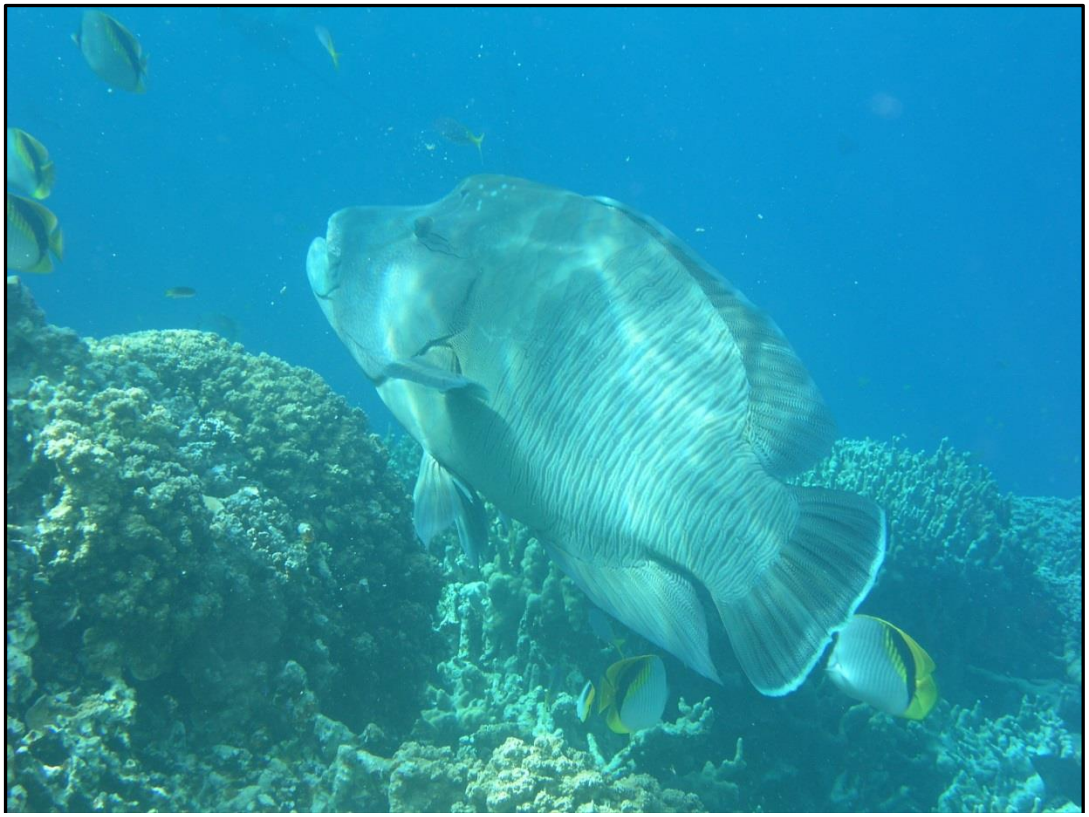

An Assessment of Maml and Kemedukl in Palau and Management Recommendations

A Report to The Nature Conservancy Micronesia Program
Technical Report No. 14-07

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EXECUTIVE SUMMARY

The Bumphead parrotfish (kemedukl) and the Napoleon wrasse (maml) are fish species that both hold high economic and cultural value in Palau. Due to intense fishing pressure, landings for both species dropped dramatically in the late 90s to the early 2000s. As a response to this sharp decline, national legislation was enacted in 2006 that imposed a total ban on the extraction, possession, and sale of the two species. Since this ban, there has been anecdotal evidence from fishermen as well as results from a general study on herbivorous fish that seem to indicate increasing encounters with the species and suggesting population recovery. However, no formal scientific study has been done to specifically assess the status of the stocks of both species.

This report is a summary of the findings of an ecological survey to assess the current status of the two populations and a willingness to pay (WTP) survey of divers to determine the contribution of the species to Palau's tourist dive industry. The report also presents policy and management options that may be implemented in order to ensure the persistence of these important species.

A total of **61,845 (556,605 kg) kemedukl** and **37,071 (151,884 kg) maml** were estimated to exist in the waters within the main Palau archipelago.

The tourist WTP survey revealed that both the **kemedukl and maml are included in the top 10 most popular species that divers come to see** when diving in Palau. The survey also indicated that ecological and management scenarios significantly affected the dive fee that tourists were willing to pay for their dive experience. With the current tourist numbers, the strictest management scenario of a closed fishery with numerous large individuals had an **estimated tourism value of $16.1 million annually**. This value is reduced to **12.6 million annually if both species were uncommon or absent**.

Market landing data from the Bureau of Marine Resources revealed a gradual **increase in price of 5 cents annually before the ban**. The current market price of the species was extrapolated from this trend and used to estimate a **2013 price of $2.02/lbs for kemedukl and $2.07/lbs for maml**. Combining the 2013 prices and the proposed sustainable landings for a scenario of effective management and strict enforcement, the **current annual fishery value for both species was estimated at about $26,000**.

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Cover photo: Picture of Cheilinus undulates at Cemetery Reef. Photo by: Steven Victor

I. INTRODUCTION

Bumphead parrotfish (scientific name: *Bolbometopon muricatum*, Palauan name: kemedukl) and Napoleon wrasse (scientific name: *Cheilinus undulatus*, Palauan name: maml) are two fish species that are ecologically and culturally important in Palau. Both are large in size and considered as charismatic megafauna. Their life history traits such as spawning aggregation and late maturation make them especially vulnerable to fishery. Due to overfishing and habitat degradation globally, kemedukl has been listed as vulnerable and maml has been listed as endangered on the International Union for Conservation of Nature (IUCN) Red List.

Due to intense fishing pressure in Palau, landings for both species dropped dramatically in the late 90s to the early 2000s. This led to a national legislation being enacted in 2006 that imposed a complete ban on the extraction, possession, and sale of the two species.

This document summarizes the findings of an ecological survey to assess the current status of the two populations (refer to Attachment A) and a willingness to pay (WTP) survey of divers to determine the contribution of the species to Palau's tourist dive industry (refer to Attachment B). This report also presents policy and management options that may be implemented in order to ensure the persistence of these important species.

Kemedukl

Kemedukl is known to be the largest of the parrotfish family and can grow up to 1.3 meters (m) in length and live up to forty years. The coloration of juvenile kemedukl is dull gray with scattered white spots, while larger adults are uniformly dark green. Both males and females of this species have similar coloration. Adult kemedukl develop bulbous forehead, which is often light green to pink, and exposed teeth plates that is only partly covered by lips. This slow-growing species is gregarious and usually occur in small aggregations, but can be found in large group sizes along seaward and clear outer lagoon reefs. Kemedukl become sexually mature at around 62 centimeters (cm).

The juvenile kemedukl are found in lagoons, often in seagrass beds, and the adult is found in clear outer lagoons and seaward reefs up to a depth of 30 m. It feeds on benthic algae and live corals. It may ram its head against corals to facilitate feeding. Each adult fish ingests over five tons of structural reef carbonates per year, contributing significantly to the bioerosion of reefs. The fish sleeps in caves and shipwrecks at night, usually in large groups.

Maml

Adult maml are generally found on reef slopes, along channels, and lagoonal reefs in waters ranging from 1 to100 m deep. They are opportunistic predators, feeding mainly on crustaceans, mollusks, fish, and echinoderms. Juvenile maml tend to favor living hidden in areas of dense branching corals, bushy macroalgae, or seagrasses, while larger individuals and adults are often found in more open habitat along reef edges and channels. The species is most often observed in solitary male-female pairs, or in small schools.

Maml are known to reach a maximum length of more than 2 meters and up to 190 kg in weight. Individuals become sexually mature at four to six years (40 – 60 cm), and are known to live for around 45- 50 years. Maml are protogynous hermaphrodites, with some members of the population becoming male at about 9 years old. The factors that control when sex change occurs are not yet known. Adults move to the down-current end of the reef and form local spawning aggregations at certain times of the year.

II. FINDINGS

Stock Assessment (See Attachment A)

The assessment estimated that there is a total of **61,845 (556,605 kg/1.23 million lbs)** kemedukl and **37,071 (151,884 kg/334,847 lbs)** maml exist in the main Palau archipelago.

According to historical market data collected from 1990 to 2006, the average landing numbers were **8,547 kg (18,843 lbs)** for kemedukl and **1,731 kg (3,816 lbs)** for maml. These numbers represent 1.5% and 1.1% of the current population respectively. Note that even with these low catch statistics, the stock declined to the point where intervention (fishery closure) was necessary. These landing data however to not take into account fish that were sold directly to restaurants and subsistence use (household and customary functions).

Because the species have patchy distributions and often occur in low numbers, there are large statistical variations associated with these estimates. These variations should be considered if proposing catch limits. If the fishery were to be opened, the conservative sustainable annual landings proposed are **487 (4,922 kg/10,851 lbs)** for kemedukl and **129 (1,222 kg/2,694 lbs)** for maml.

Willingness to Pay Survey (Attachment B)

The main goal of this survey was to determine how much people were willing to pay under different fishery management scenarios that resulted in certain fish sizes and densities for maml and kemedukl. The interviews provided three scenarios to the divers that could be linked to differing fishery management options (no fishing, low fishing, and high fishing), and the amount that they were willing to pay for each management scenario.

The survey showed that the kemedukl and maml ranked high in the top 10 marine organisms that divers were interested in. More popular species include manta rays, turtles, sharks and dolphins.

More than half of divers visiting Palau were from Japan, Taiwan and the United States.

There was a significant correlation with the level of management and the fee that tourist divers were willing to pay. Divers were willing to pay **$11.8** more for healthier kemedukl and maml populations, including **$36** more for the complete closure scenario compared to poorly managing the these resources.

Assuming that Palau receives approximately 119,000 visitors, 95,000 (80%) of which are divers, using the dive fees under each ecological scenario, the following potential revenue is calculated:

$12,984,060 for **scenario 1** – No maml or kemedukl present

$12,642,999 for **scenario 2** – Poorly managed resources (small and few fish)

$14,622,862 for **scenario 3** – Effectively managed resources (large schools of fish)

$16,056,457 for **scenario 4** – Closed Fishery (very large fish, large schools)

This is more than **three million dollars** difference between closure scenario and poor managed scenario and about **two million dollars** difference between effectively managed scenario and poor managed scenario.

Assuming that the market value for these fishes has consistently grown (historical annual increase = $.05), it is estimated that the price would be **$2.02/lbs** for kemedukl and **$2.07/lbs** for maml in **2013**. The conservative sustainable landings proposed for kemedukl and maml are **487 (10,851 lbs)** and 129 **(2,694 lbs)**, respectively (**Scenario 3**). The total market value then will be **approximately $22,000** for kemedukl and **$5,577** for maml.

In the case of **Scenario 2**, it's estimated that given the maximum allowable catch with fishing effort of 0.1 which is roughly three times higher landings than Palau's previous historical landing for kemedukl. In this case, the allowable landing will be **4,669 (92,632.96 lbs)** for kemedukl and **1,234 (10,883.88 lbs)** for maml. This will be equivalent to **$187,119** and **$22,530** total market value respectively. **Scenario 4** is a closed fishery therefore the market value would be **$0** for both species.

III. MANAGEMENT OPTIONS

There are a number of options that can be employed to manage the fishery for both species of fish. They range from opening the fishery with little management to continuing the moratorium.

It is imperative that **regular long-term monitoring** of the species be conducted to allow up-to-date information on the status of the populations of these species. A stock assessment study should be done at least every 1 – 3 years so that resource managers have an accurate knowledge of the populations. Such knowledge will allow for better management of the fishery.

Each management option presents differing restrictions, enforceability and potential implications for long-term sustainable management of these resources. They are explained below:

1. Open Fishery

Restrictions – The fishery will be similar to pre-moratorium conditions, no restrictions on the number of fish harvested.

Enforceability – No enforcement needed.

Possible Implications – Unregulated harvest of the species combined with the high commercial demand of these fish will likely result in rapid decline of the populations. In the seven years since the moratorium was enacted, there is good evidence that the fishery is recovering from overexploitation. This option is clearly unsustainable and should not be allowed.

2. Establishing Catch Limits/ Sustainable Catch Quota

Restrictions - The stock assessment report recommended using a fishing mortality rate of 0.01, which translates to capping the maximum number of maml to 129 individuals (1,222 kg), and 487 (4,922 kg) kemedukl to be harvested per year.

Enforceability – Commercial sale may be tracked through sales records (fish markets), however it will be very difficult to track and/or enforce private sales and harvest.

Possible Implications – The high demand of the fish will result in the maximum sustainable yield limit being reached in a short time. Private sale of the species will be difficult to track and possible overfishing may result.

3. Establishing Size Limits

Restrictions – Kemedukl are sexually mature at around 62 cm (24.41 in), while maml sexually mature between 40 – 60 cm (15.75 – 23.62 in). It is common knowledge that the larger the fish, the more eggs it produces. Possible restrictions on minimum/maximum sizes for harvest and/or commercial sale can be established.

Enforceability – Sizes of fish sold may be tracked at the fish markets, however it will be very difficult to track and/or enforce private sales or harvest activities.

Possible Implications – Prior to the 2006 moratorium, there were restrictions on the minimum size of maml and kemedukl that could be harvested. Limiting harvest based solely on size limits was obviously not an effective regulatory tool to manage the resources. The high demand of the fish may result in the maximum sustainable yield limit being exceeded. Private sale of the species will be difficult to track and possible overfishing may result.

4. Establishing Marine Protected Areas

Restrictions – Majority of the existing marine protected areas (MPAs) have been established with the goal of conserving multiple species. Protected areas for fish species are mainly for grouper aggregation sites that include Ngerumekaol and Ebiil Channels. Establishment of MPAs to protect maml and kemedukl will require large areas in order to protect the entire habitat for each species. For example, kemedukl need at least 10 square kilometers of area to feed, live and reproduce. Five existing MPAs are large enough to meet this area requirement. They include Ngerukewid Islands Wildlife Preserve, Ngemelis Conservation Area, Ngarchelong-Kayangel Reef Channels and Ebiil Conservation Area. Additional MPAs to be established to protect these two species will need to include large marine habitats to accommodate the needed areas in which they live.

The Protected Areas Network (PAN) is currently working on a protected area design strategy for Palau, however the areas are chosen based on multiple environmental and ecological factors, and not individual fish species.

Enforceability – Established MPAs can be well enforced, however funding is necessary to ensure there is sufficient staff and equipment to enable effective management.

Possible Implications – Establishment of MPAs to protect maml and kemedukl will require large areas. These areas could be existing fishing grounds for fishermen that fish for other species of fish. Closure of these areas could potentially be met with resistance by fishermen. Additionally, the high commercial demand for these fish could lead to overfishing in areas not within the MPAs.

5. Seasonal Closure

Restrictions – Similar to the existing regulations on harvest of rabbitfish and turtles in Palau, a seasonal closure of the fishery can be established to regulate the amount of harvest. Additional research needs to be done to determine the most appropriate closure period.

Enforceability – Enforcement of the seasonal closure will be similar to the existing regulations for turtles and rabbitfish. No fishing for, or possession of these species is allowed during the closure period.

Possible Implications – This option could result in overfishing of these species during the open season. The high commercial demand for these fish will be a major driver for large numbers of individuals to be harvested. Unregulated harvesting during the open season will most likely lead to the depletion of these species.

6. Subsistence and Customary Use Only (Non-Commercial Use)

Restrictions – The harvesting of maml and kemedukl is only allowed to meet subsistence and customary needs. These two fish species are important in Palauan culture and therefore allowed for private consumption and predetermined customary events/functions.

Enforceability – Enforcement of this option includes prohibition of commercial sale of these species. Maml and kemedukl cannot be bought or sold.

Possible Implications – This option could result in overfishing of these species if too many fish are harvested. In addition to regular monitoring of the fish stocks, this option can include voluntary reporting of the number of fish taken for customary use. This will allow resource managers to gauge the demand for these fish for customary events. Such knowledge can be use to adjust the regulations to allow the fishery to be sustainable. Voluntary reporting could also be attempted for fish caught for personal consumption. Some sort of program can be designed to encourage fishermen to participate in this reporting program.

7. Continued Moratorium

Restrictions – The moratorium is left in place until the populations recover to a stable level. On average, kemedukl grow approximately 10 cm per year. Given this, the kemedukl that were juvenile prior to the moratorium have grown into reproductively mature fish. An additional 3 to 5 years of closure will provide an opportunity for mature fish to reproduce and increase the population. Once this occurs, some sort of regulated harvest will be permitted which could include one or more of the options offered in this report.

Because of the existing low numbers of Maml, an additional option would be to continue to prohibit the harvest of this fish for a longer time period.

Enforceability – Fishing for, possession or consumption of maml or kemedukl is prohibited.

Possible Implications – Extending the moratorium would mean that potential resource users would have to continue to find alternative food fish.

8. Aquaculture

Restrictions – This is not a stand-alone management option. It is a supplemental activity to assist in the recovery of the fishery. Restrictions associated with aquaculture may include any of the options mentioned above. Culturing the species could be done either to re-stock the wild populations or for consumption.

Enforceability – Existing regulations for aquaculture activities can be revisited to ensure compatibility with culturing of maml and kemedukl. Regulations and/or mechanisms should be in place to prevent wild stocks from being harvested and sold as cultured animals.

Possible Implications – There has been a successful attempt to culture kemedukl through the collection of eggs at spawning aggregations and rearing the larvae/juvenile fish. It is unknown how mature kemedukl can be raised in high numbers to maintain a successful business. The culture of maml has not been done in Palau. The high cost of operations for aquaculture ventures could make such businesses impractical. More research is needed to determine if such endeavors are feasible.

IV. RECOMMENDATIONS

PICRC has reviewed the possible management options, including the following facts:

a. The populations of maml and kemedukl is increasing **but is still recovering** from being previously overfished;
b. maml and kemedukl serve a s**ignificant role** as a food fish for **subsistence and customary** events;
c. **live** maml and kemedukl serve a **significant role** in the **dive tourism industry** of Palau; and
d. there is a **demand** for maml and kemedukl in the **restaurant industry**.

PICRC recommends the following management options for consideration:

1. Continued Moratorium

We recommend that the moratorium be extended while **continued biological monitoring** is done to **assess the recovery** of the fishery. The information we've gathered both scientifically and from the community suggest that the population of maml and kemedukl is increasing. The stock assessment shows that the populations of these fish are still in recovery and will continue to increase if fishing mortality rates (harvest pressure) remain low or non-existent. As stated earlier, kemedukl grow approximately 10 cm per year. The 7 years of closure has allowed the fish to grow and start reproducing. An **additional 3 to 5 years of closure for kemedukl** will provide an opportunity for the now mature fish to reproduce multiple times. The existing population of maml is still very low. Maml also take approximately 6 years to sexually mature. Therefore **a longer closure period for maml will be necessary**. Prohibiting any extraction of these fish will allow the populations to recover much quicker. Once the **populations have recovered and are stable**, an **effectively-managed fishery could be implemented** to allow for **sustainable** harvest of these fish.

2. Subsistence and Customary Use Only (Non-Commercial Use) – Kemedukl Only

Because these fish play a significant role in the lives of the Palauan people, the harvest of kemedukl could be allowed **to meet subsistence and customary needs** of the people. However, **restrictions or management actions** should be implemented to gauge the amount of fish being taken. **Size limit restrictions** should accompany this option. The appropriate size restriction will still have to be determined. **Mandatory or voluntary reporting** of the numbers of fish harvested for customary activities is a possible way to get an idea of how many fish are being harvested. A voluntary program with incentives could be initiated to encourage fishermen to report their catch.

To prevent possible abuse of this opportunity, a **list of accepted customary events/functions** could be prepared. The Ministry of Arts and Culture should be consulted on the preparation of such a list.

Because the existing population of maml in Palau is still very low, the **harvesting of maml should not be allowed**. Once the population of maml is sufficient enough to allow for limited harvest, a managed fishery could be implemented.

Ongoing monitoring of the populations of maml and kemedukl is **critical** to determine if the amount of fish harvested for subsistence and customary use is and remains sustainable.

Appendix A
Stock Assessment

Analysis of Catch Quota for Kemedukl and Maml in Palauan Water

Analysis of Catch Quota for Kemedukl and Maml in Palauan Water

Aug 24, 2013

Project: Stock Assessment for Humphead Wrasse and Bumphead Parrotfish

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Executive Summary:

Catch limits for kemedukl and maml in Palauan water were calculated based on underwater visual census data collected during May 2013 and basic life history parameters collected from publications using yield per recruit simulation model created by Sadovy et al. (2007). Optimum fishing mortality for maximum sustainable yield was calculated to be 0.2 for Maml and 0.4 for kemedukl. However, we suggest using a much lower fishing mortality (0.01-0.1) for calculating the catch limit for the following reasons:

- The model assumes the population is stable. However, Palau's stock is still recovering from previous overfishing, and therefore not stable in its size structure or its population size.
- The model assumes that the population is one large population under homogenous mixing. However, both kemedukl and maml population are highly likely to be divided into metapopulations in Palau.
- The model assumes that the fecundity for a female is the same throughout its life. However, larger females are known to produce more and higher surviving larvae. Therefore, the model does not consider the additive effect from loss of larger fecund females.
- The model assumes that mortality is solely driven by fishing effort (natural mortality is fixed). Although fishing does contribute to much of the mortality, it is not wise to exclude the change in other mortality pressures such as increased natural predation and competition.
- Both kemedukl and maml have patchy distributions and thus the estimations of population size have large confidence intervals. It is wise to keep the fishing intensity low when there is a high level of uncertainty in stock size.

Additionally, both kemedukl and maml have high value for other economical and sociological activities such as ecotourism and subsistence fishing. Considering the impact of fishery to these non-fishery activities, we propose to keep the catch limit low.

With the fishing mortality rate of **0.1**, the catch limit is calculated to be **4,669** individuals for kemedukl and **1,234** for maml. However this is about three times greater than the average annual catch of the previous fishery (average annual landing for kemedukl was 1667 and 433 for maml). Knowing that the previous fishery collapsed with a third of the proposed catch limit, we suggest using a lower fishing mortality rate such as **0.01**.

A fishing mortality rate of 0.01 will generate a catch limit of **487** for kemedukl and **129** for maml. This is about a quarter of the previous annual landing. By keeping this lower fishing mortality, it will also allow the recovery process of the stock to continue. With this kind of small allowable catch, we suggest opening the fishery to selective use such as for artisanal or customary take.

Analysis Method:

Using the underwater visual census data collected during May 2013, preliminary catch limit has been calculated based on the stock's size structure and population size. Optimum fishing mortality was simulated using a user interface developed by Sadovy et al. 2007. The catch limit was calculated based on the modified equation 19 of Sadovy et al. 2007, where the catch is calculated based on the estimated number for each size bin, fishing mortality, and natural mortality.

$$C = \sum_{l} \frac{S_l F}{M + S_l F} * N_l * (1 - e^{-(M + S_l F)}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

C = Estimated catch based on the specified fishing mortality
F = User defined fishing mortality
S_l = Gear selectivity for each size class l
M = Natural mortality
l = Size class

Assumptions made for using the Sadovy et al. 2007 surplus production model:

- For stock assessment model parameters, we used Sadovy (2007) parameter for humphead wrasse (maml) and FishBase (2013) and Kobayashi et al. (2011) for bumphead parrotfish (kemedukl).
- We assumed that all reefs are pristine and are not at risk from pollution or destruction
- We assumed that all reef areas (backreef, forereef, fringing reef, and lagoon patch reef) will be fished under the same fishing intensity thus we used uniform fishing intensity.
- We assumed that fishermen only caught fish larger than 55 cm (the gear selectivity of fishing was 1.0 after the size of 55 cm).
- Due to the lack of fecundity data, recruitment parameter based on gonad weight for bumphead parrotfish was assumed to be the same as humphead wrasse.
- The model assumes the fish stock is one large population.

Current Population Size Estimation:

Current population estimate was calculated by multiplying median fish density within each habitat strata by the total area size of the corresponding habitat. Median density was used instead of the mean density due to the large counts of zeros (which was caused by the fish's schooling behavior and patch distributions).

A total of **61,845** (556,605 kg) kemedukl and **37,071** (151,884 kg) maml were estimated to exist in the waters of Palau. Note that due to the nature of these species (e.g., low density and patchy distributions), both species have large variations in the estimation of population size. This should be considered when proposing catch limits.

Table 1. Density, area size, and estimate population size for each habitat strata. Numbers in parentheses are standard deviations.

Habitat Type	No. of transects	Area size (ha)	Kemedukl no. /ha	Maml no./ha	Est. Kemedukl Number	Est. Maml Number
Fringing reef	16	308	0.75 (2.80)	1.05 (1.82)	232 (0-1,093)	323 (0-884)
Backreef	8	608	0.85 (1.10)*	0.89 (0.78)	518* (0-669)	543 68-1,017)
Forereef	40	14,102	1.23 (7.70)	0.97 (1.53)	17,382 (0-125,971)	13,698 (0-35,311)
Patch reef	26	28,399	1.56 (2.68)	0.79 (1.59)	44,231 (0-120,379)	22,508 (0-67,729)
Total	90	43,417	--	--	**61,845** (0-248,112)	**37,071** (43 – 104,941)

*We used 75% quartile of the population density for Kemedukl in Backreef since median density was 0

Previous Market Data:

Market data for kemedukl and maml were provided by Palau Department of Marine Resources. Preliminary examination of these data show high landings for kemedukl (40,000 lbs [18,000 kg] in 1995) until the late 1990s, after which time catch dropped sharply. Landings for maml were at low levels until the late 1990s, when they increased sharply and then declined very rapidly within a few years (Figure 1).

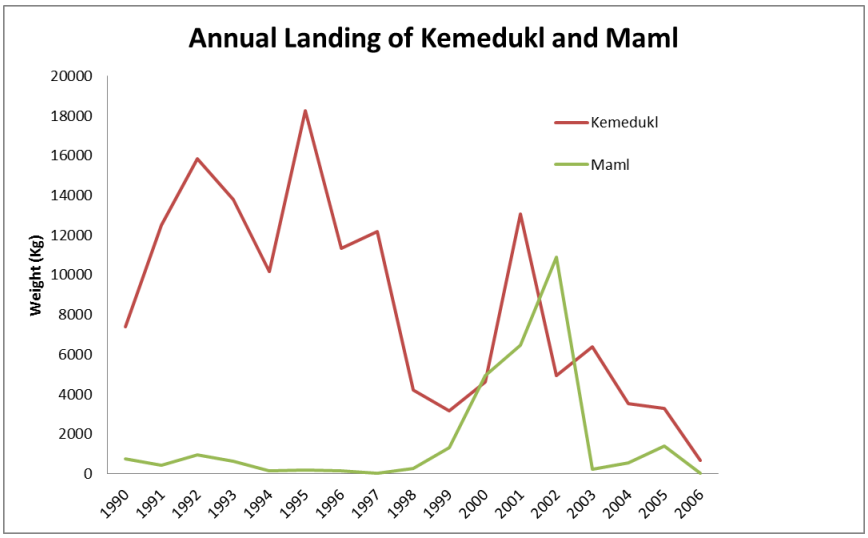

Figure 1. Market data of kemedukl and maml in Palau from 1990 to 2006.

We calculated estimates of the number of landings using an average weight for each species (Table 2 and Table 3). Average number of landing over the years was 8,547 kg for kemedukl and 1,731 kg for maml. This is 1.5% and 1.1% of the current population respectively. It is important to remember that even with this low number of catch, the stock was depleted to the point of fishery closure.

Table 2. The average weight of each species based on the mean standard length in FishBase. SL=Standard Length, TL = Total Length.

	Kemedukl	Maml
Weight (kg)	9	4
Length (cm)	70 SL (82 TL)	47 SL (60 TL)

Table 3. The number and biomass of landings calculated between 1990 and 2006.

Year	Kemedukl_Number	Kemedukl_Weight (kg)	Maml_Number	Maml_Weight (kg)
1990	823	7,404.44	193	772.01
1991	1,387	12,482.85	107	427.28
1992	1,760	15,837.16	239	955.72
1993	1,531	13,780.12	159	634.58
1994	1,128	10,155.92	34	137.44
1995	2,028	18,249.82	43	173.27
1996	1,260	11,336.17	42	166.01
1997	1,352	12,165.80	8	32.21
1998	468	4,210.24	67	269.43
1999	351	3,159.72	325	1,299.09
2000	512	4,603.96	1,234	4,935.53
2001	1,450	13,047.12	1,619	6,476.84
2002	549	4,942.79	2,721	10,883.49
2003	711	6,400.18	55	218.18
2004	393	3,533.03	143	572.89
2005	367	3,298.97	354	1,416.57
2006	77	689.01	12	49.44
Average	**1,667**	**8,546.90**	**433**	**1,730.59**

Catch limit estimation:

Humphead Wrasse (Maml)

Based on the simulation model of Sadovy et al. (2007), optimum fishing mortality was estimated to be **0.2** when calculated for maximum sustainable numbers (F_{MSY}) (Figure 2); **0.4** if calculated for maximum sustainable biomass (F_{MSY}) (Figure 3); and **0.4** if calculated for 20% of virgin spawning biomass (F_{20}) (Figure 4).

Although the model suggests fishing mortality to be between 0.2 and 0.4, we recommend using lower fishing mortality rate since the Maml population in Palau is still recovering from the stock depletion from previous fishery. Other reasons why we should be conservative with catch limits are: 1) the presence of large variation in population size estimates due to scarcity and patchy distributions; 2) the model assumes the fish stock is

one large population whereas the stock may be partitioned into subpopulations; 3) previous fishery's annual average catch was 433 [1,731kg] (which is equivalent to fishery mortality rate of 0.035).

Since our objective is not to maximize the fishery profit but to ensure sustainable level of the population, we recommend using a fishing mortality rate of **0.01**. Additionally, the natural mortality rate in the model was estimated to be 0.1 based on Australian humphead wrasse populations. Since Palau is closer to the equator, and lower latitudes are known to have higher natural mortality rate, we estimated the catch limit using a natural mortality rate of 0.3. Based on equation 1, corresponding catch limits for various fishing mortality were calculated (Table 4). Using a fishing mortality rate of 0.01 and a natural mortality estimate of 0.3, we recommend the maml catch be capped at **129** (0.3% of the estimated total population). This number can be converted into biomass of 1,222 kg, which is slightly lower than the average landing from previous years.

Table 4. Sustainable catch quota in weight (kg) for maml calculated for specified fishing mortality and natural mortality. Numbers in parenthesis are standard deviations of the estimate.

Fishing mortality (F_{MSY})	Catch Quota in kg	Catch Quota in no.
0.01	**1,222 (0-8262)**	**129 (0-775)**
0.1	11,717 (0-79192)	1,234 (0-7429)
0.2	22,374 (0-151224)	2,356 (0-14186)

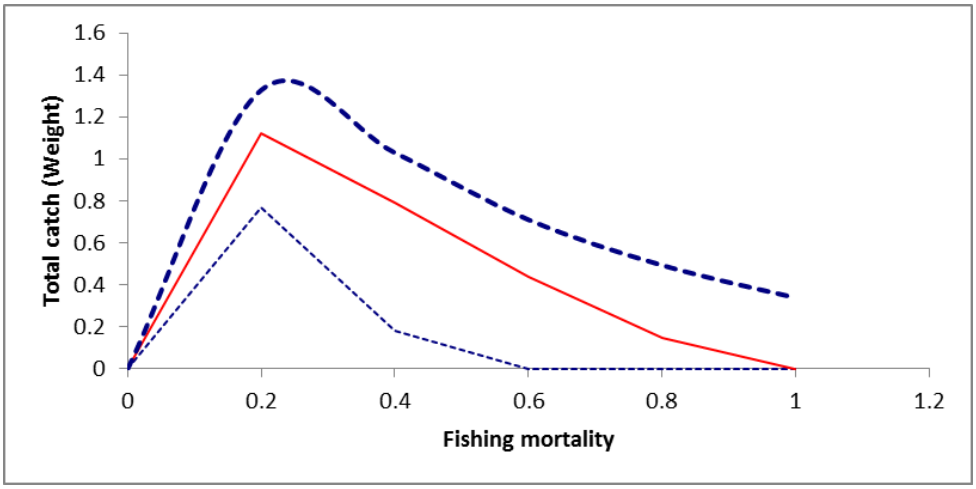

Figure 2. Catch in weight (kg) for humphead wrasse.

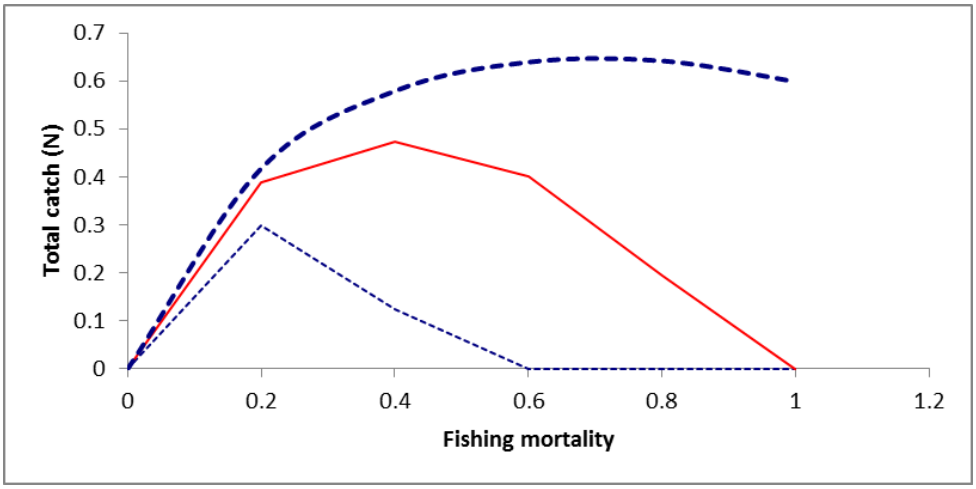

Figure 3. Catch in numbers for humphead wrasse.

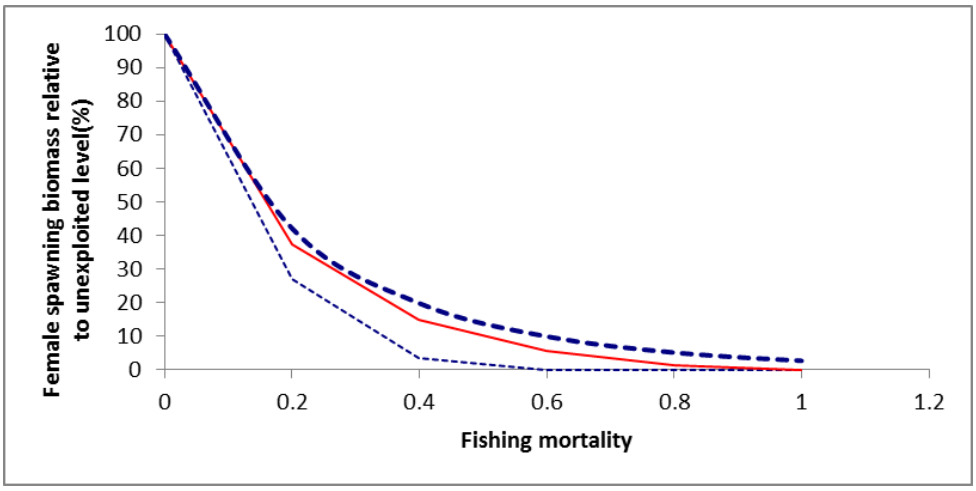

Figure 4. Spawning Stock Biomass relative to unexploited level (%) (Female)

Bumphead Parrotfish (Kemedukl)

Currently, reproductive parameters for bumphead parrotfish are not available, thus we used humphead wrasse's reproductive output parameters (e.g. steepness and gonad weight) to simulate optimum fishing mortality. Additionally, length to weight conversion parameters are not available for this species, therefore we used the parameters for *Chlorurus microrhinos*, which is similar in body shape.

Based on the simulation model of Sadovy et al. (2007), optimum fishing mortality was calculated to be **0.4** when calculated for maximum sustainable numbers (F_{MSY}) (Figure 5); **0.5** if we calculate by maximum sustainable biomass (F_{MSY}) (Figure 6); and **0.4** if we calculate for 20% of the virgin spawning biomass (F_{20}) (Figure 7).

Although the model suggests fishing mortality between 0.4 and 0.5, we recommend using lower fishing mortality rates since the Kemedukl population in Palau is still recovering from the stock depletion from the previous fishery. Another good reason to keep the fishing mortality low is because the previous fishery's annual average catch was around 1,667, which is equivalent to a fishery mortality rate of 0.035.

Since our objective is not to maximize the fishery profit but to ensure sustainable level of the population, we recommend using a fishing mortality rate of **0.01**. Additionally, the natural mortality rate in the model was estimated to be 0.1 based on Australian humphead wrasse populations. Since Palau is closer to the equator, and lower latitudes are known to have higher natural mortality rates, we estimated the catch limit using natural mortality rate of 0.3. Based on equation 1, corresponding catch limits for various fishing mortality rate were calculated (Table 5). Using a fishing mortality of 0.01 and natural mortality of 0.3, we recommend the catch be capped at **487** individuals (0.8% of the estimated total population). This number can be converted into a biomass of 4,922 kg, which is lower than all the previous catches except 2006 (the year before the closure).

Table 5. Sustainable catch quota for kemedukl calculated for specified fishing mortality and natural mortality. Numbers in parenthesis are standard deviations of the estimate.

Fishing mortality (F_{MSY})	Catch Quota in kg	Catch Quota in no.
0.01	4,922 (0-25,906)	**487 (0-2,203)**
0.1	47,179 (0-248,317)	4,669 (0-21,116)
0.2	90,093 (0-474,182)	8,916 (0-40,322)

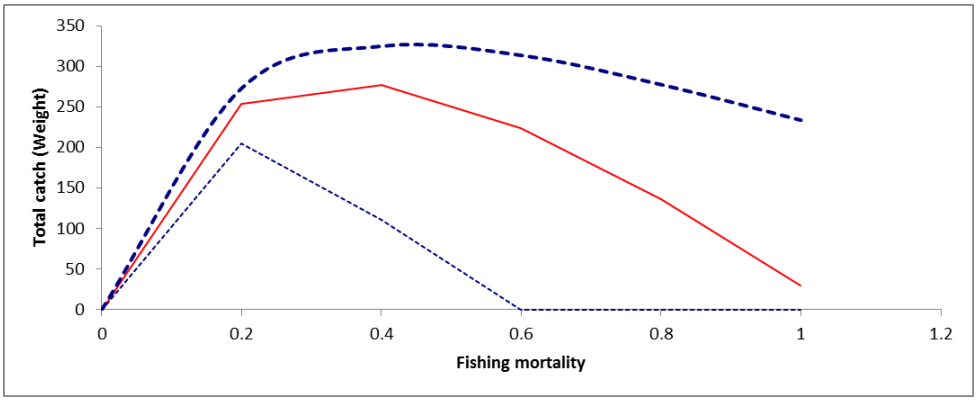

Figure 5. Catch in weight (Total) for bumphead parrotfish.

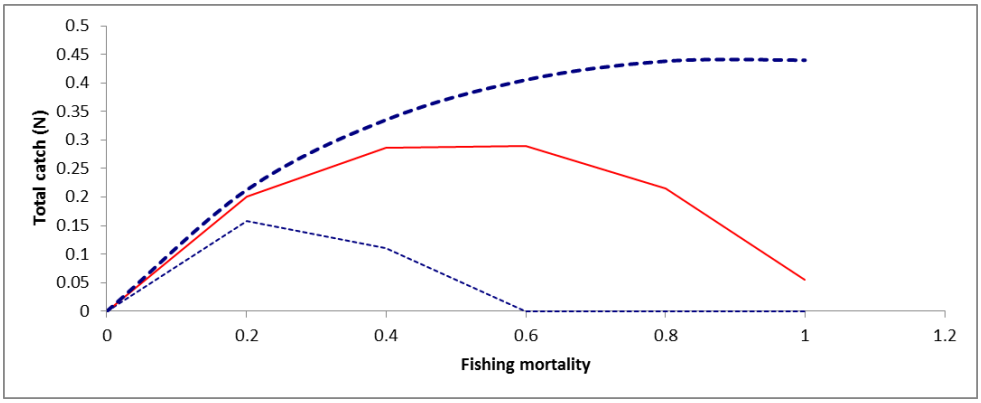

Figure 6. Catch in numbers (Total) for bumphead parrotfish.

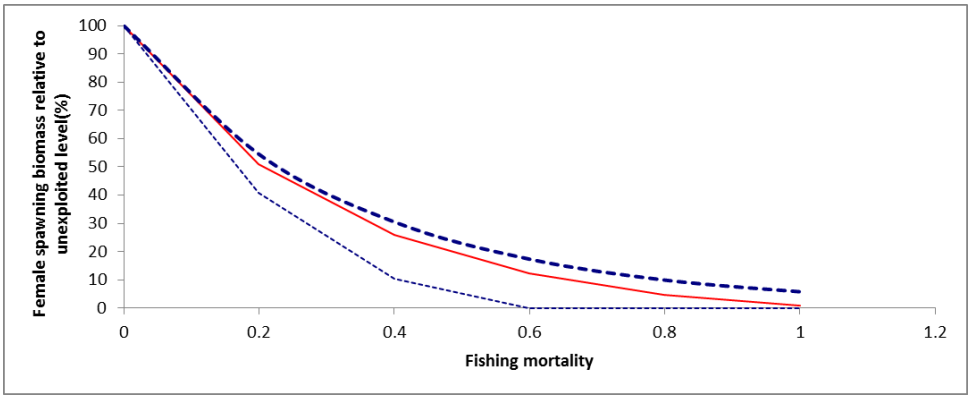

Figure 7. Number of female spawners relative to unexploited level (%) for each fishing moratality

References:

Kobayashi, D., A. Friedlander, G. Churchill, R. Nichols, and Brian Zgliczynski (2011). *Bumphead Parrotfish (Bolbometopon muricatum) Status Review*. NOAA Technical Memorandum NMFS-PIFSC-26. NOAA

Sadovy, Y., A.E. Punt, W. Cheung, M. Vasconcellos, S. Suharti, and B. D. Mapstone (2007). *Stock assessment approach for the Napoleon fish, Cheilinus undulatus, in Indonesia. A tool for quota-setting for poor-data fisheries under CITES Appendix II Non-Detriment Finding requirements*. FAO

Appendix A1:

The following tables show the detailed catch limit calculation for each size bin at fishing mortality rate (F)=0.01, and natural mortality rate (M)=0.3.

Maml

Size Bin (cm)	Selectivity	Mean Density (#/ha)	SD	Estimated StockSize	Calculated Catch Limit	Individual Biomass_g	Total Biomass_kg
25	0	0.11	0.35	4,605.63	0.00	288.93	0.00
30	0	0.25	0.79	11,017.87	0.00	495.55	0.00
35	0	0.11	0.34	4,838.35	0.00	781.95	0.00
40	0	0.20	0.54	8,541.08	0.00	1,160.85	0.00
45	0	0.15	0.37	6,442.26	0.00	1,644.90	0.00
50	0	0.13	0.33	5,609.65	0.00	2,246.65	0.00
55	1	0.07	0.24	3,207.04	27.58	2,978.62	82.14
60	1	0.03	0.15	1,383.59	11.90	3,853.29	45.84
65	1	0.04	0.15	1,554.30	13.36	4,883.07	65.26
70	1	0.03	0.15	1,205.79	10.37	6,080.34	63.04
75	1	0.01	0.06	273.99	2.36	7,457.42	17.57
80	1	0.04	0.19	1,527.06	13.13	9,026.63	118.52
85	1	0.02	0.10	672.09	5.78	10,800.23	62.41
90	1	0.04	0.21	1,867.00	16.05	12,790.46	205.33
100	1	0.05	0.20	2,072.91	17.82	17,469.58	311.38
105	1	0.01	0.10	442.86	3.81	20,182.81	76.85
110	1	0.01	0.08	380.90	3.28	23,161.33	75.86
120	1	0.01	0.08	380.90	3.28	29,962.62	98.13
Total					**128.72**		**1,222.33**

Kemedukl (at fishing mortality rate (F)=0.01, and natural mortality rate (M)=0.3)

Size Bin (cm)	Selectivity	Mean Density (#/ha)	SD	Estimated StockSize	Calculated Catch Limit	Individual Biomass_g	Total Biomass_kg
15	0	0.01	0.13	587.30	0.00	50.51	0.00
20	0	0.03	0.18	1,173.34	0.00	121.46	0.00
25	0	0.02	0.16	1,041.32	0.00	239.88	0.00
30	0	0.05	0.28	2,019.19	0.00	418.31	0.00
35	0	0.05	0.21	2,167.29	0.00	669.40	0.00
40	0	0.14	0.56	6,147.42	0.00	1,005.91	0.00
45	0	0.10	0.38	4,249.40	0.00	1,440.70	0.00
50	0	0.14	0.42	5,923.55	0.00	1,986.71	0.00
55	1	0.15	0.41	6,680.80	57.44	2,656.94	152.63
60	1	0.17	0.41	7,381.42	63.47	3,464.47	219.89
65	1	0.05	0.21	2,111.52	18.16	4,422.43	80.29
70	1	0.12	0.29	5,192.03	44.64	5,544.02	247.51
75	1	0.06	0.22	2,429.41	20.89	6,842.46	142.93
80	1	0.12	0.33	5,141.40	44.21	8,331.06	368.30
85	1	0.06	0.23	2,767.31	23.79	10,023.13	238.50
90	1	0.19	0.43	8,464.03	72.78	11,932.05	868.39
95	1	0.04	0.17	1,540.68	13.25	14,071.25	186.41
100	1	0.16	0.58	6,831.45	58.74	16,454.16	966.52
105	1	0.12	0.98	5,358.14	46.07	19,094.27	879.71
110	1	0.05	0.20	2,073.80	17.83	22,005.10	392.38
120	1	0.01	0.07	314.54	2.70	28,693.16	77.60
125	1	0.01	0.08	361.21	3.11	32,497.59	100.93
Total					**487.08**		**4,921.99**

Appendix B

Willingness to Pay Survey

Final Report on Diver's Perception Survey for Palau's Kemedukl and Maml

Final Report on Diver's Perception Survey for Palau's Kemedukl and Maml
Jan 2, 2014
Project: Stock Assessment for Humphead Wrasse and Bumphead Parrotfish

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EXECUTIVE SUMMARY:

We estimated market value for the fishery and dive tourism for kemedukl (bumphead parrotfish) and maml (Napoleon fish) in Palau. Market value was estimated for four ecological and management scenarios: 1) the two species do not exist; 2) the fishery is poorly managed, thus fish are few and small in size 3) the fishery is strictly managed, thus there are moderate numbers of medium-sized fishes; 4) the fishery is closed and there are numerous large-sized individuals.

- The most popular species that people come to see when diving in Palau were manta ray, turtle, shark, dolphin, napoleon fish, and bumphead parrotfish, respectively
- More than half of the divers were from Japan (25.1%), Taiwan (23.2%), and United States (17.8%).
- More than 2/3rd of the divers visited Palau for the first time, and more than half were part of a tour group.
- Ecological and management scenarios significantly affected the dive fee people were willing to pay for their diving experiences. In general, people were willing to pay $11.8 more for healthier ecological scenario, or $36 more for closure compared to poorly managed scenario.
- There was no significant difference between the fees people were willing to pay for poorly managed fisheries and absence of the two species.
- The average dive fee people were willing to pay ranged between $136.7 to $169.0 (USD) depending on the fish size and density. Therefore, total dive tourism market value was $12,984,060 for scenario 1, $12,642,999 for scenario 2, $14,622,862 for scenario 3, and $16,056,457 for scenario 4.
- Kemedukl and maml showed a gradual increase in price (annual increase of 5 cents for both species) while the fishery was open. Although landing pattern differs greatly between the two species, when comparing their market values, both showed similar price and has not shown significant differences for the last five years of the fishery.
- Based on the fishing effort provided by Friedlander and Koike 2013, the total fishery market value was $21,919 for kemedukl and $5,577 for maml under ecological scenario 3 (strictly regulated management). For ecological scenario 2 (poorly regulated management), the total market value was $210,104 and $53,471 for kemedukl and maml, respectively. The higher market value is due to greater landings caused by the lack of regulation.
- Palau's maml and kemedukl populations are still in recovery state since the closure in 2006. Therefore, we estimate current Palau to be close to scenario 3.
- The gain/loss of dive tourism is two to three orders of magnitude greater than the fishery market gain/loss when changing any ecological scenarios.

INTRODUCTION:

Marine organisms have multiple values depending on the person who perceives them (CBD 2006). A fisherman may see fish as his essential "crop", whereas a dive operator might see them as a nice addition to their tour business but not essential. Some fish might not have any market value but have high cultural value. It is also important to think from ecological perspective and see what ecological role each marine organism is playing. Some organisms could be important for the ecosystem to function, but people may see no values in them. When considering holistic fishery management, it is important to take into account all of these values including fishery and non-fishery values of a marine organism.

Bumphead parrotfish (scientific name: *Bolbometopon muricatum,* Palauan name: kemedukl) and Napoleon wrasse (scientific name: *Cheilinus undulatus,* Palauan name: maml) have been two species of fish that are ecologically and culturally important in Palau. Both are large in size and considered as charismatic megafauna. Kemedukl is known to be the largest of the parrotfish family and can grow up to 1.3 meters in length and live up to forty years. Maml is known to reach a maximum length of more than 2m and up to 190kg in weight and also live over 30 years. Their life history traits such as spawning aggregation and late maturation make them especially vulnerable to fishery. Due to overfishing and habitat degradation, kemedukl has been listed as vulnerable and maml has been listed as endangered under the IUCN red list. Kemedukl plays an important ecological role as the "excavator" of the reef, where they remove limestone and dead corals from the reef as they feed on algae and live corals which free up new colonizing sites.

In order to estimate the values of kemedukl and maml in tourism industry in Palau, we conducted willingness to pay surveys of visiting tourist divers in Palau. To compare the dive tourism market values with fishery market values, we also estimated fishery market values using historical market price projection and allowable catch numbers suggested by Friedlander and Koike 2013.

METHOD:

Willingness to Pay Survey Analysis

Diver willingness-to-pay (WTP) survey was developed to assess the market values of kemedukl and maml to the dive tourism in Palau. The surveys were designed to ask the following questions: 1) what are the top five preferred marine organisms they expect to see; 2) how much are divers willing to pay for certain fish sizes and densities of kemedukl and maml; 3) what are the general tourist demographics (gender, country, tour group, age, income range, previous dive experiences, number of prior visits to Palau); and 4) what are the tourist perspective on conservation (scored from 1 to 5).

Table 1. Ecological case scenarios presented to the tourist divers. Case scenario 1 was presented as a control for the rest of the scenarios.

Scenario	Fisheries management	Kemedukl/Maml present	Max fish size (m)	Density (number per school)
1	-	No	-	-
2	Poor Management	Yes	0.2-0.5	1-5
3	Effective Management	Yes	0.5-1	10-20
4	No Fishing	Yes	>2	50-100

Staffs from the Palau International Coral Research Center (PICRC) interviewed visiting tourist divers and snorkelers between 11-30 November, 2013 at either the local dive shops or at the Rock Islands in Palau's southern lagoon during lunch time between dives. Total of 13 dive operators participated in this study (Table 2).

Once the survey data were collected and entered, they were analyzed to assess the most popular species, tourist demographics, and divers' willingness to pay under different management scenarios.

Table 2. List of participating dive shops

No.	Tour Operator	Phone
1	Fish N' Fins	488-2637
2	Neco Marine	488-1755
3	Sam's Tours	488-7267
4	Aqua Magic Palau	488-1119
5	Cruise Control	488-6691
6	Day Dream	488-3551
7	Divers Palau	488-6767
8	Maml Divers	488-8029
9	Pacific Divers Oasis	488-4192
10	Carp Island Resort	488-2277
11	Peleliu Divers	345-5555
12	Blue Marlin	488-2214
13	Splash (PPR)	488-2600

Fishery Market Value Analysis for the Two Species

Previous fishery market data between 1990 and 2006 was examined for both kemedukl and maml, and included date, weight, and market price at the time. We projected the market price for 2013, and multiplied these values by the suggested total allowable landings (Friedlander and Koike 2013) in order to estimate the fishery market value of the two species under each management scenario.

ANALYSIS RESULTS:

Willingness to Pay Survey Analysis

Interviews to assess tourist diver's willingness to pay for Palau's kemedukl and maml under certain ecological condition were conducted between 11-30 November, 2013 by PICRC. A total of 324 divers were interviewed during this time period.

Marine organisms of interest:

The most popular species that people came to see in Palau were manta ray, turtle, shark, dolphin, and napoleon fish, respectively (Table 3). It is worthy to note that both maml and kemedukl ranked high among divers as preferred species (5th and 6th).

Table 3. Ranking and summed number of votes casted by tourist divers for marine organisms they want to see.

Ranking	Species	Counts	Percentage
1	Manta Ray	239	14.9%
2	Turtle	228	14.2%
3	Shark	193	12.1%
4	Dolphin	177	11.1%
5	**Napoleon Fish**	175	10.9%
6	**Bumphead Parrotfish**	124	7.7%
7	Small Fish	94	5.9%
8	Coral	81	5.1%
9	Tuna	54	3.4%
10	Barracuda	52	3.2%
11	Ship Wrecks	49	3.1%
12	Grouper	27	1.7%
13	Snapper	14	0.9%
14	Others	18	1.1%
	(blank)	76	4.7%

Tourist demographics:

More than half of the divers were from Japan, Taiwan, and United States (Table 4). More than half of the divers visited Palau for the first time (68%) and was also part of a tour group (54%).

Table 4. Number and percentage of tourist divers visiting from each country.

Country	Number	Percentage
Japan	79	25.1%
Taiwan	73	23.2%
USA	56	17.8%
China	25	7.9%
Germany	15	4.8%
Australia	12	3.8%
Palau	11	3.5%
Switzerland	6	1.9%

Czech Republic	4	1.3%
South Korea	4	1.3%
Yap	4	1.3%
Austria	3	0.9%
France	3	0.9%
Italy	3	0.9%
Netherlands	3	0.9%
Spain	3	0.9%
Canada	2	0.6%
New Zealand	2	0.6%
Slovakia	2	0.6%
Colombia	1	0.3%
Finland	1	0.3%
Guam	1	0.3%
Philippines	1	0.3%
Trinidad & Tobago	1	0.3%
Total	315	100%

Tourist diver's willingness to pay:

The main goal of this survey was to determine how much people were willing to pay under different fishery management scenarios that resulted in certain fish sizes and densities for maml and kemedukl. The interviews provided three scenarios to the divers that could be linked to differing fishery management options (no fishing, low fishing, and high fishing), and the amount that they were willing to pay for each management scenario. Since there was few number of snorkeler surveys (34 surveys), only scuba diver survey was analyzed for this report.

Management scenario was significantly correlated with the fee that tourist divers were willing to pay. People were willing to pay $11.8 more for every healthier ecological case scenario, or $36 more for closure compared to poorly managed scenario (Figure 1 & Table 5).

Table 5. Mean dive price tourists are willing to pay for each case scenario.

Scenario	Average Dive Fee (USD)	Annual Total Dive Fee (USD)
1 (control)	136.7	12,984,060
2 (poor management)	133.1	12,642,999
3 (effective management)	153.9	14,622,862
4 (closed fishery)	169.0	16,056,457

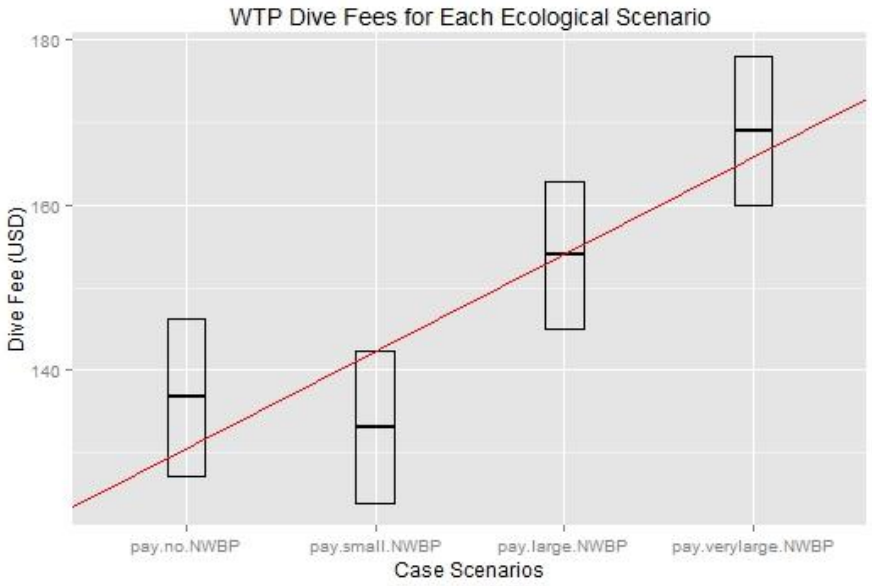

Figure 1. Diver's willingness to pay (WTP) for the four different ecological scenarios (pay.no.NWBP = scenario 1, pay.small,NWBP = scenario 2, pay.large.NWBP = scenario 3, pay.verylarge.NWBP = scenario 4). The box indicates 95% confidence interval. The red line indicates the WTP model for Palau (dive fee (USD) = 118.71+11.78*case scenario number).

According to the Palau Visitor's Authority (PVA), 118,754 people visited Palau in 2012 and that 80% of the visitor came to Palau to go diving. Since we have no other additional information, we assume that Palau will receive the same number of tourists for the year of 2013. Therefore, we expect an annual number of 95,003 tourist divers visiting Palau. When we multiply these tourist diver numbers with mean dive fees under each ecological scenario, we get $12,984,060 for scenario 1, $12,642,999 for scenario 2, $14,622,862 for scenario 3, and $16,056,457 for scenario 4. This is more than three million dollars difference between closure scenario and poor managed scenario (24% more) and about two million dollars difference between effectively managed scenario and poor managed scenario (13% more). It is also interesting to note that there was no significant difference between the fees people were willing to pay for condition of poorly managed fishery and absence of the two species, but there are significant difference in willingness to pay between well managed scenarios (scenario 3 and 4) and poorly managed scenarios (scenario 1 and 2).

Fishery Market Value Analysis for the Two Species

Market data for kemedukl and maml were provided by the Palau Department of Marine Resources. Kemedukl had relatively high landings (40,000 lbs) in 1995 until the late 1990s, after which time catch dropped sharply. Landings for maml were at low levels until the late 1990s, when they increased sharply and then declined very rapidly within a few years (figure 2).

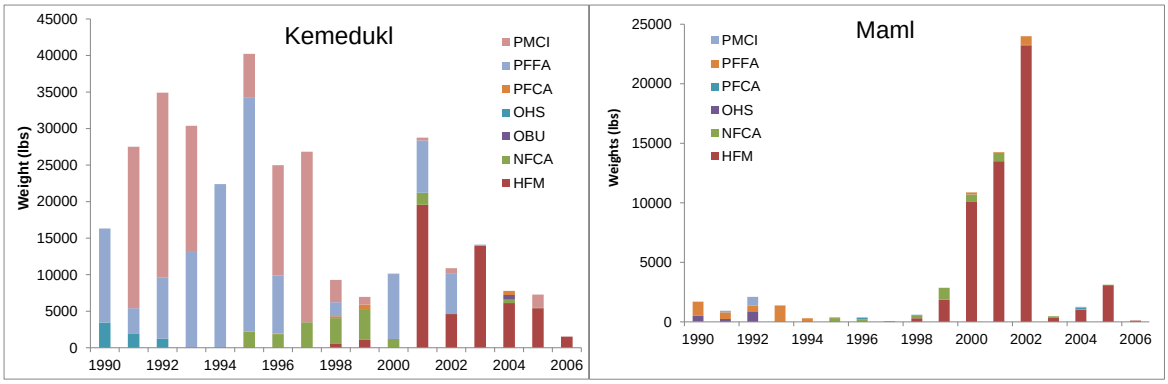

Figure 2. Market data of *kemedukl* and *maml* in Palau from 1990 to 2006.

From the early 1990s to the close of the fisheries in 2006, the two fish species showed gradual increases in price (annual increase of 5 cents for both species). When comparing their overall market value, maml has priced significantly higher than kemedukl (figure 3).

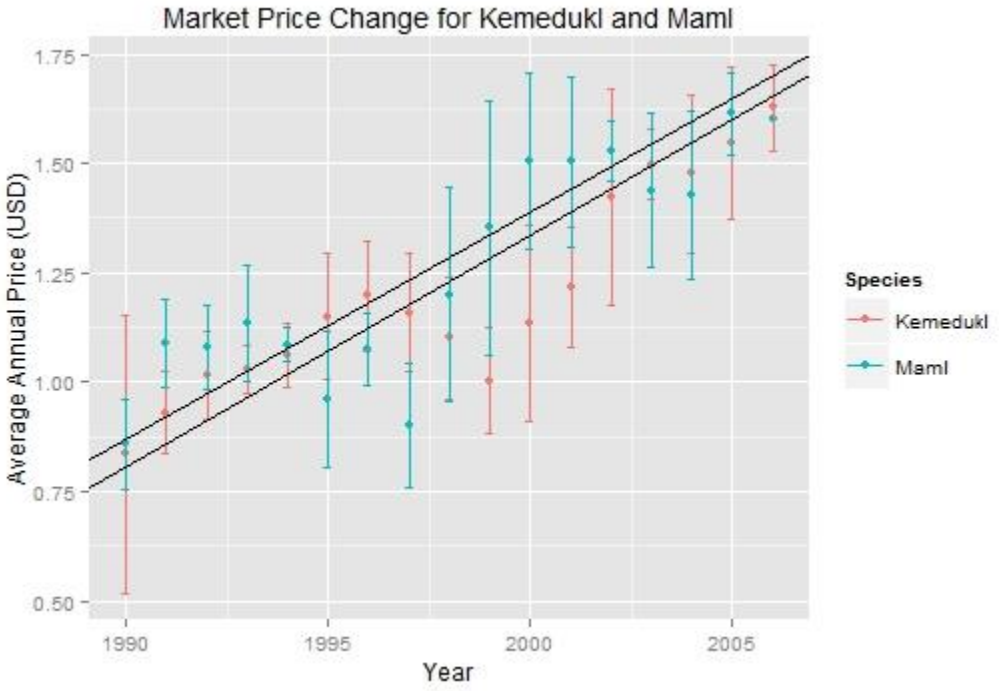

Figure 3. Historical annual mean market price of kemedukl and maml between 1990 and 2006. The error bars show standard deviation from the mean price. Black line is the price trend for the two species.

If the market value for these fishes has consistently grown, we estimate the fish's price to be $2.02/lbs for kemedukl and $2.07/lbs for maml in 2013. The conservative sustainable landings proposed for kemedukl and maml are 487 (10,851 lbs) and 129 (2,694 lbs), respectively (Friedlander and Koike 2013). We expect this would be equivalent to the scenario 3 used in WTP survey. If we multiply this with each market price, the total market value will be $21,919.02 for kemedukl and $5,576.58 for maml. For scenario 2, we estimate the maximum allowable catch with fishing effort of 0.1 which gives about three times higher landings than Palau's previous historical landing for kemedukl. In this case, the allowable landing will be 4,669 (104,011.89 lbs) for kemedukl and 1,234 (25,831.56 lbs) for maml. The low number of landing weight for maml is likely due to the average weight used for calculation (market landed fish are usually skewed toward large size of the

population). This will be equivalent to $210,104.02 and $53,471.33 total market value respectively. As for scenario 4, the fishery is closed thus the value would be $0 for both species.

Comparison of the Two Market Values

For each case scenario, we have estimated both fishery and tourism market values (Table 6).

Table 6. Comparison of estimated market values between fishery and dive tourism for each species.

Case Scenario	Estimated Dive Tourism Market Value	Estimated Fishery Market Value (Both Spp)	Estimated Fishery Market Value (Kemedukl)	Estimated Fishery Market Value (Maml)
1 (control)	12,984,060	--	--	--
2 (poor management)	12,642,999	263,575	210,104	53,471
3 (effective management)	**14,622,862**	**27,496**	21,919	5,577
4 (closed fishery)	**16,056,457**	0.00	0.00	0.00

Currently, Palau's fishery for kemedukl and maml is closed to recover the two species stock size from previous overfishing. The density from the stock assessment survey showed high density of both species compared to most areas in the world (kemedukl density in Palau is 0.75 ha^{-1} to 1.56 ha^{-1} depending on the habitat and 0.79 ha^{-1} to 1.05 ha^{-1} for maml). However this is still much lower compared to pristine environment where densities of up to 20 maml per hectare have been recorded (Zgliczynski et al. 2013 and Gillet 2010). From these reference values, we can say that Palau's maml and kemedukl population is still in recovery and thus the current state for these species in Palau is close to 3. If the fishery is reopened with tight restriction allowing the population to continue recovering (scenario 3), we could expect the dive tourism to generate $14,622,862 (USD) and fishery market creating $27,496 (USD) annually. However, if the fishing effort cannot be well regulated and stocks become overfished, we could expect scenario 2, where dive tourism brings in $12,642,999 and the fishery market brings in $263.575 (USD) annually. Increase in annual market price of $236,079, due to more landing initially, seems to be a significant increase in fishery market, but when compared with the loss of $1,979,863 per year in dive tourism, the loss is quite considerable. Additionally, we suspect that the harvest level in scenario 2 is not sustainable, thus these gains will be short lived. In the end, the decrease in the stock size in the succeeding years will decrease the market income from the fishery in scenario 2. Furthermore, this will suffer the dive industry even greater. If the fishery remains closed, we could expect the dive tourism to bring in $16,506,457. Here again, we see that the gain in dive tourism from scenario 3 to 4 ($1,433,695) is much greater than the loss in fishery market closure ($27,496). One thing to note is that this comparison is solely based on the market values of the fish and no other market costs/gains such as environmental impact costs, hotel cost/gain, restaurant cost/gain, and fishery operators' salary cost/gain is not included.

From a pure monetary stand point, scenario 4 with a closed fishery shows the most increase in market gains. However, maml and kemedukl have strong cultural and subsistence importance to Palauan. Another point to make is, the amount of allowable catch in scenario 3 is too low for a viable commercial fishery, thus we feel allowing subsistence fishery solely would be the most practical option. This, however, could become a challenge on enforcement since there is no formal catch reporting system for subsistence fishery yet. Given the difficulty in accurately accounting the number of fish harvested, regular monitoring of maml and kemedukl populations should be mandatory.

Reference:

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Gillett, R. (2010). Monitoring and management of the humphead wrasse, *Cheilinus undulates*. FAO Fisheries and Aquaculture Circular No. 1048.

Zgliczynski, B. J., I. D. Williams, R. E. Schroeder, M. O. Nadon, B. L. Richards, S. A. Sandin (2013). The IUCN red list of threatened species: an assessment of coral reef fishes in the US Pacific Islands. *Coral Reefs* 32, Issue 3, pp 637-650.

Appendix B1

Willingness to Pay Survey for

Napoleon wrasse (*Maml*) and Bumphead parrotfish (*Kemedukl)*

Introduction

Napoleon wrasse (Maml) and Bumphead parrotfish (Kemedukl) are two species of fishes that are ecologically and culturally important in Palau. They are also one of the largest species of fish you will see in Palau waters. There has been a decline in the number of these fishes due to heavy fishing. In order to restore the population and to develop a sustainable management plan, the Government of Palau closed the fishery in 2006.

The Palau International Coral Reef Center (PICRC) and the University of Hawaii is currently conducting a valuation survey of Napoleon wrasse (Maml) and Bumphead parrotfish (Kemedukl) as part of ongoing research efforts. We would appreciate it if you could answer the following questions to improve our understanding for better future management of these important species.

Napoleon wrasse (Maml)

Bumphead Parrotfish (Kemedukl)

For more information, please visit our site: http://www.picrc.org/

Section 1: Diving and Snorkeling Questions

Question 1:

Please circle the top 5 animals/objects that you would like to see today.

Shark	**Turtle**	**Manta ray**
Napoleon wrasse	**Bumphead parrotfish**	**Grouper**
Snapper	**Tuna**	**Barracuda**
Small colorful reef fish	**Dolphin**	**Ship or other wrecks**
Coral	**Other:_____**	

Section 2: Willingness to Pay Questions

Question 2:

In Palau have you been DIVING or SNORKELING?
(please circle one, or just diving if you've done both)

How much did you pay for one dive or snorkel trip here in Palau (excluding the cost of renting dive gear, just diving cost if you did both)?

_____US$

With this in mind, please answer the following questions.

Question 3:

Would you pay the following prices to dive or snorkel in an environment where you will likely see large species such as shark, turtles, manta, and groupers but no Napoleon wrasse or bumphead parrotfish:

Please circle Yes or No for each price:

- **$30LESS than what you paid today (Yes, No)**
- **The same price you paid today (Yes, No)**
- **$30 MORE than what you paid today (Yes, No)**
- **$60 MORE than what you paid today (Yes, No)**
- **$90 MORE than what you paid today (Yes, No)**
- **$120 MORE than what you paid today (Yes, No)**

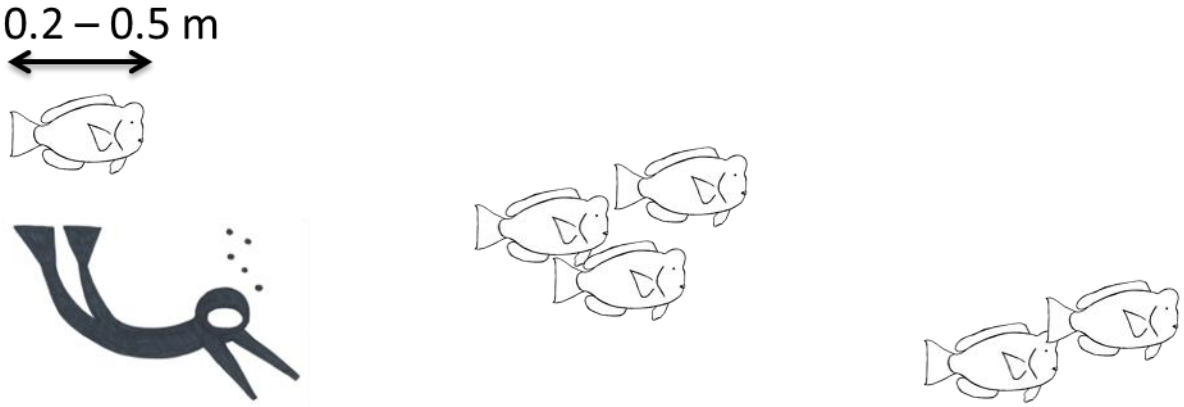
***Question4*:**

Would you pay the following prices to dive in an environment where you will likely see only few, small-sized Napoleon wrasse and bumphead parrotfish? You will also still see other large animals.

This can occur in an over fished environment, where the fishery has little or no restriction. Fish are small (20-50cm) since they are often caught before they fully grow up. Fish school size will also be small (1 -5 fish per school) since reproductive success is lower.

Please circle Yes or No for each price:

- **$30 LESS than what you paid today (Yes, No)**
- **The same price you paid today (Yes, No)**
- **$30 MORE than what you paid today (Yes, No)**
- **$60 MORE than what you paid today (Yes, No)**
- **$90 MORE than what you paid today (Yes, No)**
- **$120 MORE than what you paid today (Yes, No)**



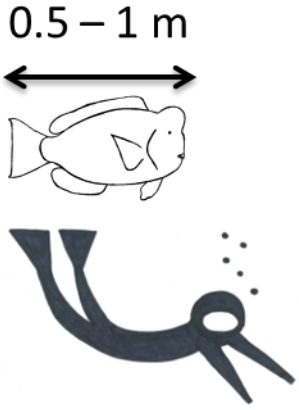
Question 5:

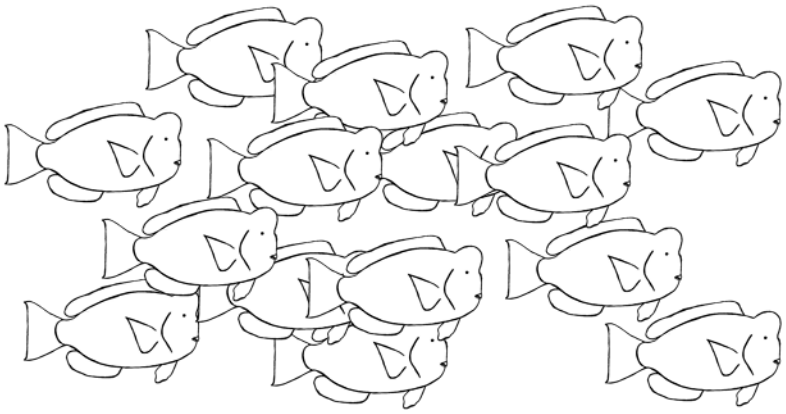
Would you pay the following prices to dive in an environment where you will likely see large Napoleon wrasse and bumphead parrotfish in schools of 10? You will also still see other large animals

You will often see this in a fished environment under effective management. Fish maintain their healthy size (50cm to 1m) with relatively large schools (number of fish in a school would range around 10-20). Fish live to have multiple chances to reproduce, although older and larger females that produce many more offspring are still rare.

Please circle Yes or No for each price:

- **$30 LESS than what you paid today (Yes, No)**
- **The same price you paid today (Yes, No)**
- **$30 MORE than what you paid today (Yes, No)**
- **$60 MORE than what you paid today (Yes, No)**
- **$90 MORE than what you paid today (Yes, No)**
- **$120 MORE than what you paid today (Yes, No)**





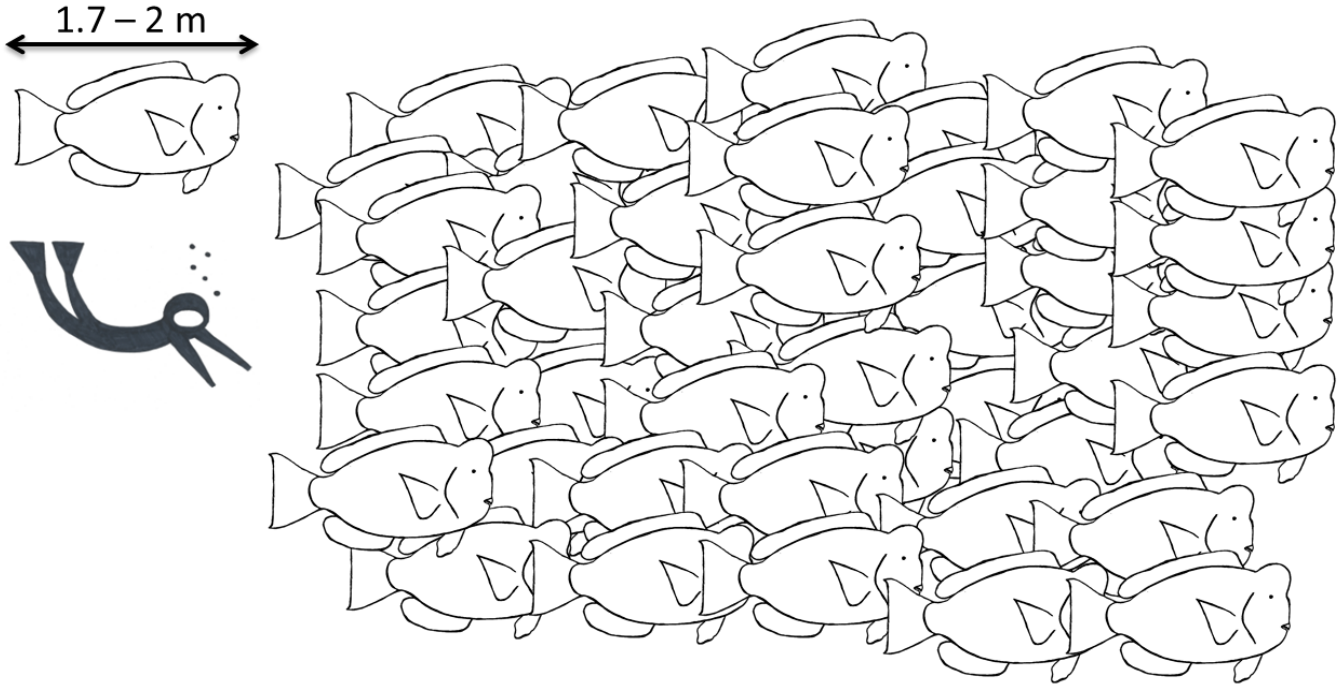
Question 6:

Would you pay the following prices to dive in an environment, where you will likely see very large Napoleon wrasse and bumphead parrotfish in a school of 50s – 100s? You will also still see other large animals.

This would be more likely to occur if fishing for these species is prohibited. These fish can live to their maximum age and can become large in size (>2.0m). Large females produce many more eggs than smaller ones, which in turn lead to a larger number of fish (number of fish per school can be up to 100s).

Please circle Yes or No for each price:

- **$30 LESS than what you paid today (Yes, No)**
- **The same price you paid today (Yes, No)**
- **$30 MORE than what you paid today (Yes, No)**
- **$60 MORE than what you paid today (Yes, No)**
- **$90 MORE than what you paid today (Yes, No)**
- **$120 MORE than what you paid today (Yes, No)**



Section 3: Demographic Information

Question 7:

a. What is your gender? (Male , Female) *{please circle one}*

b. Where is your primary residence? ( )

c. Are you on a group tour? (Yes, No) *{please circle one}*

d. What is your age range? *{please circle one}*

(18 – 25) (26 – 34) (35 – 44) (45 – 60)(61 – 75)(76+)

e. What is your annual, pre-tax household income range in US$ *{please circle one}*

(35,000 or less) (36,000 – 70,000) (71,000 – 105,000) (106,000 - 140,000) (141,000 – 175,000) (176,000 – 210,000) (210,000 or more)

f. How many dives have you completed? (Total # of lifetime dives)

(Less than 10) (11-50) (51-100) (100 or more) *{please circle one}*

g. Is this your first time in Palau? (Yes, No) *{please circle one}*

Question 8:

To what extent do you agree with the following statements related to fishing and protection of marine species? Please select a number from One (1) to (5) (1 being strongly **disagree** and 5 being strongly **agree**) that indicates how much you identify, or agree with, each of the following statements.

Environmental Perception	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Fishing should be regulated to ensure sustainability even if that means I won't be able to eat as much of that fish.	1	2	3	4	5
I do not mind paying extra diving fees to help conservation efforts that will increase the size/number of fish.	1	2	3	4	5
Heavy fishing pressure can cause problems for the health of the coral reefs.	1	2	3	4	5

Thank you for your cooperation!