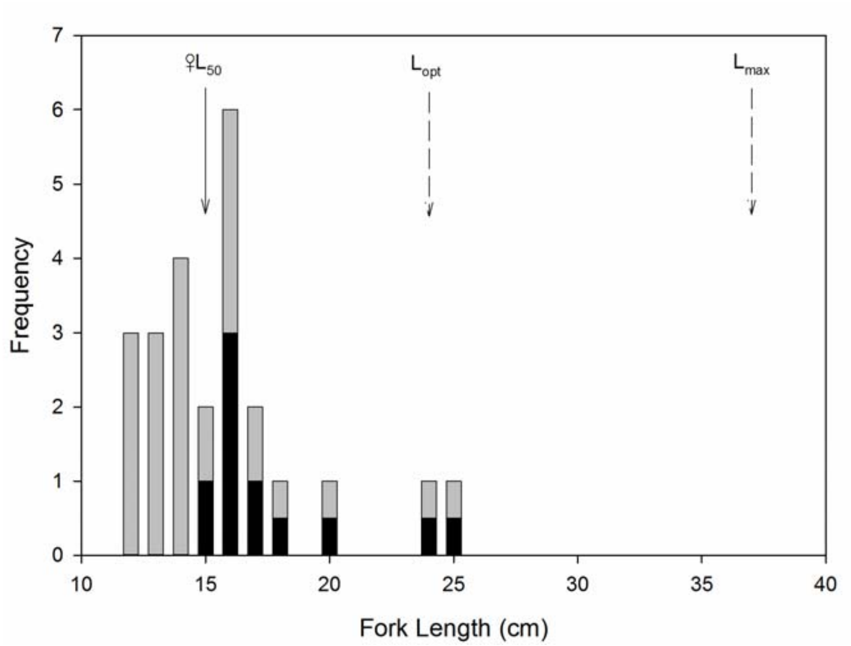
Figure 90. *Iko yaŋgawe* & *iko* (*Lutjanus timorensis*). Inter-laser distance 32 mm.

Lutjanus vitta* (Quoy & Gaimard, 1824)** or ***isale. Figure 91.



0 new specimens; 24 total (Figure 92)
Mean FL = 16 cm
43% of estimated L_{max} (37 cm)
67% of estimated L_{opt} (24 cm)
107% of published ♀L_{50} (15 cm)
29% mature ♀

← Figure 91. *Isale* (*Lutjanus vitta*). Inter-laser distance 39 mm.

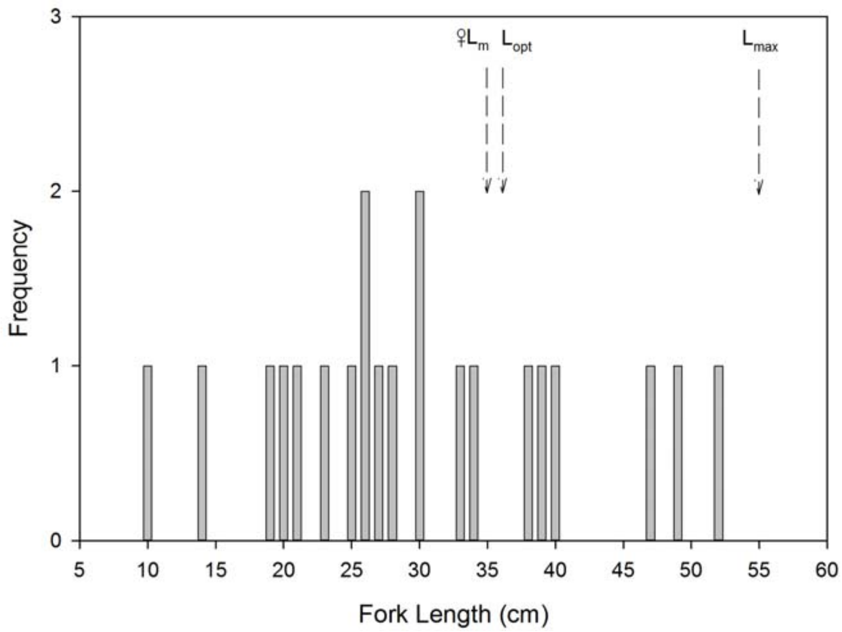


← Figure 92. Size structure of *Lutjanus vitta*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Macolor macularis* Fowler, 1931** or ***labaikã tewe yayã. Figure 93.

4 new specimens; 21 total (Figure 94)
Mean FL = 30 cm (↓)
55% of estimated L_{max} (55 cm)
83% of estimated L_{opt} (36 cm)
86% of estimated ♀L_m (35 cm)

← Figure 93. *Labaikã tewe yayã* (*Macolor macularis*).



← Figure 94. Size structure of *Macolor macularis*.

Macolor niger* (Forsskål, 1775)** or ***labaikã yasai. Figure 95.

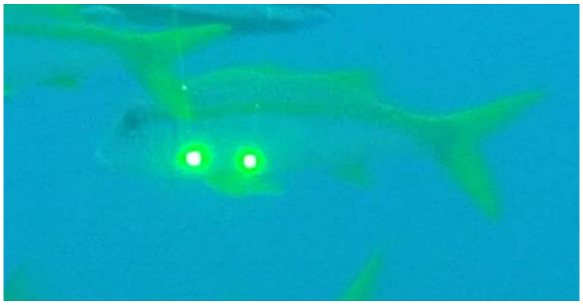
Figure 95. *Labaikã yasai* (*Macolor niger*). Inter-laser distance 31 mm.

0 new specimens; 5 total
Mean FL = 28 cm
47% of estimated L_{max} (60 cm TL)
72% of estimated L_{opt} (39 cm TL)
74% of estimated ♀L_m (38 cm TL)

Note: L_{max}, L_{opt}, & ♀L_{50} values are presented as total length because the relationship between total and fork lengths is unknown. The above percentages are likely underestimates.

Mullidae

Mulloidichthys vanicolensis* (Valenciennes, 1831)** or ***imake (previously reported as ***itale yumi yayã***). Figure 96.



0 new specimens; 7 total
Mean FL = 21 cm
62% of estimated L_{max} (34 cm)
95% of estimated L_{opt} (22 cm)
124% of published ♀L_{50} (17 cm)

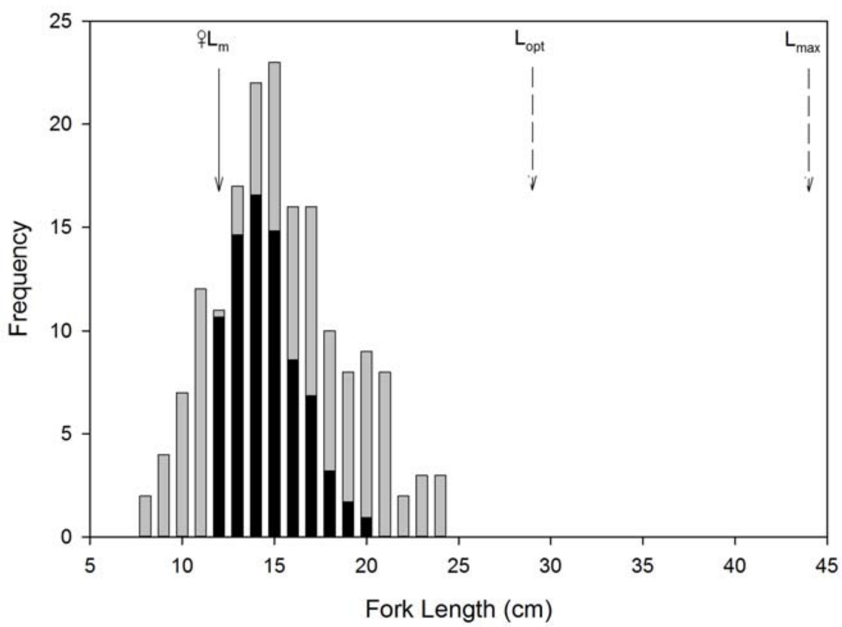
← Figure 96. *Itale yumi yayã* (*Mulloidichthys vanicolensis*). Inter-laser distance 31 mm.

Parupeneus barberinus* (Lacepède, 1801)** or ***iwaŋgale. Figure 97.

Figure 97. *Iwaŋgale* (*Parupeneus barberinus*). Inter-laser distance 39 mm.

19 new specimens; 173 total (Figure 98)
Mean FL = 15 cm (no change)
34% of estimated L_{max} (44 cm)
52% of estimated L_{opt} (29 cm)
125% of published ♀L_m (12 cm)
45% mature ♀

Note: L_{max} of Allen & Swainston (1993) may be an overestimate for the region; of 284 individuals physically collected or captured on video, the largest individual at KWMA was 25 cm FL.

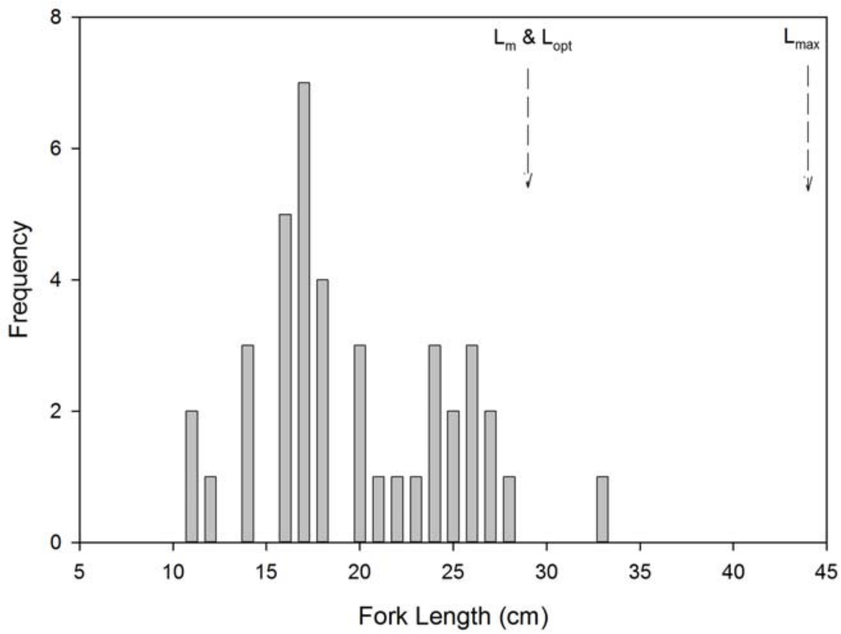


← Figure 98. Size structure of *Parupeneus barberinus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Parupeneus cyclostomus **(Lacepède, 1801)** or ***iwaŋgale bokole***. Figure 99.

13 new specimens; 40 total (Figure 100)
Mean FL = 19 cm (↑)
43% of reported L_{max} (44 cm)
66% of estimated L_{opt} (29 cm)
66% of estimated ♀L_m (29 cm)

← Figure 99. ***Iwaŋgale bokole*** **(*Parupeneus cyclostomus*).**

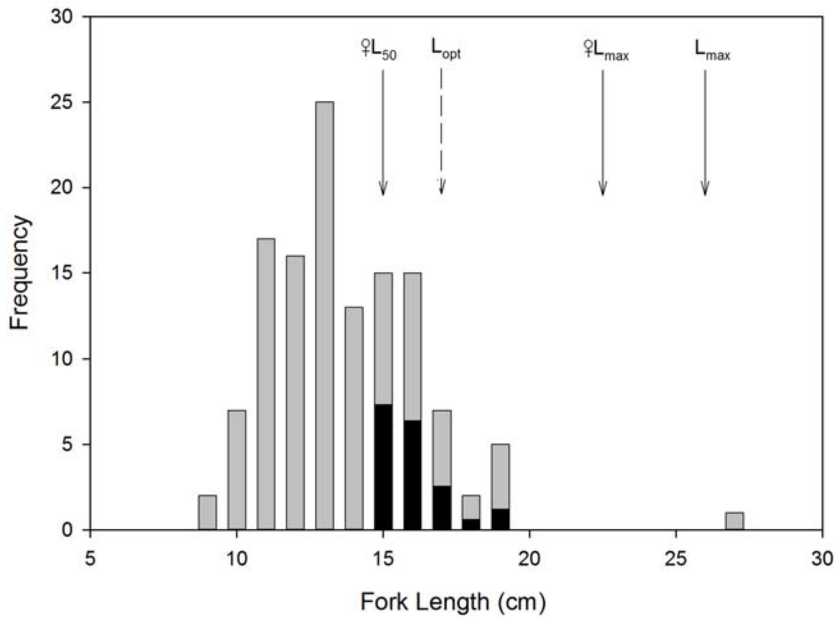


← Figure 100. Size structure of *Parupeneus cyclostomus*.

Parupeneus multifasciatus **(Quoy & Gaimard, 1825)** or ***iwaŋgale bote***. Figure 101.

17 new specimens; 125 total (Figure 102)
Mean FL = 14 cm (no change)
54% of reported L_{max} (26 cm)
82% of estimated L_{opt} (17 cm)
93% of published ♀L_{50} (15 cm)
14% mature ♀

← Figure 101. ***Iwaŋgale bote*** **(*Parupeneus multifasciatus*).**

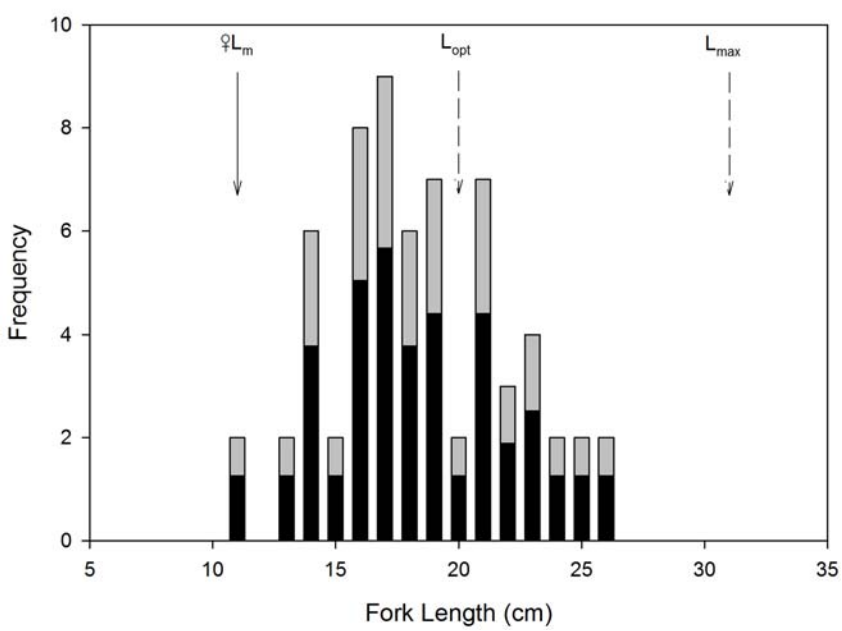


← Figure 102. Size structure of *Parupeneus multifasciatus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Parupeneus trifasciatus* (Lacepède, 1801)** or ***walia. Figure 103.

12 new specimens; 64 total (Figure 104)
Mean FL = 18 cm (no change)
58% of estimated L_{max} (31 cm)
90% of estimated L_{opt} (20 cm)
164% of published ♀L_m (11 cm)
63% mature ♀

← Figure 103. *Walia* (*Parupeneus trifasciatus*). Inter-laser distance 39 mm.



← Figure 104. Size structure of *Parupeneus trifasciatus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Nemipteridae

Scolopsis bilineata **(Bloch, 1793)** or ***buamea***. Figure 105.

Figure 105. *Buamea* (*Scolopsis bilineata*). Inter-laser distance 39 mm.

0 new specimens; 10 total
Mean FL = 13 cm
57% of reported L_{max} (23 cm TL)
87% of estimated L_{opt} (15 cm TL)
108% of published ♀L_m (12 cm TL)
90% mature ♀

Note: L_{max}, L_{opt}, & ♀L_m values are presented as total length because the relationship between total and fork lengths is unknown. The above percentages are likely underestimates. (

Scolopsis ciliata **(Lacepède, 1802);** Kala name not yet recorded. Figure 106.

Figure 106. *Scolopsis ciliata*. Inter-laser distance 32 mm.

3 new specimens; 9 total
Mean FL = 13 cm (↑)
59% of reported L_{max} (22 cm TL)
93% of estimated L_{opt} (14 cm TL)
87% of estimated ♀L_m (15 cm TL)

Note: L_{max}, L_{opt}, & ♀L_m values are presented as total length because the relationship between total and fork lengths is unknown. The above percentages are likely underestimates.

Scolopsis margaritifera **(Cuvier, 1830);** Kala name not yet recorded. Figure 107.

Figure 107. *Scolopsis margaritifera*. Inter-laser distance 31 mm.

First report; 3 specimens
Mean FL = 15 cm
50% of reported L_{max} (30 cm TL)
79% of estimated L_{opt} (19 cm TL)
75% of estimated ♀L_m (20 cm TL)

Note: L_{max}, L_{opt}, & ♀L_m values are presented as total length because the relationship between total and fork lengths is unknown. The above percentages are likely underestimates.

Priacanthidae

Priacanthus hamrur* (Forsskål, 1775)** or ***iko indu (previously reported as ***indu iko***). Figure 108.

Figure 108. *Iko indu* (*Priacanthus hamrur*). Inter-laser distance 39 mm.

0 new specimens; 4 total
Mean FL = 23 cm
58% of published L_{max} (40 cm TL)
88% of estimated L_{opt} (26 cm TL)
115% of published ♀L_{50} (20 cm, assumed FL)
43% mature ♀

Note: L_{max} & L_{opt} values are presented as total length because the relationship between total and fork lengths is unknown. The corresponding percentages are likely underestimates.

Scaridae

***Cetoscarus bicolor* (Rüppell, 1829);** Kala name not yet recorded. Figure 109.

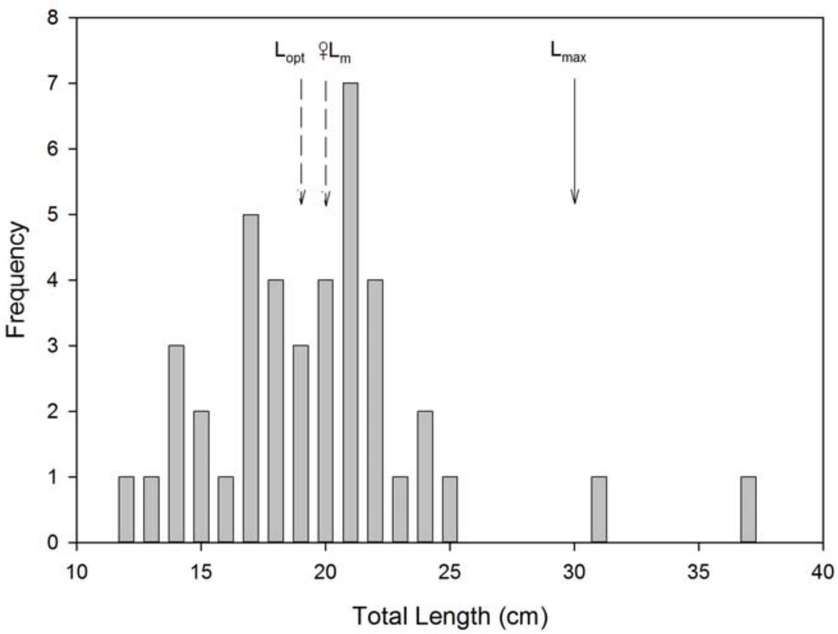
Figure 109. *Cetoscarus bicolor* initial phase (left) and terminal male (right). Inter-laser distance 31.5 and 31 mm, respectively.

First report; 4 specimens
Mean FL = 33 cm
45% of estimated L_{max} (74 cm)
67% of estimated L_{opt} (49 cm)
94% of published ♀L_{50} (35 cm)

Chlorurus bleekeri* (de Beaufort, 1940)** or ***iŋga bobo (intial phase) and ***iŋga talã*** (terminal male). Figure 110.

Figure 110. *Iŋga bobo* (left) and *iŋga talã* (right) or *Chlorurus bleekeri* initial phase (left) and terminal male (right). Inter-laser distance 31.5 mm.

18 new specimens; 41 total (Figure 111)
Mean TL = 19 cm (↑)
63% of published L_{max} (30 cm)
100% of estimated L_{opt} (19 cm)
95% of estimated ♀L_m (20 cm)



← Figure 111. Size structure of *Chlorurus bleekeri*.

Chlorurus bowersi* (Snyder, 1909)** or ***guniau. Figure 112.

5 new specimens; 9 total
Mean FL = 22 cm (no change)
71% of published L_{max} (31 cm)
110% of estimated L_{opt} (20 cm)
105% of estimated ♀L_m (21 cm)

← Figure 112. *Guniau* (*Chlorurus bowersi*). Inter-laser distance 31 mm.

Chlorurus japanensis **(Bloch, 1789);** Kala name not yet recorded. Figure 113.

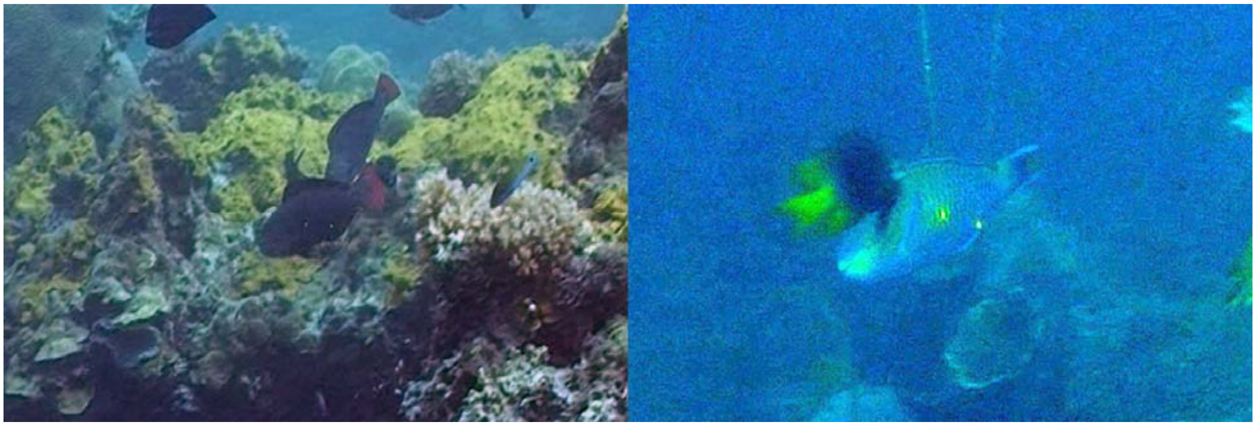
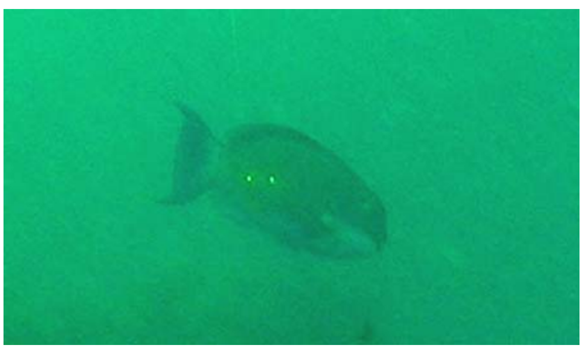


Figure 113. *Chlorurus japanensis* initial phase (left) and terminal male (right). Inter-laser distance 32 mm.

First report; 7 specimens
Mean TL = 18 cm
60% of reported L_{max} (30 cm)
95% of estimated L_{opt} (19 cm)
90% of estimated ♀L_m (20 cm)

Chlorurus microrhinos **(Bleeker, 1854);** Kala name not yet recorded. Figure 114.



First report; 3 specimens
Mean FL = 25 cm
60% of estimated L_{max} (42 cm TL)
93% of estimated L_{opt} (27 cm TL)
81% of published ♀L_{50} (31 cm)
25% mature ♀

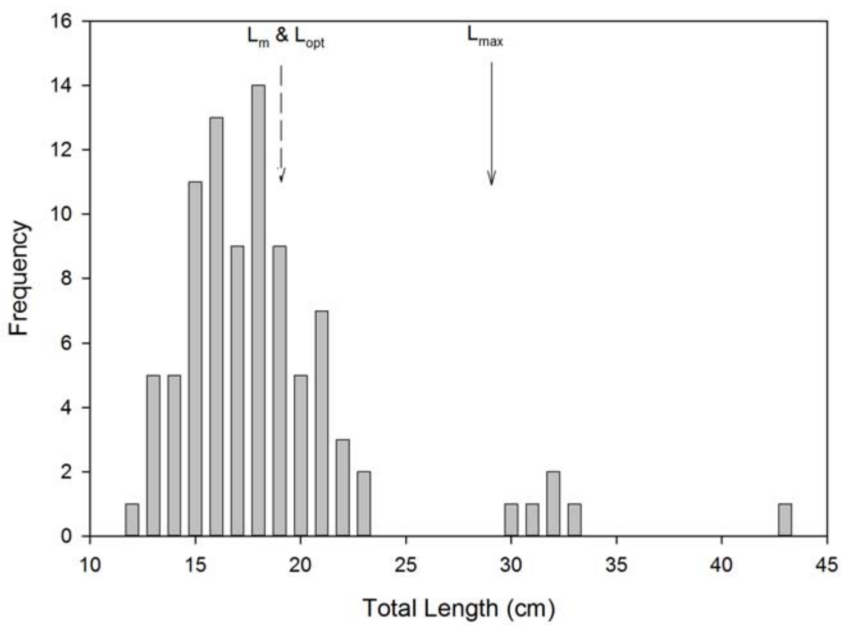
← Figure 114. *Chlorurus microrhinos*. Inter-laser distance 32 mm.

Scarus flavipectoralis* Schultz, 1958** or ***iŋga talaŋ (initial phase) and ***iŋga tali lau*** (terminal male). Figure 115.

Figure 115. *Iŋga talaŋ* (left) and *iŋga tali lau* (right) or *Scarus flavipectoralis* initial phase (left) and terminal male (right). Inter-laser distance 36 and 39 mm, respectively.

32 new specimens; 90 total (Figure 116)
Mean TL = 18 cm (no change)
62% of reported L_{max} (29 cm)
95% of estimated L_{opt} (19 cm)
95% of estimated ♀L_m (19 cm)

Note: L_{max}, estimated from Allen & Swainston (1993) may be an underestimate. The estimated lengths of 7% of the individuals captured on video was greater than L_{max}.



← **Figure 116. Size structure of *Scarus flavipectoralis*.**

***Scarus ghobban* Forsskål, 1775;** Kala name not yet recorded. Figure 117.

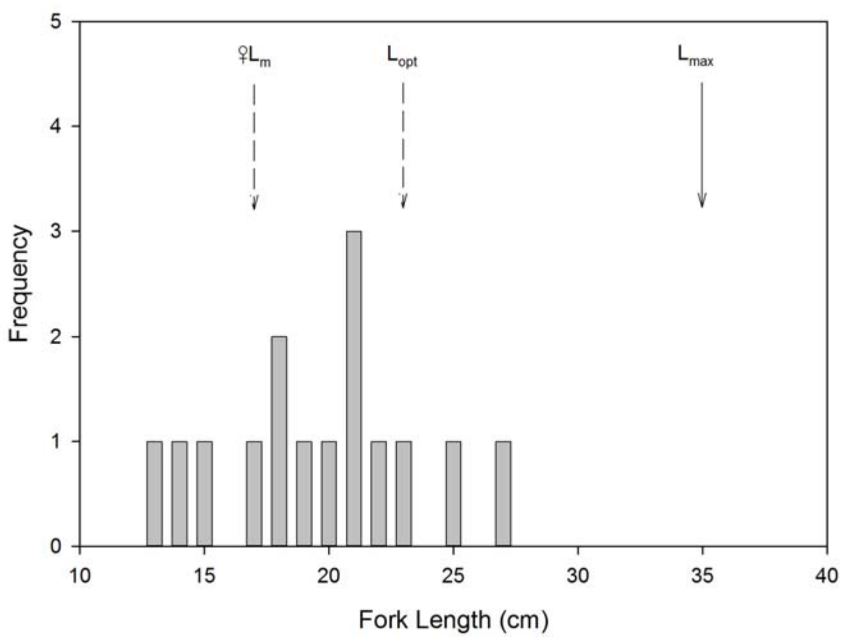
First report; 7 specimens
Mean FL = 33 cm
36% of reported L_{max} (91 cm)
55% of estimated L_{opt} (60 cm)
127% of published ♀L_m (26 cm)
36% mature ♀

← Figure 117. *Scarus ghobban*. Inter-laser distance 32 mm.

Scarus niger* Forsskål, 1775** or ***iŋga tumi. Figure 118.

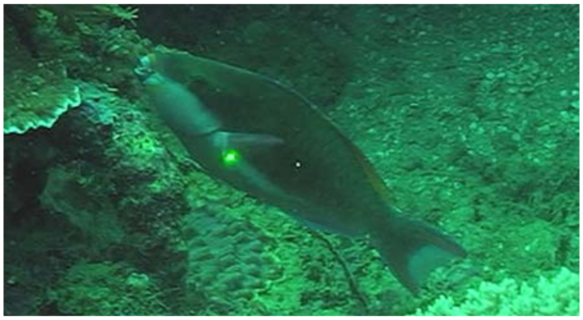
12 new specimens; 16 total (Figure 119)
Mean FL = 21 cm (↑)
60% of reported L_{max} (35 cm)
91% of estimated L_{opt} (23 cm)
124% of published ♀L_{50} (17 cm)

← Figure 118. *Iŋga tumi* (*Scarus niger*). Inter-laser distance 31.5 mm.



← Figure 119. Size structure of *Scarus niger*.

***Scarus oviceps* Valenciennes, 1840;** Kala name not yet recorded. Figure 120.



← **Figure 120. *Scarus oviceps*. Inter-laser distance 39 mm.**

First report; 3 specimens
Mean FL = 26 cm
74% of reported L_{max} (35 cm TL)
113% of estimated L_{opt} (23 cm TL)
124% of published ♀L_{50} (21 cm)

Note: L_{max} & L_{opt} values are presented as total length because the relationship between total and fork lengths is unknown. The corresponding percentages are likely underestimates.

***Scarus rubroviolaceus* Valenciennes, 1840;** Kala name not yet recorded. Figure 121.

First report; 3 specimens
Mean FL = 24 cm
38% of reported L_{max} (64 cm)
57% of estimated L_{opt} (42 cm)
89% of published ♀L_{50} (27 cm)

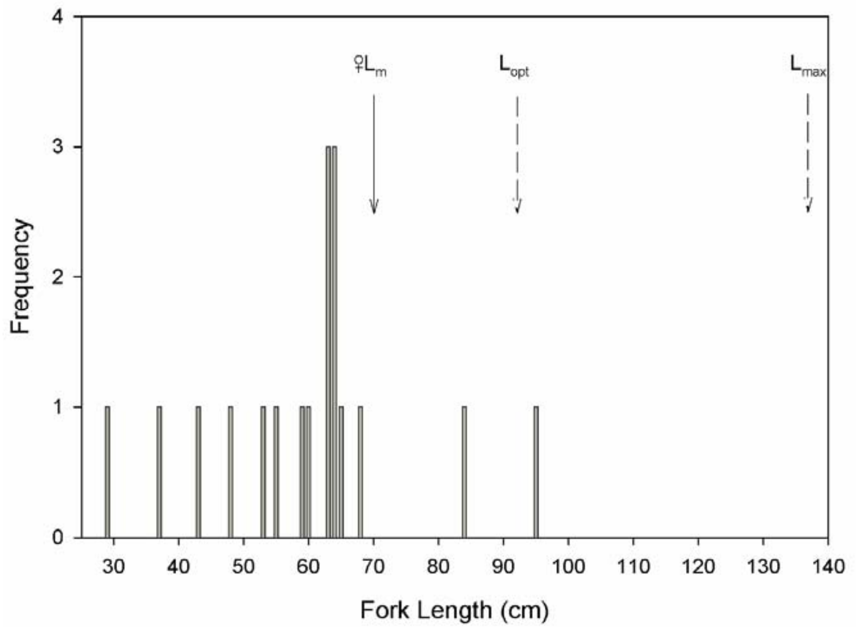
← **Figure 121. *Scarus rubroviolaceus* (initial phase). Inter-laser distance 31.5 mm.**

<u>Scombridae</u>

Gymnosarda unicolor* (Rüppell, 1836)** or ***itaŋgi talalo (previously reported as ***itaŋgi talaloŋa***). Figure 122.

0 new specimens; 18 total (Figure 123)
Mean FL = 59 cm
43% of estimated L_{max} (137 cm)
64% of estimated L_{opt} (92 cm)
85% of published ♀L_{m} (70 cm)

← **Figure 122. *Itaŋgi talalo* (*Gymnosarda unicolor*). Inter-laser distance 31.5 mm.**

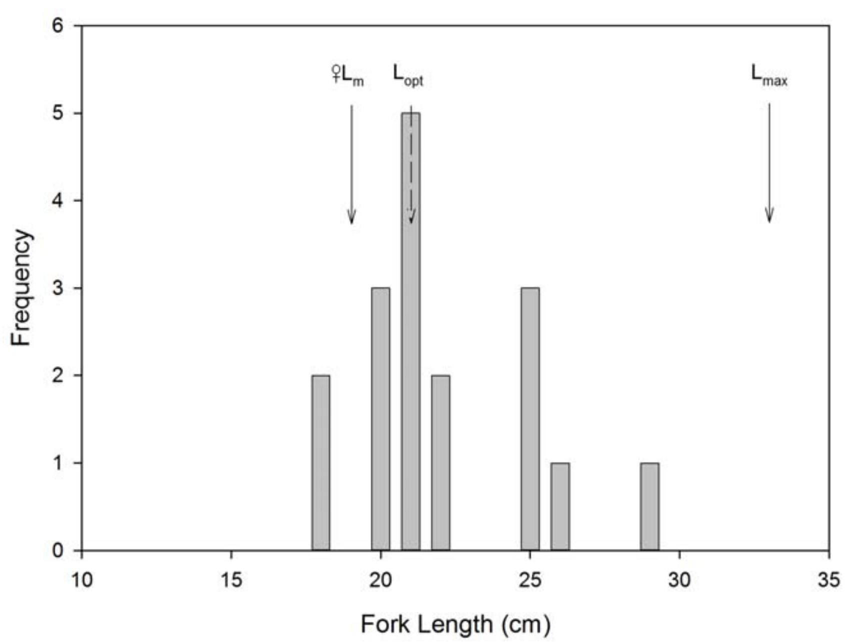


← **Figure 123. Size structure of *Gymnosarda unicolor*.**

Rastrelliger kanagurta* (Cuvier, 1816)** or ***indala. Figure 124.

7 new specimens; 17 total (Figure 125)
Mean FL = 22 cm (↓)
67% of reported L_{max} (33 cm)
105% of estimated L_{opt} (21 cm)
116% of published ♀L_{50} (19 cm)

← **Figure 124. *Indala* (*Rastrelliger kanagurta*). Inter-laser distance 31.5 mm.**



← **Figure 125. Size structure of *Rastrelliger kanagurta*.** .

Scomberomorus commerson* (Lacepède, 1800)** or ***itaŋgi. Figure 126.

1 new specimen; 11 total
Mean FL = 66 cm (↓)
30% of reported L_{max} (218 cm)
45% of estimated L_{opt} (148 cm)
102% of published ♀L_m (65 cm)
65% mature ♀

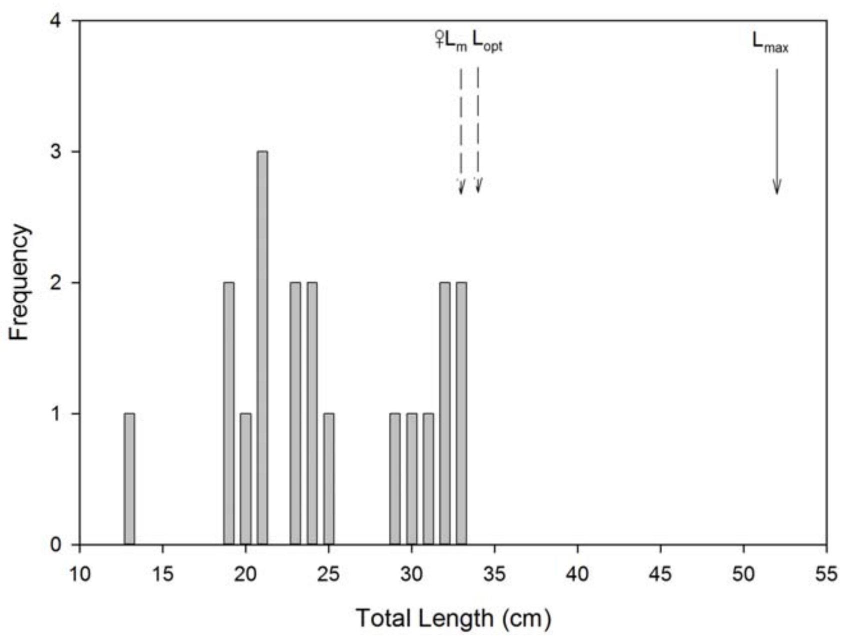
← Figure 126. *Itaŋgi* (*Scomberomorus commerson*). Inter-laser distance 31 mm.

<u>Serranidae</u>

Anyperodon leucogrammicus* (Valenciennes, 1828)** or ***ikula damasã. Figure 127.

2 new specimens; 19 total (Figure 128)
Mean TL = 25 cm (no change)
48% of reported L_{max} (52 cm)
74% of estimated L_{opt} (34 cm)
76% of estimated ♀L_m (33 cm)

← Figure 107. *Ikula damasã* (*Anyperodon leucogrammicus*). Inter-laser distance 39 mm.



← Figure 128. Size structure of *Anyperodon leucogrammicus*.

Cephalopholis boenak* (Bloch, 1790)** or ***ikula bobo. Figure 129.

0 new specimens; 10 total
Mean TL = 16 cm
67% of reported L_{max} (24 cm)
107% of estimated L_{opt} (15 cm)
107% of published ♀L_{50} (15 cm)
63% mature ♀

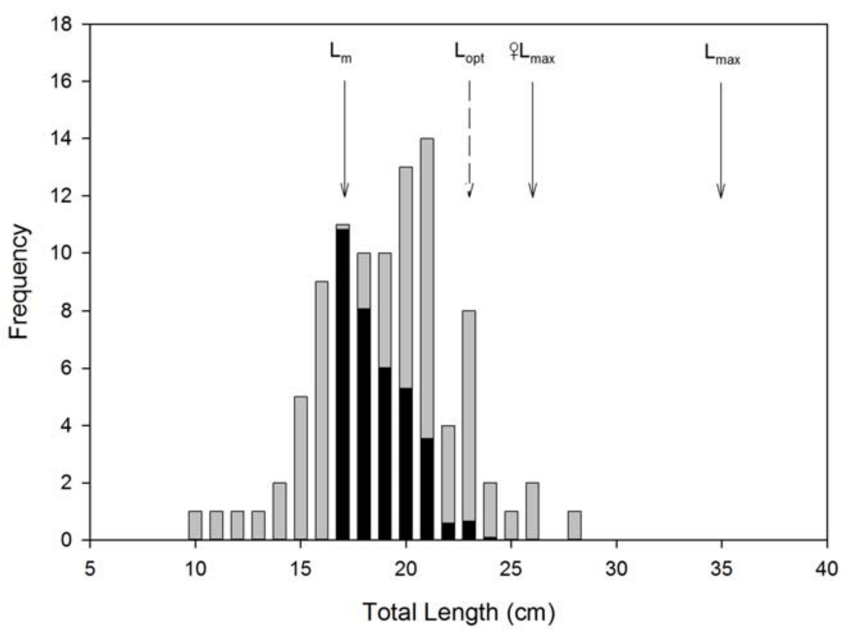
← Figure 129. *Ikula bobo* (*Cephalopholis boenak*).

Cephalopholis cyanostigma* (Valenciennes, 1828)** or ***ikula sa. Figure 130.

Figure 130. *Ikula sa* (*Cephalopholis cyanostigma*). Inter-laser distance 39 mm.

10 new specimens; 96 total (Figure 131)
Mean TL = 19 cm (no change)
54% of reported L_{max} (35 cm)
83% of estimated L_{opt} (23 cm)
83% of published ♀L_{50}, (23 cm)
37% mature ♀

Note: The estimate of % mature ♀ is based on L_m. If a problematic estimate of ♀L_{50} (Longenecker *et al.* 2011) is used, as few as 0.8 % may be mature ♀.

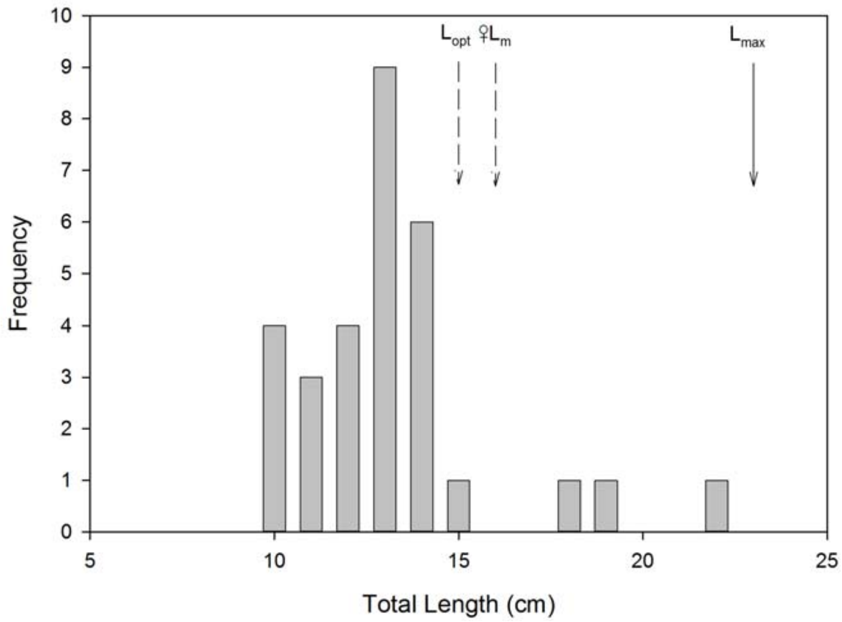


← Figure 131. Size structure of *Cephalopholis cyanostigma*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals.

Cephalopholis microprion* (Bleeker, 1852)** or ***ikula yuyeŋ. Figure 132.

5 new specimens; 30 total (Figure 133)
Mean TL = 13 cm (no change)
57% of reported L_{max} (23 cm)
87% of estimated L_{opt} (15 cm)
81% of estimated ♀L_m (16 cm)

← Figure 132. *Ikula yuyeŋ* (*Cephalopholis microprion*). Inter-laser distance 39 mm.



← Figure 133. Size structure of *Cephalopholis microprion*.

Cephalopholis sexmaculata* (Rüppell, 1830)** or ***ikula talulumua (previously reported as ***ikula tumi***). Figure 134.

0 new specimens; 4 total
Mean TL = 24 cm
51% of published L_{max} (47 cm)
77% of estimated L_{opt} (31 cm)
100% of published ♀L_m (24 cm)

← Figure 134. *Ikula talulumua* (*Cephalopholis sexmaculata*). Inter-laser distance 36 mm.

Cephalopholis urodeta* (Forster, 1801)** or ***ikula karu guŋ-guŋ. Figure 135.

0 new specimens; 6 total
Mean TL = 18 cm
67% of reported L_{max} (27 cm)
106% of estimated L_{opt} (17 cm)
100% of estimated ♀L_m (18 cm)
49% mature ♀

← Figure 135. *Ikula karu guŋ-guŋ* (*Cephalopholis urodeta*). Inter-laser distance 39 mm.

Epinephelus fasciatus* (Forsskål, 1775)** or ***ikula laga. Figure 136.

0 new specimens; 3 total
Mean FL = 16 cm
40% of reported L_{max} (40 cm)
62% of estimated L_{opt} (26 cm)
114% of published ♀L_m (14 cm)(

← Figure 136. *Ikula laga* (*Epinephelus fasciatus*). Inter-laser distance 39 mm.

Epinephelus merra* Bloch, 1793** or ***ikula talõ. Figure 137.

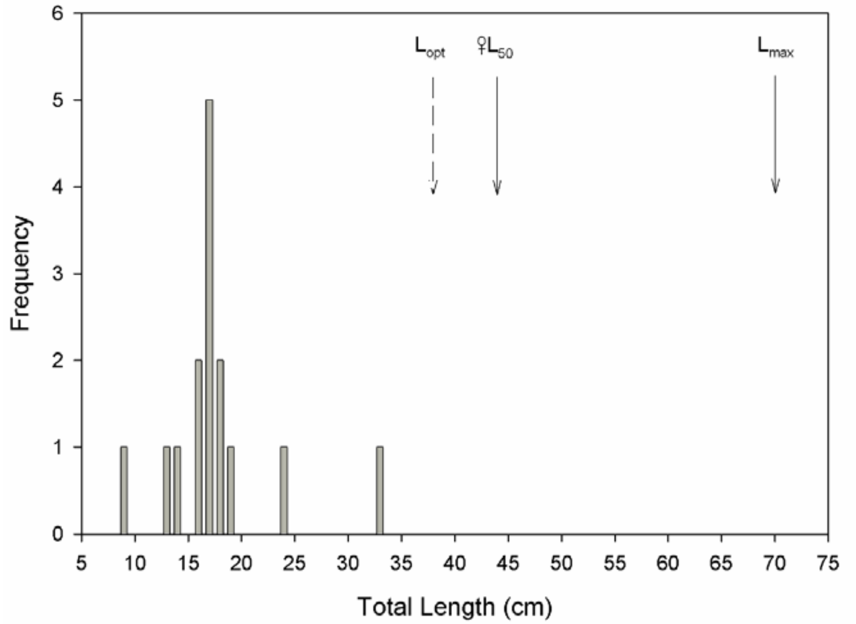
0 new specimens; 3 total
Mean FL = 22 cm
79% of reported L_{max} (28 cm)
122% of estimated L_{opt} (18 cm)
200% of published ♀L_{50} (11 cm)

← Figure 137. *Ikula talõ* (*Epinephelus merra*). Inter-laser distance 32 mm.

Plectropomus areolatus* (Rüppell, 1830)** or ***ikula su (previously reported as ***ikula su mani balã***). Figure 138.

0 new specimens; 15 total (Figure 139)
Mean TL = 18 cm
26% of reported L_{max} (70 cm)
39% of estimated L_{opt} (46 cm)
45% of published ♀L_{50} (40 cm)
0% mature ♀

← Figure 138. *Ikula su* (*Plectropomus areolatus*). Inter-laser distance 39 mm.



← **Figure 139. Size structure of *Plectropomus areolatus.***

Plectropomus leopardus **(Lacepède, 1802)** or ***ikula su*** (previously reported as ***yula***). Figure 140.

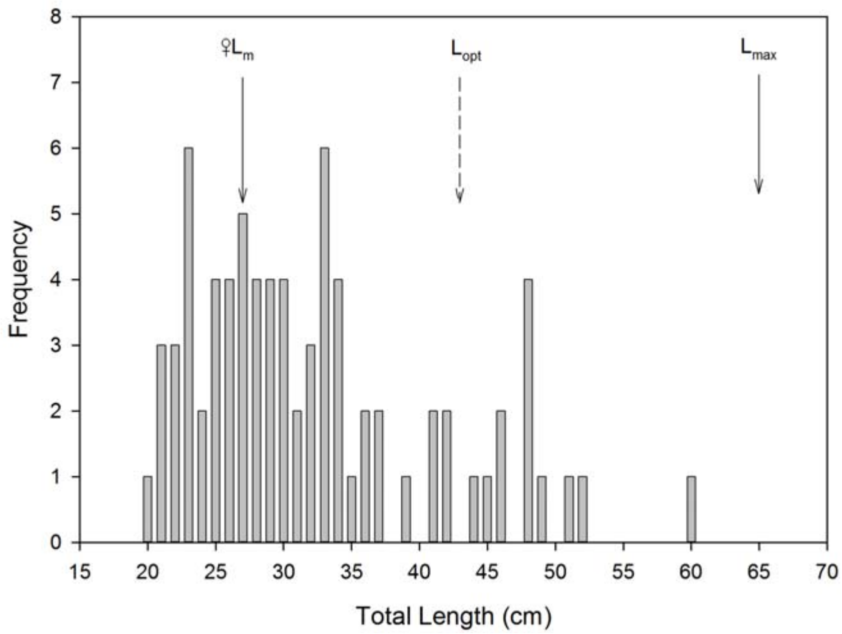
0 new specimens; 10 total
Mean TL = 32 cm
47% of estimated L_{max} (68 cm)
71% of estimated L_{opt} (45 cm)
100% of published ♀L_{50} (32 cm)
56% mature ♀

← **Figure 140. *Ikula su* (*Plectropomus leopardus*). Inter-laser distance 36 mm.**

Plectropomus oligacanthus **(Bleeker, 1855)** or ***ikula su tatalõ***. Figure 141.

16 new specimens; 77 total (Figure 142)
Mean FL = 32 cm (no change)
49% of reported L_{max} (65 cm)
74% of estimated L_{opt} (43 cm)
119% of published ♀L_m of (27 cm)

← **Figure 141. *Ikula su tatalõ* (*Plectropomus oligacanthus*). Inter-laser distance 31.5 mm.**



← **Figure 142. Size structure of *Plectropomus oligacanthus*.**

<u>Siganidae</u>

Siganus doliatus* Guérin-Méneville, 1829-38** or ***indaŋa. Figure 143.

Figure 143. *Indaŋa* (*Siganus doliatus*). Inter-laser distance 31 mm.

3 new specimens; 6 total
Mean FL = 17 cm (↑)
57% of reported L_{max} (30 cm TL)
89% of estimated L_{opt} (19 cm TL)
94% of published ♀L_m (18 cm TL)

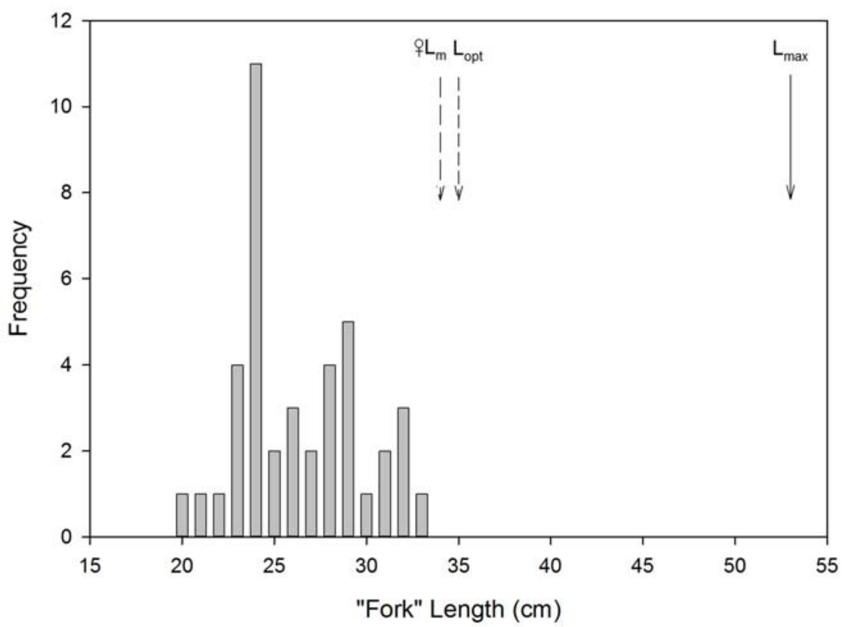
Note: L_{max}, L_{opt}, & ♀L_m values are presented as total length because the relationship between total and fork lengths is unknown. The above percentages are likely underestimates.

Siganus javus* (Linnaeus, 1766)** or ***yulawe kokoranawa. Figure 144.

Figure 144. *Yulawe kokoranawa* (*Siganus javus*). Inter-laser distance 39 mm.

8 new specimens; 41 total (Figure 145)
Mean "FL" = 26 cm (↑)
49% of reported L_{max} (53 cm TL)
74% of estimated L_{opt} (35 cm TL)
76% of estimated ♀L_m (34 cm TL)

Note: L_{max}, L_{opt}, & ♀L_m values are presented as total length because the relationship between total length and the length to the middle ray of the slightly emarginate caudal fin (*i.e.*, "fork" length) is unknown. The above percentages are likely underestimates.

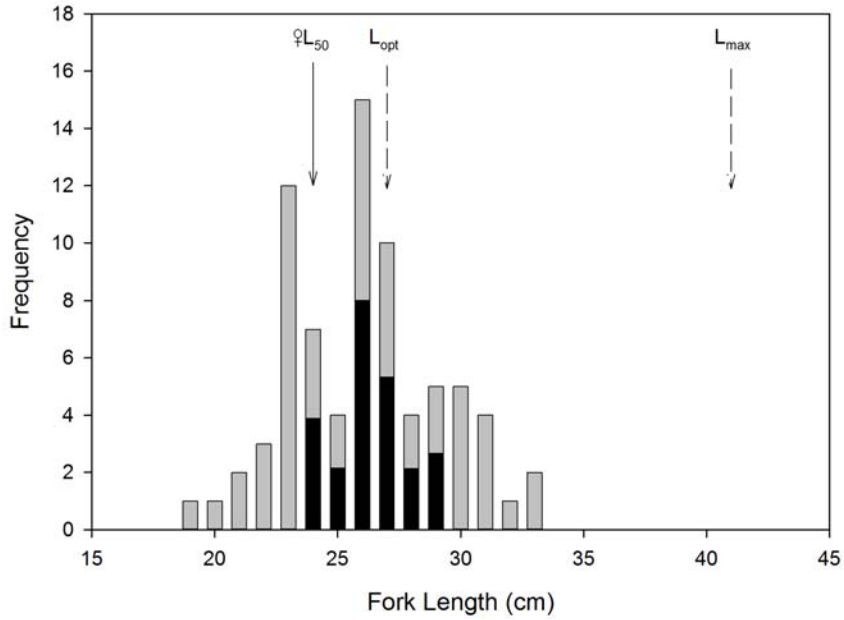


← Figure 145. Size structure of *Siganus javus*.

Siganus lineatus* (Valenciennes, 1835)** or ***yulawe. Figure 146.

5 new specimens; 76 total (Figure 127)
Mean "FL" = 26 cm (no change)
63% of estimated L_{max} (41 cm)
96% of estimated L_{opt} (27 cm)
108% of published ♀L_{50} (24 cm)
32% mature ♀

← Figure 146. *Yulawe* (*Siganus lineatus*).



← **Figure 147. Size structure of *Siganus lineatus*. The dark portion of bars represent estimated number of mature females, light portion represents all other individuals**.

Siganus puellus* (Schlegel, 1852)** or ***indaŋa malũ (previously reported as ***indaŋa***). Figure 148.

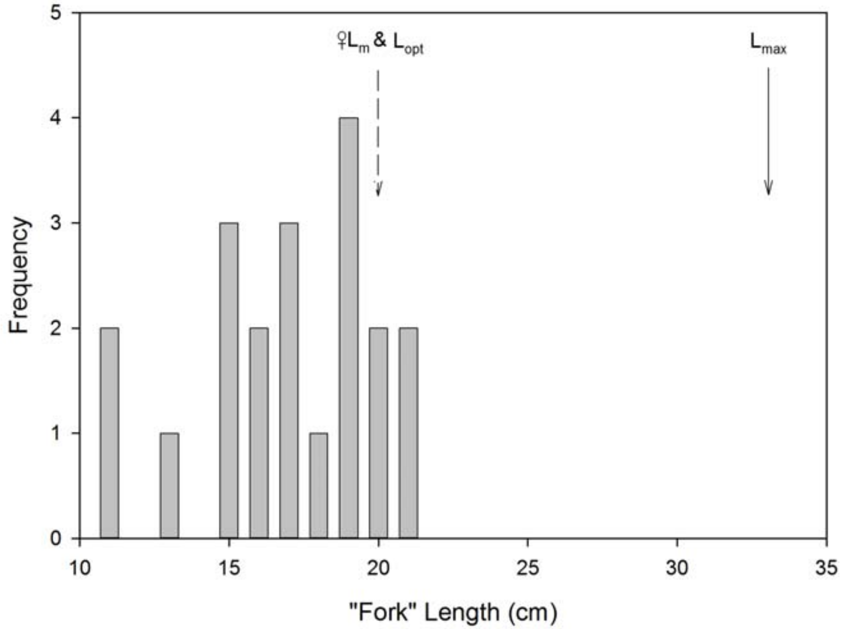
1 new specimens; 4 total
Mean FL = 25 cm (↑)
66% of estimated L_{max} (38 cm)
100% of estimated L_{opt} (25 cm)
100% of estimated ♀L_m (25 cm)

← **Figure 148. *Indaŋa malũ* (*Siganus puellus*). Inter-laser distance 32 mm.**

Siganus vulpinus* (Schlegel & Müller, 1845)** or ***indaŋa. Figure 149.

12 new specimens; 20 total (Figure 150)
Mean TL = 17 cm (↑)
57% of reported L_{max} (30 cm)
85% of estimated L_{opt} (20 cm)
85% of estimated ♀L_m (20 cm)

← **Figure 149. *Indaŋa* (*Siganus vulpinus*). Inter-laser distance 31 mm.**



← Figure 150. Size structure of *Siganus vulpinus*.

Time Series

Plots of annual average length estimates are presented in Figure 151 for *luduŋ ŋai* or *mai* (*Caesio cuning*), *ikula sa* (*Cephalopholis cyanostigma*), *itale* (*Lutjanus biguttatus*), *iwaŋgale* (*Parupeneus barberinus*), and *iwaŋgale bote* (*Parupeneus multifasciatus*). Three-year moving averages suggest that the average size of all species is relatively stable. Mean lengths for all species are within a few centimeters of female reproductive size.

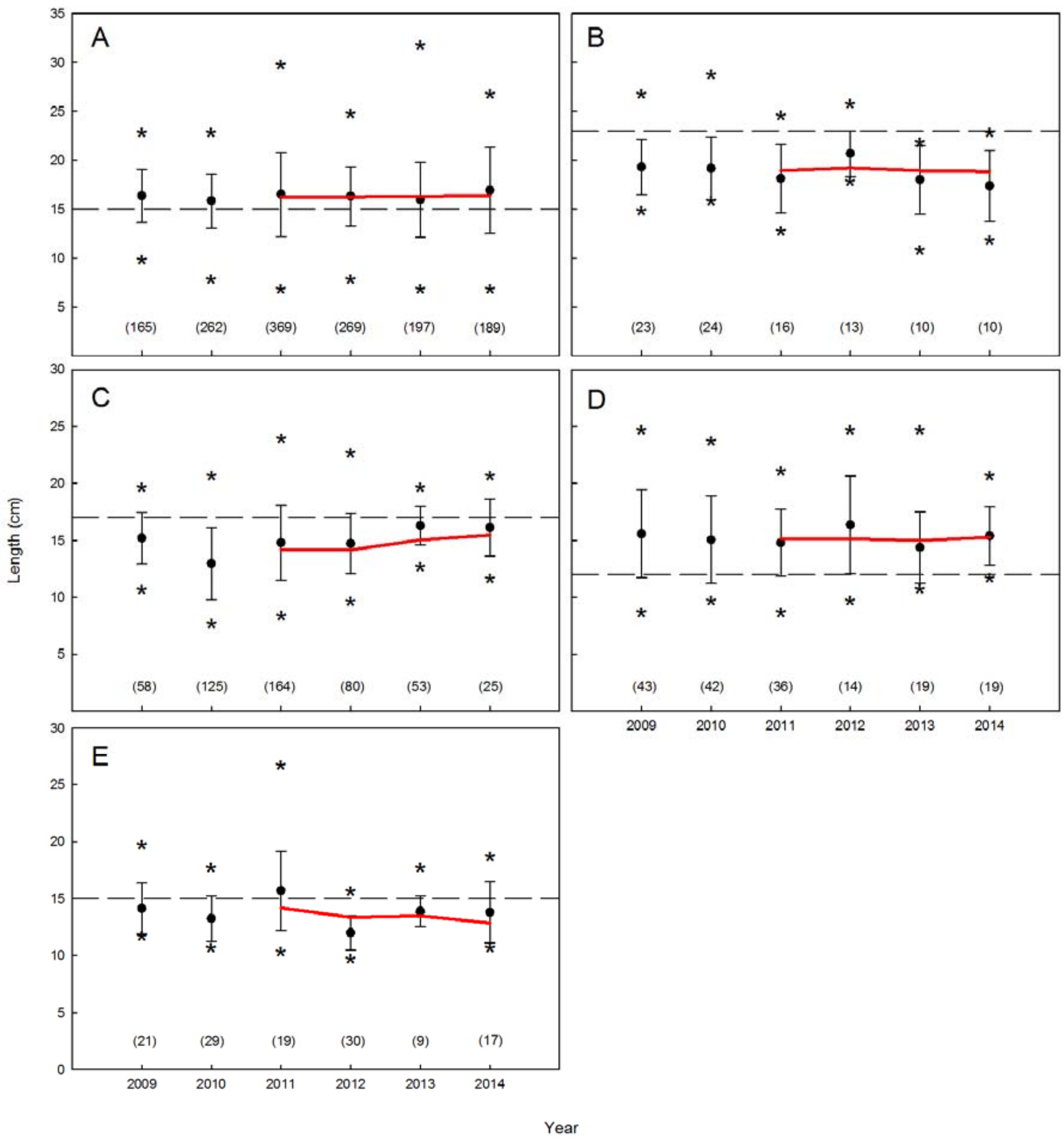


Figure 151. Time-series plots of average length. Red lines = 3-year moving average; dashed lines = female L_{50}, solid circles = annual means; vertical bars = standard deviation; asterisks = minima and maxima. Number of specimens in parentheses. A) *luduŋ mai* (*Caesio cuning*), B) *ikula sa* (*Cephalopholis cyanostigma*), C) *itale* (*Lutjanus biguttatus*), D) *iwaŋgale* (*Parupeneus barberinus*), E) *iwaŋgale bote* (*Parupeneus multifasciatus*).

DISCUSSION

The purpose of this report is to provide baseline data for the evaluation of a newly established reef-fish management plan at KWMA. However, we wish to emphasize that aspects of village life that are consistent with marine conservation should not be abandoned. Several characteristics of the village and its fishery appear to reduce the risk of overfishing. These are reproduced below from Longenecker *et al*. (2011):

1) Customary tenure. Given that Kamiali residents do not view themselves as conservation practitioners in the marine environment, we agree with Polunin (1984) and Ruttan (1998) that the intent of traditional resource management is to increase human gain from the natural environment, not to conserve biological resources. However, customary tenure appears to have a conservation function because outsiders are prohibited from fishing within the Kamiali Wildlife Management Area. Territoriality at KWMA resulted in a *de facto* limited-entry fishery.
2) Distance to commercial markets. Kamiali is 64 km from the city of Lae, the nearest place where fish can be sold commercially. Cinner & McClanahan (2006) suggest that proximity to markets (<16 km) increases the likelihood of overfishing in Papua New Guinea. Commercial fishing in Kamiali presents an economic challenge. Because there are no roads, individuals selling fish must have a motorized vessel to transport fish to market. The cost of operating these is high; a liter of fuel can cost up to $2 (US). Based on our own travels to the village on these vessels, approximately 100 liters of fuel is used in a typical round trip, resulting in an overhead cost of about $200 (US) per commercial sale. Because there is no electrical service in Kamiali, ice must be purchased in Lae. Therefore, economic success in commercial fishing requires that a sufficient quantity of fish be caught before ice melts, and that market prices justify a costly trip to Lae. Variability in catch rate and market prices in the face of high fuel costs thus presents a significant barrier to entry into commercial fishing.
3) Subsistence economy. Because cash is limited, technologies that may lead to fishery overexploitation are cost-prohibitive. Fishing is done primarily from small, human-powered, handmade, outrigger canoes (Longenecker *et al*. 2008c). Transportation to bottom-fishing sites and propulsion while trolling requires a significant input of human energy. Hook-and-line fishing with homemade handreels and weights, or handcrafted outriggers, is the dominant fishing technique. Two spearing methods are also used. Most common is aerial hand-launching of bamboo poles fitted with metal tines (Longenecker *et al*. 2008c). Catching fish by this method appears to be infrequent. Less common are homemade spearguns used while free-diving. Because dive fins are not used, a depth refuge from spearing exists. Gillnets are rare, and we have not seen traps or weirs at Kamiali. Finally, lack of refrigeration reduces the motivation to catch more than can be used within a few days.
4) Plant-based diet. Although fish is the major source of dietary protein consumed by Kamiali residents, the majority of their calories are derived from fruits and vegetables grown in swidden gardens. Time spent fishing is limited by the need to conduct labor-intensive gardening.
5) Family and community obligations. As above, time spent fishing must be balanced against other time-intensive activities. These include building and repairing houses and canoes (both made from materials harvested from the surrounding forests), and attending community meetings.

The factors listed above do not act in isolation. Distance to market is negatively related to the likelihood that a community will exclude outsiders from exploiting its marine environment. On the other hand, communities that subsist on marine resources may be more likely to exclude outsiders (Cinner 2005).

The community at KWMA is undergoing a transformation from a common-property system to a cash-based economy (Wagner 2002). This is of some concern because lower dependence on marine resources may reduce the likelihood that a community employs exclusionary marine tenure regimes (Cinner 2005). Cinner *et al*. (2007) indicate that customary management is at risk during economic modernization such as that underway at KWMA. They suggest that marine conservation initiatives based on customary tenure are more likely to succeed if organizations help reduce the impact of socioeconomic transformations. The Kamiali Initiative, by establishing a pathway to economic development that is based on effective environmental conservation, is helping to maintain a traditional lifestyle as the village economy changes.

Baseline Information

Above, we calculated the average length of free-swimming individuals for 100 species. We also presented average length as a percentage of theoretical length at optimum yield (L_{opt}) and length at female adult size. When possible, we estimated the percentage of reproductively sized females in each population.

The exploited reef-fish community can be characterized as follows. A typical, free-swimming individual at KWMA is 57% of its maximum length and 90% of its estimated optimum length. In the subset of 34 species for which female L_{50} is known, a typical individual is 101% of female reproductive size. Of the remaining 66 species for which L_m (either published or estimated) is our only indicator of female reproductive size, an average individual is 101% of size-at-maturity*. Considering sex ratios, known for 35 species, approximately 32% of a population, on average, is composed of mature females.

We also plotted a time series of average-length data for the more commonly exploited reef fishes (Figure 151). Average length appears stable for all species considered [*luduŋ mai* (*Caesio cuning*), *ikula sa* (*Cephalopholis cyanostigma*), *itale* (*Lutjanus biguttatus*), *iwaŋgale* (*Parupeneus barberinus*), and *iwaŋgale bote* (*Parupeneus multifasciatus*].

Mean lengths of four species are greater than [*luduŋ mai* (*Caesio cuning*), *iwaŋgale* (*Parupeneus barberinus*)] or within a few centimeters of [*ikula sa* (*Cephalopholis cyanostigma*), *itale* (*Lutjanus biguttatus*), and *iwaŋgale bote* (*Parupeneus multifasciatus*)] reproductive length. *Ikula sa* (*Cephalopholis cyanostigma*) appears to have the greatest negative deviation from reproductive size, however the L_{50} estimate (Longenecker *et al*. 2011) may be high.

Plan 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.

---

* This value is likely to be an underestimate because L_m estimates are from the empirical equations of Froese and Binohlan (2000). These equations systematically overestimate female size-at-maturity for exploited fishes at KWMA. On the basis of results to date, the equations overestimate female L_{50} for 26 of 29 species for which L_{50} is known. Further, the degree of overestimation increases as maximum size increases.

Continued monitoring of free-swimming fish populations will enable an objective evaluation of the new reef-fish management plan (Longenecker *et al*. 2014b). Increasing average lengths would suggest that the management plan had a positive effect on coral-reef-fish populations at KWMA. This would provide justification for promoting similar management plans in other subsistence villages of the Indo-Pacific. No change in average lengths would suggest that fishing at KWMA is sustainable, but would also suggest that the plan had no real impact on reef-fish populations. Promoting a similar plan elsewhere would be of dubious value. Decreasing average lengths would suggest that fishing at KWMA is not sustainable and that another approach to managing coral reef fishes is needed.

ACKNOWLEDGMENTS

An anonymous private foundation generously provided financial support for this study. We thank the residents of Kamiali for their hospitality, openness, and willingness to have their environment and fishing practices examined. We especially thank the Kamiali Wildlife Management Committee for permission to conduct this work.

LITERATURE CITED

Abdussamad, E.M., N.G.K. Pillai, H. Mohamed Kasim, O.M.M.J. Habeeb Mohamed and K. Jeyabalan. 2010. Fishery, biology and population characteristics of the Indian mackerel, *Rastrelliger kanagurta* (Cuvier) exploited along the Tutucorin coast. Indian Journal of Fisheries 57:17-21.

Allen, G.R. 1985. Snappers of the world. An annotated and illustrated catalogue of lutjanid species known to date. FAO Fisheries Synopsis No. 125 Vol. 6. 208 pp.

Allen, G.R., and R. Swainston. 1993. *Reef Fishes of New Guinea: A Field Guide for Divers, Anglers and Naturalists*. Christensen Research Institute, Madang. 132 pp.\

Anand, P.E.V., and N.G.K. Pillai. 2002. Reproductive biology of some common coral reef fishes of the Indian EEZ. Journal of the Marine Biological Association of India 44(1&2):122-135.

Barba, J. 2010. Demography of parrotfish: age, size and reproductive variables. MS Thesis, James Cook University. 137 pp.

Bellwood, D.R. 2001. Scaridae: Parrotfishes. Pp 3468-3492 *in* Carpenter, K.E., and V.H. Niem (eds). *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 6. Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles, sea turtles, sea snakes and marine mammals*. FAO. Rome.

Boaden, A.E., and M.J. Kingsford. 2013. Distribution and habitat associations of the bridled monocle bream *Scolopsis bilineatus* (Nemipteridae): a demographic approach. Journal of Fish Biology 83:618-641.

Brandl, S.J., and D.R. Bellwood. 2013. Pair formation in the herbivorous rabbitfish *Siganus doliatus*. Journal of Fish Biology 82:2031-2044.

Breder, C.M., & D.E. Rosen, 1966. Modes of reproduction in fishes. T.F.H. Publications, Neptune City, New Jersey. 941 p.

Caillart , B., M.L. Harmelin-Vivien, R. Galzin, and E. Morize. 1994. Part III. Reef fish communities and fishery yields of Tikehau Atoll (Tuamotu Archipelago, French Polynesia). Atoll Research Bulletin 415:1-38.

Chan, T.T.C., and Y. Sadovy. 2002. Reproductive biology, age and growth in the chocolate hind, *Cephalopholis boenak* (Bloch, 1790), in Hong Kong. Marine and Freshwater Research 53:791-803.

Choat, J.H. and D.R. Robertson, 1975. Protogynous hermaphroditism in fishes of the family Scaridae. Pp. 263-283 *in* R. Reinboth (ed). *Intersexuality in the Animal Kingdom*. Springer, Heidelberg.

Choat, J.H., and D.R. Robertson. 2002. Age-based studies on coral reef fishes. Pp 57-80 *in* P.F. Sale (ed). *Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem*. Academic Press, San Diego.

Cinner, J.E. 2005. Socioeconomic factors influencing customary marine tenure in the Indo-Pacific. Ecology and Society 10(1):36.

Cinner, J.E., and T.R. McClanahan. 2006. Socioeconomic factors that lead to overfishing in small-scale coral reef fisheries of Papua New Guinea. Environmental Conservation 33(1):73-80.

Cinner, J.E., S.G. Sutton and T.G. Bond. 2007. Socioeconomic thresholds that affect use of customary fisheries management tools. Conservation Biology 21(6):1603-1611.

Craig, P.C., J.H. Choat, L.M. Axe and S. Saucerman. 1997. Population biology and harvest of the coral reef surgeonfish *Acanuthurus lineatus* in American Samoa. Fishery Bulletin 95(4):680-693.

Craig, P.C. 1998. Temporal spawning patterns of several surgeonfishes and wrasses in American Samoa. Pacific Science 52(1):35-39.

Cole, K.S. 2008. Assessment of reproductive status and reproductive output of three Hawaiian goatfish species, *Mulloidichthys flavolineatus* (yellowstripe goatfish), *M. vanicolensis* (yellowfin goatfish), and *Parupeneus porphyreus* (whitesaddle goatfish) (family Mullidae). DAR Dingel Johnson Grant Report for 2007-2008 Award. <http://hawaii.gov/dlnr/dar/coral/pdfs/COLE%20FINAL%20REPORT%20JULY%2030%2008.pdf>

Collette, B.B., and C.E. Nauen. 1983. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. FAO Fisheries Synopsis No. 125 Vol. 2. 137 pp.

Davis, T.L.O., and G.J. West. 1992. Growth and mortality of Lutjanus vittus (Quoy and Gaimard) from the North West Shelf of Australia. Fishery Bulletin 90:395-404

Davis, T.L.O., and G.J. West. 1993. Maturation, reproductive seasonality, fecundity, and spawning frequency in *Lutjanus vittus* (Quoy and Gaimard) from the North West Shelf of Australia. Fishery Bulletin 91:224-236.

DeVolder, C., C. Schreyer and J. Wagner. 2012. *Kala Kaŋa Bi Ŋa Kapia – Diksineri bilong Tok Ples Kala (Kala Dictionary)*. University of British Colombia, Okanagan. 36 pp.

Evans, R.D, G.R. Russ and J.P. Kritzer. 2008. Batch fecundity of Lutajanus carponotatus (Lutjanidae) in implications of no-take marine reserves on the Great Barrier Reef, Australia. Coral Reefs 27:179-189.

Ferreira, B.P. 1995. Reproduction of the common coral trout *Plectropomus leopardus* (Serranidae : Epinephelinae) from the central and northern Great Barrier Reef, Australia. Bulletin of Marine Science 56(2):653-669.

Friedlander, A.M., J.D. Parrish and R.C. DeFelice. 2002. Ecology of the introduced snapper *Lutjanus kasmira* (Forsskal) in the reef fish assemblage of a Hawaiian Bay. Journal of Fish Biology 60:28-48.

Froese, R. 2004. Keep it simple: three indicators to deal with overfishing. Fish and Fisheries 5:86-91.

Froese, R., and C. Binohlan. 2000. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. Journal of Fish Biology 56:758-773.

Froese, R., and D. Pauly (eds). 2012. FishBase. World Wide Web electronic publication. <www.fishbase.org>, version (08/2012). Accessed 10/2012.

Grandcourt E.M. 2002. Demographic characteristics of a selection of exploited reef fish from the Seychelles: preliminary study. Marine and Freshwater Research 53:123-130.

Grandcourt E.M., F. Francis, A. Al Shamsi, K. Al Ali and S. Al Ali. 2003. Stock assessment and biology of key species in the demersal fisheries of the Emirate of Abu Dhabi. Environmental Research and Wildlife Development Agency, Abu Dhabi. 75 pp.

Grandcourt E.M., T.Z. Al Abdessalaam, F. Francis and A.T. Al Shamsi. 2011. Reproductive biology and implications for management of the painted sweetlips *Diagramma pictum* in the southern Arabian Gulf. Journal of Fish Biology 79:615-632.

Hamilton, R.J., M. Matawai and T. Potuku. 2004. Spawning aggregations of coral reef fish in New Ireland and Manus Provinces, Papua New Guinea: Local knowledge field survey report. (UNRESTRICTED ACCESS VERSION). Report prepared for the Pacific Island Countries Coastal Marine Program, The Nature Conservancy. TNC Pacific Island Countries Report No. 4/04.

Heemstra, P.C., and J.E. Randall. 1993. Groupers of the world (family Serranidae, subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. FAO Fisheries Synopsis No. 125 Vol. 16. 382 pp.

Heupel, M.R., L.M. Currey, A.J. Williams, C.A. Simpendorfer, A.C. Ballagh and A.L. Penny. 2009. The comparative biology of lutjanid species on the Great Barrier Reef. Project Milestone Report. Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns. 30 pp.

Heupel, M.R., A. Penny, A.J. Williams, J.P. Kritzer, D.J. Welch, R.J. Marriott, C.R. Davies, and B.D. Mapstone. 2010. Demographic characteristics of exploited tropical lutjanids: a comparative analysis. Fishery Bulletin 108:420-432.

Hubble, M. 2003. The ecological significance of body size in tropical wrasses (Pisces : Labridae). B.Sc. (Hons) Thesis, Heriot-Watt University. 187 pp.

Jehangeer, M.I. 2003 Some population parameters of the goatfish, *Mulloidichthys vanicolensis* from the lagoon of Mauritius. Pp 82-88. *in* M.L.D. Palomares, B. Samb, T. Diouf, J.M. Vakily and D. Pauly (eds). *Fish Biodiversity: Local Studies as Basis for Global Inferences*. ACP-EU Fisheries Research Report 14. 281pp.

Kritzer, J.P. 2002. Biology and management of small snappers on the Great Barrier Reef. Pp 66-84 *in* A.J. Williams, D.J. Welch, G. Muldoon, R. Marriott, J.P. Kritzer and S.A. Adams (eds). *Bridging the gap: A Workshop Linking Student Research with Fisheries Stakeholders*. CRC Reef Research Centre Technical Report #48. CRC Reef Research Centre, Townsville.

Kritzer, J.P. 2004. Sex-specific growth and mortality, spawning season, and female maturation of the stripey bass (*Lutjanus carponotatus*) on the Great Barrier Reef. Fishery Bulletin 102:94-107.

Lewis, A.D., B.R. Smith and R.E. Kearney. 1974. Studies on tunas and baitfish in Papua New Guinea waters. Research Bulletin #11. Department of Agriculture, Stocks, and Fisheries, Port Moresby. 12 pp.

Longenecker, K. 2008. Relationships Between otolith- and body-size for Hawaiian reef fishes. Pacific Science 62(4):533-539.

Longenecker, K., and R. Langston. 2008. A rapid, low-cost technique for describing the population structure of reef fishes. Hawaii Biological Survey Contribution 2008-002. 34 pp.

Longenecker, K., R. Langston and B. Barrett. 2008a. A compendium of life history information for some exploited Hawaiian reef fishes. Bishop Museum Technical Report 44. 67 pp.

Longenecker, K., A. Allison and H. Bolick. 2008c. A preliminary account of marine fish diversity and exploitation at Kamiali Wildlife Management Area, Papua New Guinea. Bishop Museum Technical Report 46. 116 pp.

Longenecker, K., A. Allison, H. Bolick, S. James, R. Langston, R. Pyle, D. Pence and S. Talbot. 2009. A preliminary assessment of exploited reef-fish populations at Kamiali Wildlife Management Area, Papua New Guinea. Bishop Museum Technical Report 49. 75 pp.

Longenecker, K., R. Langston, H. Bolick and A. Allison. 2010. Population Size Structure and Rapid Reproductive Analysis of Exploited Reef-fish Populations at Kamiali Wildlife Management Area, Papua New Guinea. Bishop Museum Technical Report 52. 101 pp.

Longenecker, K., R. Langston, H. Bolick and U. Kondio. 2011. Reproduction, Catch, and Size Structure of Exploited Reef-Fishes at Kamiali Wildlife Management Area, Papua New Guinea. Bishop Museum Technical Report 57. 169 pp.

Longenecker, K, R Langston, H Bolick & U Kondio. 2012. Size structure and reproductive status of exploited reef-fish populations at Kamiali Wildlife Management Area, Papua New Guinea. Bishop Museum Technical Report 59. 95 pp.

Longenecker, K, R Langston & H Bolick. 2013a. Rapid reproductive analysis and length-dependent relationships of *Lutjanus biguttatus* (Perciformes: Lutjanidae) from Papua New Guinea. Pacific Science 67(2):295-301.

Longenecker, K, R Langston, H Bolick & U Kondio. 2013b. Rapid reproductive analysis and length-weight relation for blacktail snapper, *Lutjanus fulvus* (Actinopterygii: Perciformes: Lutjanidae), from a remote village in Papua New Guinea. Acta Ichthyologica et Piscatoria 43(1):51-55.

Longenecker, K, R Langston, H Bolick & U Kondio. 2013c. Size and reproduction of exploited reef fishes at Kamiali Wildlife Management Area, Papua New Guinea. Bishop Museum Technical Report #62. 94 pp.

Longenecker, K, R Langston, H Bolick & U Kondio. 2014a. Rapid reproductive analysis and length-weight relation for red-bellied fusilier, *Caesio cuning*, and longfin emperor, *Lethrinus erythropterus* (Actinopterygii: Perciformes: Caesiondiae and Lethrinidae) from a remote village in Papua New Guinea. Acta Ichthyologica et Piscatoria 44(1):75-84.

Longenecker, K, G Ben, L Edi, E Gaip, T Jiana, G Kawa, T Keputong, G Muiya, K Nadup, T Nadup, T Nandang, B Naru, S Naru, J Nero, G Rueben, Y Tana, D Tom & M Tusi. 2014b. Coral reef fish management plan for Kamiali Wildlife Management Area, Morobe Province, Papua New Guinea. Pacific Biological Survey Contribution 2014-004. 25 pp.

Loubens, G. 1980. *Biologie de quelques espèces de poisons du lagon néo-calédonien*. II. *Sexualité et reproduction*. Cahiers de l'Indo-pacifique II(1):41-72.

Lyle, J.M. 1987. Observations on the biology of *Carcharhinus cautus* (Whitley), *C. melanopterus* (Quoy & Gaimard) and *C. fitzroyensis* (Whitley) from Northern Australia. Australian Journal of Marine and Freshwater Research 38:701-710.

Mackie, M.C., D.J. Gaughan and Buckworth, R.C. 2003 Stock assessment of narrow-barred Spanish mackerel (*Scomberomorus commerson*) in Western Australia. Final Report FRDC Project No. 1999/151. 242 pp.

Marriott, R.J, B.D. Mapstone and G.A. Begg. 2007. Age-specific demographic parameters, and their implications for management of the red bass, *Lutjanus bohar* (Forsskal 1775): A large, long-lived reef fish. Fisheries Research 83:204-215.

Mishina, H., B. Gonzares, H. Pagaliawan, M. Moteki and H. Kohno. 2006. Reproductive biology of blacktip grouper, Epinephelus fasciatus, in Sulu Sea, Philippines. La Mer 44:23-31.

Montgomery, W.L., and R. Galzin. 1993. Seasonality in gonads, fat deposits and condition of tropical surgeonfishes (Teleostei: Acanthuridae). Marine Biology 115:529-536.
Munro, J.L. and D. McB. Williams. 1985. Assessment and management of coral reef fisheries: biological, environmental and socio-economic aspects. Pp 543-578 *in Proceedings of the Fifth International Coral Reef Congress, Tahiti, 27 May-1 June 1985*. 4. Antenne Museum-EPHE, Moonea, French Polynesia.
Murty, V.S. 2002. Marine ornamental fish resources of Lakshadweep. Central Marine Fisheries Research Institute Special Publication 72. 134 pp.
Myers, R.F. 1999. Micronesian reef fishes: a comprehensive guide to the coral reef fishes of Micronesia. Coral Graphics, Barrigada. 330 pp.
Page, M. 1998. The biology, community structure, growth and artisanal catch of parrotfishes of American Samoa. Department of Marine and Wildlife Resources, American Samoa. 51 pp.
Pakoa, K. 1998. Vital statistics of marine fishes of Vanuatu. Naga 21:27-29.
Polunin, N.V.C. 1984. Do traditional marine "reserves" conserve? A view of Indonesian and New Guinean evidence. Senri Ethnological Studies 17:267-283.
Randall, J.E., G.R. Allen and R.C. Steene. 1990. *Fishes of the Great Barrier Reef and Coral Sea*. University of Hawaii Press, Honolulu. 507 pp.
Rasband, W.S. 2009. ImageJ, National Institutes of Health, Bethesda, MD. http://rsb.info.nih.gov/ij/
Rhodes, K.L., and M.H. Tupper. 2007. Preliminary market-based analysis of the Pohnpei, Micronesia, grouper (Serranidae: Epinephelinae) fishery reveals unsustainable fishing practices. Coral Reefs 26:335-344.
Robbins, W.D. 2006. Abundance, demography and population structure of the grey reef shark (*Carcharhinus amblyrhynchos*) and the white tip reef shark (*Triaenodon obesus*) (Fam. Charcharhinidae). PhD Thesis. James Cook University. 197 pp.
Russell, D.J., and A.J. McDougall. 2008. Reproductive biology of mangrove jack (*Lutjanus argentimaculatus*) in northeastern Queensland, Australia. New Zealand Journal of Marine and Freshwater Research 43(2):219-232.
Ruttan, L.M. 1998. Closing the commons: cooperation for gain or restraint? Human Ecology 26:43-66.
Sabetian, A. 2010. Parrotfish fisheries and population dynamics: a case-study from Solomon Islands. PhD Thesis. James Cook University, Townsville. 227 pp.
Shakeel, H, and H Ahmed. 1996. Exploitation of reef resources: grouper and other food fishes. Pp 117-136 *in* Nickerson, D. J. and Maniku, M.H. (eds). *Report and Proceedings of the Maldives/FAO National Workshop on Integrated Reef Resources Management in the Maldives. Male, 16-20 March, 1996, Madras*. BOBP,Report No. 76. 250 pp.
Sheaves, M. 1995. Large lutjanid and serranid fishes in tropical estuaries: Are they adults or juveniles? Marine Ecology Progress Series. 129:31-40.
Sivadas, M., and A. Anasukoya. 2005. On the fishery and some aspects of the biology of dogtooth tuna, *Gymnosarda unicolor* (Ruppell) from Minicoy, Lakshadweep. Journal of the Marine Biological Association of India 47:111-113.
Sivakami, S., S.G. Raje, M. Feroz Khan, J.K. Shobha, E. Vivekanandan and U. Raj Kumar. 2001 Fishery and biology of Priacanthus hamrur (Forsskal) along the Indian coast. Indian Journal of Fisheries 48:277-289.
Sudekum, A.E., J.D. Parrish, R.L. Radke and S. Ralston. 1991. Life history and ecology of large jacks in undisturbed, shallow oceanic communities. Fishery Bulletin 89:493-513.
Taylor, B.M. and J.H. Choat. 2014. Comparative demography of commercially important parrotfish species from Micronesia. Journal of Fish Biology 84:383-402.
Taylor, B.M., K.L. Rhodes, A. Marshell and J.L. McIlwain. 2014. Age-based demographic and reproductive assessment of orangespine *Naso lituratus* and bluespine *Naso unicornis* unicornfishes. Journal of Fish Biology. 85:901-916.
Thresher, R.E. 1984. *Reproduction in Reef Fishes*. T.F.H. Publications, Inc. Ltd., Neptune City, New Jersey. 399 pp.
Wagner, J. 2002. Commons in transition: an analysis of social and ecological change in a coastal rainforest environment in rural Papua New Guinea. PhD dissertation. McGill University, Montreal. 340 pp.
Were, A.S. 2009. Some aspects of the biology and fishery of groupers (Teleostei: Serranidae) in the inshore waters of South Coast, Kenya. M.Phil. Thesis. Moi University, Eldoret. 69 pp.
Williams, A.J., L.M. Currey, G.A. Begg, C.D. Murchie and A.C. Ballagh. 2008. Population biology of coral trout species in eastern Torres Strait: Implications for fishery management. Continental Shelf Research 28:2129-2142.