# Summary of the 2015 fishery creel and market survey in Palau

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## Background:

In May 2015, BMR staff with assistance of Dr. Steve Lindfield (previously working at the Palau International Coral Reef Center) initiated a creel and market survey with Palau's most popular fish market, the JR5 central market (previously known as Happy Fish Market). This survey provided information on the fishery, the species caught, the size of reef fish and quantity of fish landed. The survey built upon a previous training conducted by the Secretariat of the Pacific Community in September 2014. This survey started on the 11th May 2015 but its continuation was postponed after the 14th August 2015, so here we report on data collected over this 3-month period. A summary of the results and recommendations for continuing and improving the surveys are presented.

## Methods:

This market survey utilized new technology, stereo-video, for recording the species composition and lengths of reef fish. The use of a compact 3D camera for filming at the fish market was first trialed in 2014 by Steven Lindfield and Jeremy Prince. Since then the use of stereo-video systems has also been used to monitor fishing catches for the Northern Reef Fisheries Management Project in Palau. It has proven to be an efficient way to collect data on the species and sizes of fish landed with minimal interference to fishers at the landing site.

*Location:*
The JR5 fish market (previously known as Happy Fish Market) is located in Koror state on the waterfront behind the shell gas station on the causeway to Malakal. It is the only fish market regularly selling reef fish in Palau. There are other markets that sell small pelagic fish such as tuna or small markets that are only open intermittently. JR5 supplies fresh fish to restaurants and local buyers and is the easiest location for monitoring fishing catches of reef fish. It also sells pelagic fish occasionally including some frozen fish (such as marlin and mahi mahi) sourced from longline vessels. Other catches of fish are sold directly to hotels and restaurants but it is unknown what volume of fish is sold outside this market.

*Equipment:*
Fujifilm 3D-W3 camera is currently the best compact stereo-camera that can effectively be used to film fish landings. The camera lenses are separated 7.5 cm apart, allowing measurements to approx. 2 m distance. These compact 3D cameras (Fig. 1) can take stills or video in stereo, which can be uploaded into a computer and split into left and right images. These images are then able to be analysed using EventMeasure-Stereo software (www.seagis.com.au).


**Figure 1.** The Fujifilm 3D-W3 camera used to record fish landings
*Survey protocol:*

To gather data on each fish landing survey, a short survey questionnaire and datasheet are to be filled in (also known as a creel survey). This creel survey method has been adjusted from a previous survey protocol and training provided by the Secretariat of the Pacific Community (SPC) in September 2014. It was found that the interview datasheet was too long and fishers were not willing to participate (but they did mostly comply) after a long day or night of fishing. So this was survey form was shorted and only the minimum necessary information included. See Appendix I for a copy of this new survey form. These survey forms are used to record basic information on the location, length of trip, weather etc. It also allows the calculation of catch-per-unit-effort (CPUE) for each fishing method by dividing the total catch in weight by the time spent actually fishing and by the number of people fishing.

The fish market survey requires at least one surveyor to be present at the market when fish are landed, either by boat or delivered by truck. The unloading of fish from the boat or truck typically transfers fish from an icebox/cooler to a plastic baskets used at the market. This transfer of fish provides a time where each fish can be filmed using the stereo-video camera without interrupting the normal flow of market operation (see Figure 1). This way the fish do not need to be touched and can be completed in several minutes or less depending on the volume. However, the downside is that not all fish will land in the basket in a way that allows measurements and large fish will need to be measured separately if they do not land flat in the basket.

When surveying the market, preferably two people are present, which allows one person to focus on the filming of the catch and the other can interview the skipper and fill in the survey form.

For details on the camera settings and step-by-step instructions for the use of this camera system and the survey protocol, please refer to a separate document Monitoring fish landings in Palau with a stereo-video camera - standard operating procedures (or email Steve Lindfield for a copy).

**Figure 2:** Video frames of a typical data collection where the fish are unloaded from the boat into a basket to be weighed.

*Frequency and timing of surveys:*

For this trial period of surveys, it was planned to survey the market four (4) days every fortnight, with one of those days on the new and full moons. The choice of full and new moons is a period where some species may be caught when aggregating for spawning. The main objective of the project is to sample at least 40 landings of the two main methods, 20 from night spear fishing and 20 from line fishing each quarter for four quarters. This level of survey effort was recommended by a prior report from the training by SPC in September 2014 (see Moore et al 2015 for details[1]).

Surveys start at 5:30 am, as although the market officially opens at 6am, sometimes fish are landed before then so it is important that surveyors are available before the first boat unloads its catch. Typically surveyors need to be present until 9 am, which is when the bulk of the landings occur from the previous nights fishing. However the market normally knows which fishers are

[1] Moore, B., Rechelluul, P., Victor, S., Secretariat of the Pacific Community, 2015. Creel survey and demographic assessments of coastal finfish fisheries of southern Palau, September 2014.

expected to show up and can communicate that to the surveyors if there are no other boats expected. As not many fishers land fish during the middle of the day, it is not time efficient to have people at the market all day waiting for a landings. But in the afternoons between 4pm and 7pm is the time when the majority of the daytime catch will come in, so it is good to have surveys present at this time. But unfortunately for this survey, afternoon data collection did not happen as regularly as the morning surveys.

## Results:

*Creel and market survey:*

During the 3-month period in Summer 2015 (11th May – 14th August), 54 fishing trips were surveyed at JR5 on 21 different days. Four different fishing methods were used to catch fish for the market – the main method was spearfishing at night (41 surveys - 76%), followed by gillnet (6 surveys - 11%) line fishing (5 surveys - 9%) and daytime spearfishing (1 survey - 2%).

Table 1: Summary of catch data collected for each fishing method

| Fishing method | Spear - night | Handline | Net | Spear - day |
|---|---|---|---|---|
| Number of landings | 41 | 5 | 6 | 1 |
| Total weight (lbs) of fish sold | 11319 | 844 | 642 | 113 |
| Maximum catch (lbs) per trip | 646 | 459 | 206 | 113 |
| Average catch (lbs) per trip | 276 ± 25 | 169 ± 80 | 107 ± 28 | - |
| Mean time spent fishing (hrs) | 6.5 ± 0.2 | 7.2 ± 1 | 4.6 ± 0.6 | 5.1 ± 0.3 |
| Mean no. of fishers per trip | 2.9 ± 0.2 | 3.6 ± 1.6 | 1.7 ± 0.3 | 3.0 ± 0.8 |
| Average CPUE by weight (lbs) | 15 ± 1.3 | 6.5 ± 1.8 | 16 ± 4.7 | - |
| Average CPUE by weight (kg) | 7 ± 0.6 | 2.9 ± 0.8 | 7 ± 2.2 | - |

Twenty-five different skippers landed fish at the markets, of which the number of people fishing on each trip was on average 3 people. The average length of each fishing trip was 12 hrs for which the time spent engaged in fishing activities averaged 6 hours.

In total, the surveyed landings represented 12 918 lbs (5860 kg) of fish bought by the market. On average this was 240 lbs (109 kg) of fish per trip. The highest catches were from night-spearfishing (average of 276 lbs) compared to line-fishing (169 lbs on average) and gillnet fishing (107 lbs).

There was an additional 647 lbs of fish caught but not landed at the market – either they were rejected by the market, kept for personal consumption, sold or used elsewhere such as customs. This represented 5% of the total catch surveyed.

Invertebrates catches were also recorded on 6 fishing trips, of which the majority (104 lbs) were lobsters and 50 lbs of giant clam. This represented an additional 154 lbs of fish (1% of total catch surveyed).

The average catch-per-unit-effort (CPUE) was 15 lbs (7kg) per fisher per hour. This was similar for net fishers (16 lbs / 7 kg) and spearfishermen (15 lbs / 7kg) and higher than line fishers (6.5lbs / 3 kg).

The majority of fishing trips (42 trips - 80%) caught fish in Koror state, but there was also fishing done in Aimeliik state (5 trips), Airai (2 trips), Kayangel (1), Ngaraard (1), Ngardmau (1), Ngatpang (1). Fishing was mostly done in the back reefs (27 trips) compared to the reef front (17 trips) and 5 trips each recorded fishing on the lagoon patch reefs and inshore near the islands.

*Volume of total catch measured:*

The total volume of fish purchased at the market can be determined from monthly records from the fish market. The data for the survey period here is presented in Appendix B. However as the data is grouped by month, we could only look in detail at the two full months of survey – June and July. Table 1 summarizes the weight (lbs) of fish that were landed at the market when surveys were conducted and the comparative total volume of fish purchased by the market. On average, the surveys captured 15% of these reef fish landings at the market. As 7 random days (23% of days in the month) were surveyed each month, it is expected if all landings were surveyed it should be similar to this 23%. However as survey staff were not present all day, not all landings were surveyed, especially some of the line fishing catches of mixed reef fish.

Average monthly landings provided for the 4-month period were 11813 lbs of mixed reef fish, 6743 lbs of parrotfish, and 3497 of um (*Naso unicornis*). Total volumes of fish passing through the market each year could be requested to get annual volumes of fish.

Other groups of fish are also landed during these months including rabbitfish (typically *Siganus fuscescens*), tuna and other pelagic such as wahoo and billfish. See Apendix II.

| Month | Fish group | Surveyed catch | Total landings | Proportion surveyed |
|---|---|---|---|---|
| June | Mixed | 1474 | 12398 | 12% |
| | Parrotfish | 1345 | 7266 | 19% |
| | Um | 662 | 3350 | 20% |
| | Monthly total | 3481 | 23014 | 15% |
| | | | | |
| July | Mixed | 2550 | 14808 | 17% |
| | Parrotfish | 1286 | 7387 | 17% |
| | Um | 238 | 3766 | 6% |
| | Monthly Total | 4074 | 25960 | 16% |

*Stereo-video survey:*

3784 fish were recorded and identified to species level from the stereo-video camera. This represented 86 different species from 20 families. From these samples there was 2675 fish measured for length (71%).

The most common fish landed at the market was the parrotfish Ngyaoch/Berkisim (*Hipposcarus longiceps*), followed by the unicornfishes Um (*Naso unicornis*) and Erangel (*Naso lituratus*). All species recorded are listed below in Appendix I, sorted by their family name. The top thirty species are listed below in Table 2. The length frequencies of the top 10 species are presented in Figure 3.

**Table 2:** Top 30 fish species recorded from the stereo-video footage with the number counted and the numbers of fish where length measurements were made, along with average length in mm and inches.

| Taxa | Number counted | Lengths recorded | Avg. length (mm) | Avg. length (inches) |
|---|---|---|---|---|
| *Hipposcarus longiceps* | 868 | 605 | 306 | 12.0 |
| *Naso unicornis* | 354 | 220 | 381 | 15.0 |
| *Naso lituratus* | 348 | 233 | 240 | 9.5 |
| *Parupeneus barberinus* | 286 | 219 | 272 | 10.7 |
| *Lutjanus gibbus* | 281 | 187 | 285 | 11.2 |
| *Scarus rubroviolaceus* | 205 | 137 | 330 | 13.0 |
| *Chlorurus microrhinos* | 156 | 123 | 308 | 12.1 |
| *Siganus punctatus* | 147 | 114 | 231 | 9.1 |
| *Acanthurus nigricauda* | 138 | 98 | 223 | 8.8 |
| *Atule mate* | 115 | 95 | 281 | 11.1 |
| *Siganus argenteus* | 104 | 77 | 224 | 8.8 |
| *Monotaxis grandoculis* | 68 | 48 | 358 | 14.1 |
| *Sargocentron spiniferum* | 62 | 40 | 257 | 10.1 |
| *Lethrinus xanthochilus* | 57 | 48 | 367 | 14.5 |
| *Cetoscarus ocellatus* | 51 | 40 | 347 | 13.7 |
| *Siganus corallinus* | 44 | 30 | 194 | 7.6 |
| *Lethrinus olivaceus* | 39 | 23 | 456 | 17.9 |
| *Rastrelliger kanagurta* | 39 | 38 | 289 | 11.4 |
| *Lethrinus obsoletus* | 33 | 28 | 270 | 10.6 |
| *Cephalopholis argus* | 29 | 25 | 305 | 12.0 |
| *Lutjanus bohar* | 26 | 13 | 457 | 18.0 |
| *Caranx melampygus* | 17 | 10 | 395 | 15.6 |
| *Caranx sexfasciatus* | 16 | 14 | 415 | 16.3 |
| *Plectorhinchus lineatus* | 16 | 9 | 402 | 15.8 |
| *Scarus prasiognathos* | 15 | 11 | 301 | 11.9 |
| *Scarus schlegeli* | 15 | 9 | 260 | 10.2 |
| *Lethrinus lentjan* | 15 | 11 | 298 | 11.7 |
| *Acanthurus xanthopterus* | 14 | 11 | 392 | 15.4 |
| *Scarus oviceps* | 14 | 12 | 271 | 10.7 |

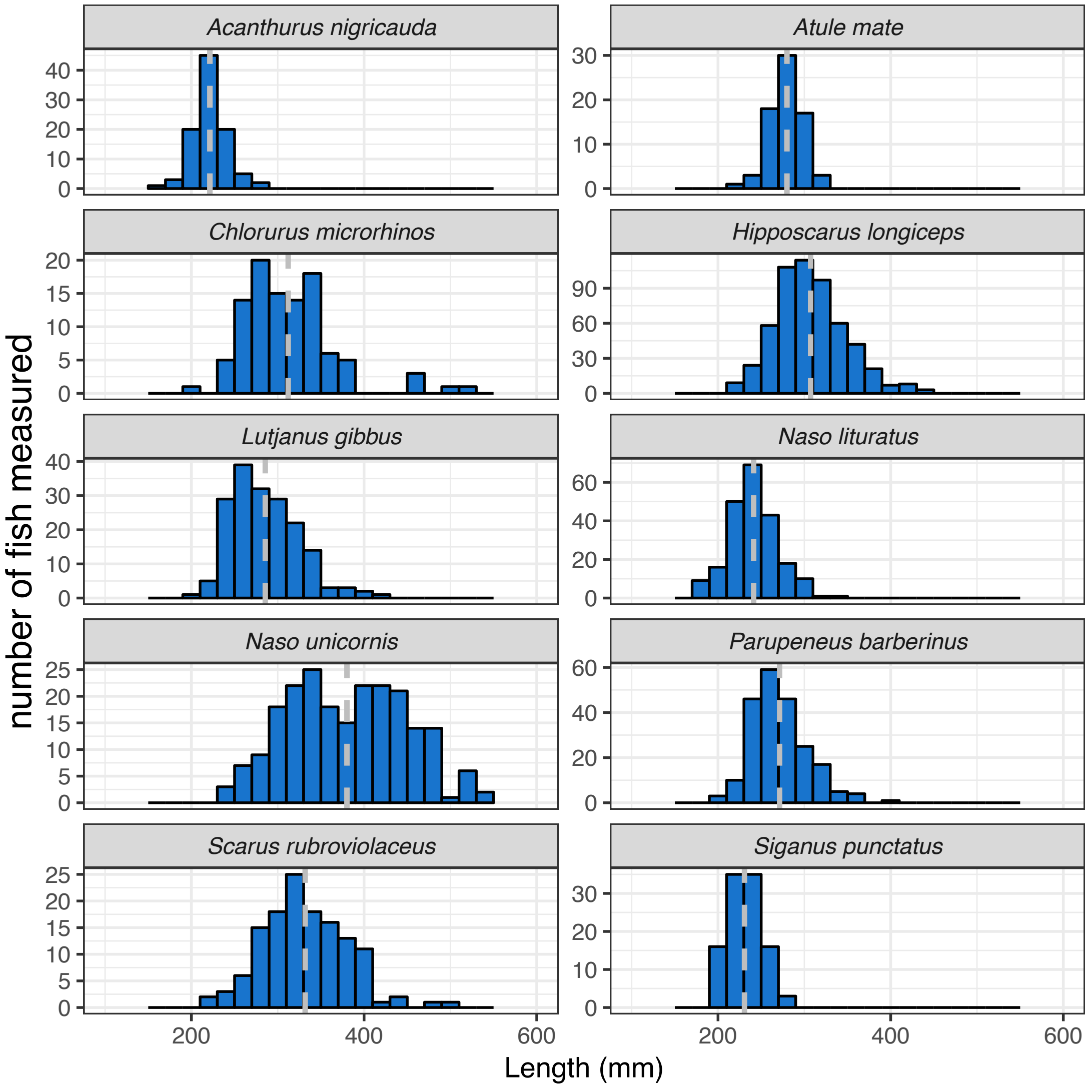



**Figure 3:** Length frequencies of the top 10 species, dashed line is the average length.

*Processing times:*

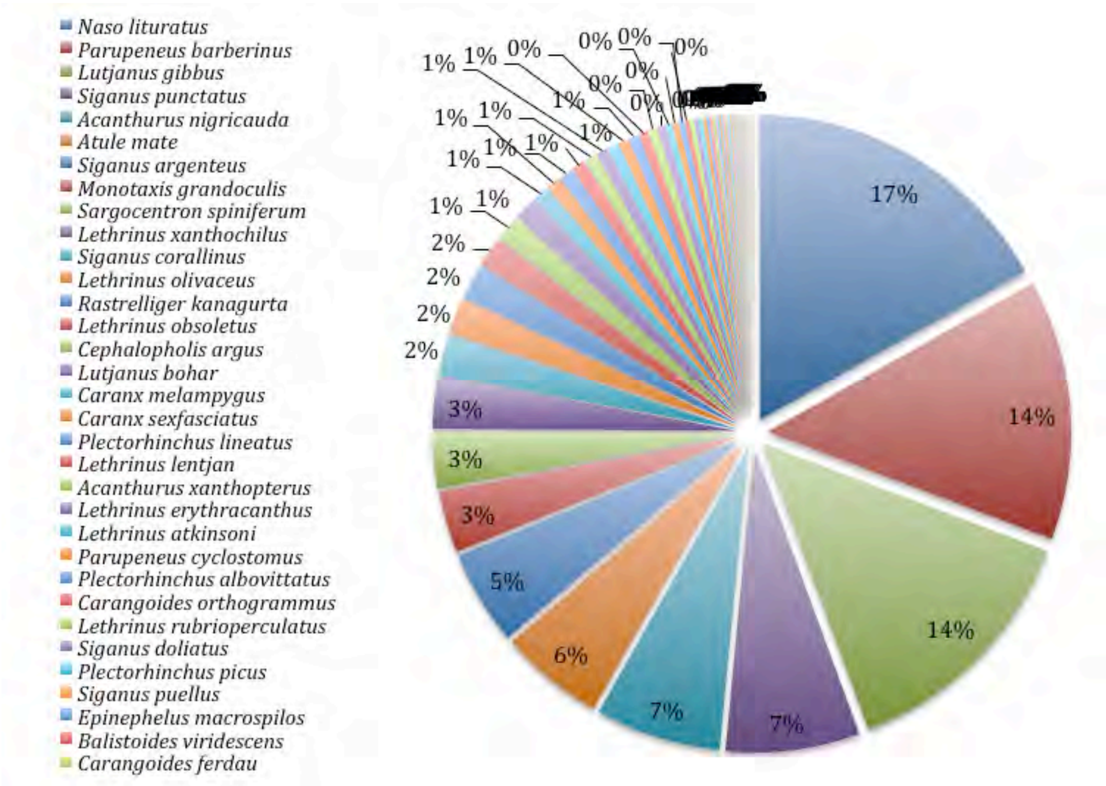
Although the data collection can be very efficient taking only a few minutes to record the entire catch from each boat, the time taken to analyze the stereo-video footage is very time consuming. It has been calculated that it takes approximately 10 hours to analyze the video footage from each day of market sampling.

*Species composition within market categories*

As most reef fish are recorded by the market in three categories (mixed, parrotfish and um) it is important to determine what percentage of each species comprises the total catch for each category. The species composition of mixed reef fish is presented below in a pie chart (Figure 3a) and consists of 69 different species. It shows that the unicornfish *Naso lituratus* – (Palauan name : erangel) was the most commonly caught (17% of all fish), followed by the goatfish *Parupeneus barberinus* - bang (14%), and *Lutjanus gibbus* - keremlal (14%)

The parrotfish group was composed of 16 different species, but was vastly dominated by *Hipposcarus longiceps* – Ngyaoch/Berkism (63%) followed by *Scarus rubroviolaceaus* – Butiliang/Mesekelat mellemau (14%) and *Chlorurus microrhinos* – Otord (11%).

a)



b)

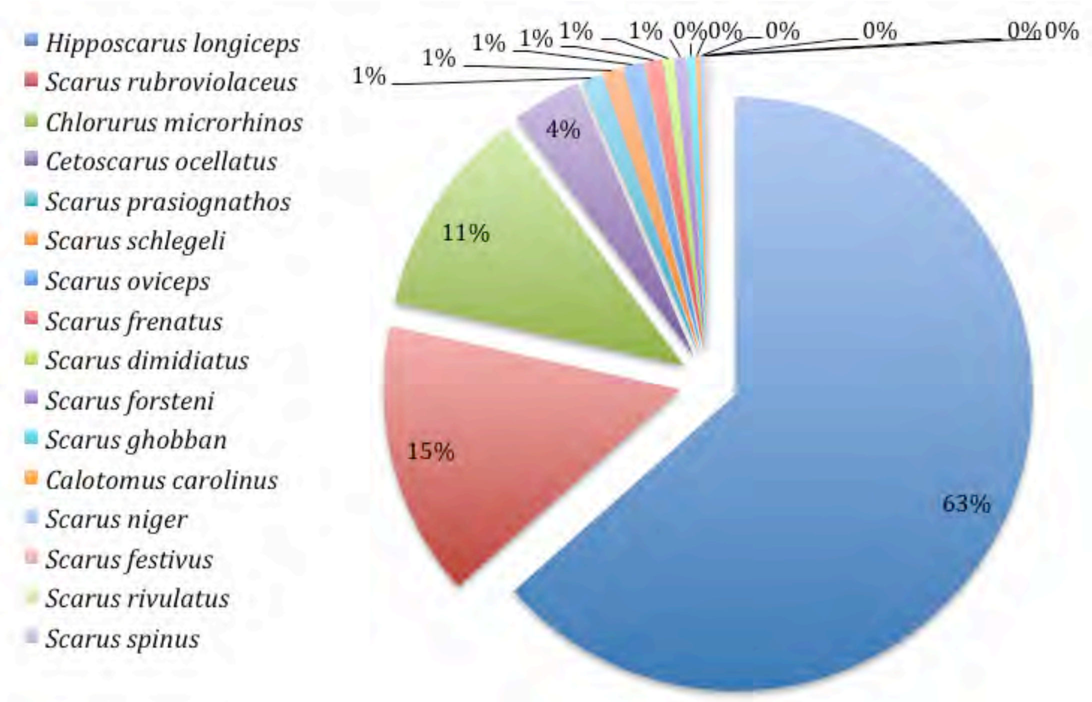



**Figure 3:** Pie charts showing the catch composition for a) the mixed reef fish category and b) the parrotfish category

## Discussion and recommendations

This data collection program, although only conducted for 3 months, was able to provide important information to further characterize Palau's reef fishery and generate length data on range of species. It is important to continue this creel and market survey in the future and the information in this report suggest ways to improve the data collection.

This creel survey was adjusted from the previous training from SPC as the survey forms previously used (see Moore et al 2015) were found to be too long and fishers had some reservations on answering all questions after a long day or night of fishing. The previous method of manually measuring of the fish on a measure board was also distracting to the market process as it needed to be when the fish are landed, which is often the busiest time for buyers at the market. To efficiently measure all fish, a minimum of three staff members would be needed inside the market, which was less than optimal when buyers wanted to get the fish that need to be measured. Observers would also need to be familiar with the scientific names of the fish landed, as local names or common names can often refer to multiple species. For these reasons we adopted a shortened creel survey form and the use of stereo-video camera to measure the size of fish and record imagery to allow accurate species identifications and cross checking. These new methods allow data collection at the market to be very efficient and with minimal disturbance to the market, which is desirable for a long term survey program. However the use of the camera results in long processing times, which needs to be done on the computer and preferable with a dedicated video analyst.

As the fish are recorded in three different groups and we now know the species composition for each group, this well help to see what species are most targeted and if their size changes over time, it will also help when prioritizing management practices (such as size limits) for certain species.

Below is a discussion on the main areas for improvement and recommendations for future surveys.

1) Improving length measurements from the stereo-video camera

These fish are recorded with the stereo-video camera as they are transferred from a cooler to the plastic baskets used on the floating dock at the market, so there is minimal disturbance to the fishers and market staff. But as the fish can be obscured from view if loaded many fish at a time, or bent on the side of the basket or if filming commences after they have been transferred, it was not possible to get lengths from every individual fish. But from these samples there was 2675 fish measured for length (71%). This can provide good data to monitor changes over time and conduct stock assessments such at the length-based spawning potential ratio (LB-SPR) utilized for assessing stocks in the northern reefs.

The fact that some fish may not land flat or are obscured for some length measurements are inevitable with this way of sampling and if happens to a random sample of fish, it should not affect the quality of the data if a small proportion of the fish are not measured. But if it is the largest fish that cannot be measured as they are bent on the basket, this is a problem as length frequency data would show an under sampling of the larger fish. For this reason it is important for any fish that is too big to fit flat in the basket is to be measured separately. This can either be done at the dock, with the other surveyor pulling the fish out of the basket and onto the dock to be filmed before placing back in the basket. Or once the basket is carried into the market after weighing these fish can be filmed or photographed.

To also improve the data collection, it is good to ask the fishers when unloading the catch to do so, one fish at a time. If a handful of fish are thrown into the basket at the same time it is difficult to measure the fish from the video footage.

2) Matching the creel data to the stereo-video data

This report was based on data from the creel survey form to calculate total landings from the weights at the market, whereas the stereo-video camera just provided species identifications and lengths. There were a few instances where there was creel data collected but no footage from the camera as the surveyors arrived just after the fish had been unloaded or there was a problem with the camera such as a flat battery. Although the creel data is priority to determine the methods used and the weight of fish landed, it would be good to have the length and species composition data together for every landing. In the future and for more regular surveys, it would be good if there is clear communication with the market and if it is a survey day and a landing happens without people ready to survey the catch, the catch could be set-aside in a separate cooler for later measuring.

As the data is collected in two different ways – the creel survey form (see appendix II) and the stereo-video camera. It is important to easily link these data. Although it can be done by checking the time code from camera to show when the camera was filming and relate to the creel data. It would be easier to have a landing number for each fish landing. This is recorded on the creel form, and also should be written on a laminated card that can be placed on the dock when filming the catch being unloaded. That way when processing the stereo-video footage it is simple for the analyst to enter this number as a 'period' and then from that data a unique LandingID can be created from the survey date, location and the landing number. (e.g, 20150612_JR5_1). This would be easier to link the two data types in a database.

3) Survey timing and frequency

This survey intensity of 4 days per fortnight was adequate to sample the night-spearfishing catch, providing more than twice the recommended minimum number of surveys to detect a change in suggested by SPC after their training in 2014. It was previously calculated at that at least 20 surveys for each of the two main methods (linefishing and night-spearfishing) is needed in order to detect a change in CPUE (weight) over time. However it is clear that more sampling needs to be conducted to adequately survey the line-fishing catch as only 5 surveys were completed.

The under-representation of line fishing catch is due to the line-fishing catch coming in at less-predictable times in the late afternoons and evenings, when survey staffs were not present. There were only four landings surveyed in the afternoons and only one of which was line fishing. Also likely that line-fishing catches occur on weekends, for which these times were not sampled at all during this 3-month period. It is recommended that future surveys take place on weekends, especially in the afternoons. If the sample sizes are still too low with 4 surveys per fortnight, then it may be needed to survey more regularly.

With a team of two people, it will be too labor intensive to have the team survey the early morning landings and the afternoon/evening landings. Therefore unless there is another survey team that can sample the market in the afternoon these times will need to be split across two days. As these 4 days per fortnight are chosen randomly (with the exception of a new or full moon), it should be decided that the afternoon catch takes place the day after the morning sampling. This is preferred over the day before as it will not be an early morning start after working in the evening.

Some days there are no landings at the market, this happens when market is already full of fish (which happened on June 9-10) or when the weather is bad. It should not be expected that staff be at the market all the time if no landings are going to come and this can be communicated through the fish market.

4) Future monitoring

To keep on top of video analysis for a long-term monitoring project, someone is needed who can analyze stereo-video footage using the software EventMeasure. With surveys being done twice a week and video analysis taking approx. 10hrs to complete for a day of sampling, this would keep someone busy almost full time. It would be preferable if the video analysis is completed by either marine research organization in Palau (PICRC or CRRF) who both have experience analyzing stereo-video footage.

The current recommendation of 4 days per fortnight is to provide a minimal sample to detect a change in CPUE and enough length measurements to allow SPR stock assessments. However if there is greater capacity, funding and interest if would be preferable to survey more frequently for at least for one year to explore how the fishery changes across moon phases, locations, seasons etc. It has been suggested that there is a shift in species composition caught in relation to the grouper closed season[2] (1st April – 31st October) and would be good to explore that in more detail. A more frequent sampling (5 days a week) would be more comparable to the fishery monitoring that is done across Micronesia by Javier Cuetos-Bueno and Peter Houk at the University of Guam.

[2] Bejarano Chavarro, S., Mumby, P.J., Golbuu, Y., 2014. Changes in the spear fishery of herbivores associated with closed grouper season in Palau, Micronesia. Animal Conservation 17, 133–143

Future monitoring should also take place outside the fish market. The market is the one place where we know there is invoice data to show the total volumes of fish sold, but it is currently unknown what proportion of the total reef fish catch goes through the market. Likely a high proportion is sold directly to restaurants, consumed locally and provided to customary events such as funerals and weddings. Collecting data at these locations is more difficult, but one way to gather important data from restaurants would be to mandate the business to report on their purchases of fish. This could be done as a part of their business license to return forms on total volumes and categories of fish purchased. They should also be periodically surveyed with the stereo camera to get data on the size of fish and accurate species identification, or even better that some willing restaurants could also record their own fish purchase with a 3D camera and for that some incentive could be provided such as a ticket/label to say they support sustainable fisheries in Palau.

If any questions or suggestions to improve this report, please contact Steve Lindfield, Coral Reef Research Foundation, Palau – steve.lindfield@yahoo.com.

## Acknowledgements:

Percy Rechelluul and Lora Demei from the Bureau of Marine Resources were the main data collectors and transcribed the creel survey results. JR5 market and fishers supplied data and we appreciate their willingness to have landings surveyed. Funding was provided by Rare Micronesia to support video analysis of the stereo-video footage and report writing.

**Appendix I:** All fish species recorded from the stereo-video footage with the number counted and the numbers of fish where length measurements were made, along with average length in mm and inches.

| Family | Taxa | Number counted | Lengths recorded | Avg. length (mm) | Avg. length (inches) |
|---|---|---|---|---|---|
| Acanthuridae | *Naso unicornis* | 354 | 220 | 381 | 15.0 |
| | *Naso lituratus* | 348 | 233 | 240 | 9.5 |
| | *Acanthurus nigricauda* | 138 | 98 | 223 | 8.8 |
| | *Acanthurus xanthopterus* | 14 | 11 | 392 | 15.4 |
| | *Acanthurus mata* | 1 | 1 | 244 | 9.6 |
| | *Acanthurus olivaceus* | 1 | 1 | 224 | 8.8 |
| Balistidae | *Balistoides viridescens* | 5 | 3 | 463 | 18.2 |
| | *Pseudobalistes flavimarginatus* | 1 | | | |
| Belonidae | *Tylosurus crocodilus* | 2 | | | |
| Caesionidae | *Caesio lunaris* | 1 | 1 | 292 | 11.5 |
| Carangidae | *Atule mate* | 115 | 95 | 281 | 11.1 |
| | *Caranx melampygus* | 17 | 10 | 395 | 15.6 |
| | *Caranx sexfasciatus* | 16 | 14 | 415 | 16.3 |
| | *Carangoides orthogrammus* | 10 | 7 | 339 | 13.4 |
| | *Carangoides ferdau* | 5 | 5 | 356 | 14.0 |
| | *Caranx papuensis* | 1 | 1 | 520 | 20.5 |
| Epinephelidae | *Cephalopholis argus* | 29 | 25 | 305 | 12.0 |
| | *Epinephelus macrospilos* | 6 | 5 | 296 | 11.7 |
| | *Epinephelus corallicola* | 4 | 3 | 346 | 13.6 |
| | *Aethaloperca rogaa* | 3 | 2 | 283 | 11.2 |
| | *Epinephelus howlandi* | 2 | 1 | 274 | 10.8 |
| | *Variola louti* | 2 | 2 | 442 | 17.4 |
| | *Anyperodon leucogrammicus* | 1 | | | |
| | *Epinephelus maculatus* | 1 | | | |
| | *Epinephelus tauvina* | 1 | 1 | 310 | 12.2 |
| Gerreidae | *Gerres acinaces* | 3 | 3 | 257 | 10.1 |
| Haemulidae | *Plectorhinchus lineatus* | 16 | 9 | 402 | 15.8 |
| | *Plectorhinchus albovittatus* | 11 | 4 | 500 | 19.7 |
| | *Plectorhinchus picus* | 7 | 5 | 436 | 17.2 |
| | *Plectorhinchus chaetodonotoides* | 2 | 1 | 361 | 14.2 |
| | *Plectorhinchus chrysotaenia* | 1 | 1 | 456 | 18.0 |
| Holocentridae | *Sargocentron spiniferum* | 62 | 40 | 257 | 10.1 |
| Kyphosidae | *Kyphosus vaigiensis* | 4 | 3 | 329 | 13.0 |
| Labridae: Scarinae | *Hipposcarus longiceps* | 868 | 605 | 306 | 12.0 |
| | *Scarus rubroviolaceus* | 205 | 137 | 330 | 13.0 |
| | *Chlorurus microrhinos* | 156 | 123 | 308 | 12.1 |
| | *Cetoscarus ocellatus* | 51 | 40 | 347 | 13.7 |
| | *Scarus prasiognathos* | 15 | 11 | 301 | 11.9 |
| | *Scarus schlegeli* | 15 | 9 | 260 | 10.2 |
| | *Scarus oviceps* | 14 | 12 | 271 | 10.7 |
| | *Scarus frenatus* | 13 | 10 | 301 | 11.8 |
| | *Scarus dimidiatus* | 8 | 6 | 242 | 9.5 |
| | *Scarus forsteni* | 8 | 6 | 268 | 10.5 |
| | *Scarus ghobban* | 6 | 5 | 386 | 15.2 |
| | *Calotomus carolinus* | 3 | 1 | 237 | 9.3 |
| | *Scarus niger* | 3 | 3 | 270 | 10.6 |
| | *Scarus festivus* | 1 | 1 | 361 | 14.2 |

| | | | | | |
|---|---|---|---|---|---|
| | *Scarus rivulatus* | 1 | | | |
| | *Scarus spinus* | 1 | 1 | 170 | 6.7 |
| Lethrinidae | *Monotaxis grandoculis* | 68 | 48 | 358 | 14.1 |
| | *Lethrinus xanthochilus* | 57 | 48 | 367 | 14.5 |
| | *Lethrinus olivaceus* | 39 | 23 | 456 | 17.9 |
| | *Lethrinus obsoletus* | 33 | 28 | 270 | 10.6 |
| | *Lethrinus lentjan* | 15 | 11 | 298 | 11.7 |
| | *Lethrinus erythracanthus* | 13 | 4 | 329 | 13.0 |
| | *Lethrinus atkinsoni* | 12 | 9 | 241 | 9.5 |
| | *Lethrinus rubrioperculatus* | 10 | 7 | 296 | 11.6 |
| | *Lethrinus semicinctus* | 1 | 1 | 245 | 9.7 |
| Lutjanidae | *Lutjanus gibbus* | 281 | 187 | 285 | 11.2 |
| | *Lutjanus bohar* | 26 | 13 | 457 | 18.0 |
| | *Lutjanus vitta* | 5 | 5 | 252 | 9.9 |
| | *Lutjanus semicinctus* | 3 | 3 | 283 | 11.1 |
| | *Lutjanus monostigma* | 2 | 2 | 343 | 13.5 |
| | *Macolor macularis* | 2 | 1 | 442 | 17.4 |
| | *Aphareus rutilans* | 1 | | | |
| | *Aprion virescens* | 1 | | | |
| | *Lutjanus argentimaculatus* | 1 | 1 | 367 | 14.4 |
| | *Lutjanus kasmira* | 1 | 1 | 180 | 7.1 |
| | *Lutjanus rivulatus* | 1 | 1 | 594 | 23.4 |
| Mugilidae | *Ellochelon vaigiensis* | 1 | 1 | 302 | 11.9 |
| Mullidae | *Parupeneus barberinus* | 286 | 219 | 272 | 10.7 |
| | *Parupeneus cyclostomus* | 12 | 10 | 294 | 11.6 |
| Muraenidae | *Gymnothorax javanicus* | 2 | | | |
| | *Gymnothorax monostigmus* | 1 | 1 | 326 | 12.9 |
| Ostraciidae | *Ostracion cubicus* | 1 | | | |
| Pomacanthidae | *Pomacanthus xanthometopon* | 1 | 1 | 261 | 10.3 |
| Scombridae | *Rastrelliger kanagurta* | 39 | 38 | 289 | 11.4 |
| Siganidae | *Siganus punctatus* | 147 | 114 | 231 | 9.1 |
| | *Siganus argenteus* | 104 | 77 | 224 | 8.8 |
| | *Siganus corallinus* | 44 | 30 | 194 | 7.6 |
| | *Siganus doliatus* | 9 | 8 | 188 | 7.4 |
| | *Siganus puellus* | 7 | 6 | 192 | 7.6 |
| | *Siganus lineatus* | 2 | 1 | 238 | 9.4 |
| | *Siganus guttatus* | 1 | | | |
| | *Siganus punctatissimus* | 1 | | | |
| Sphyraenidae | *Sphyraena qenie* | 2 | 1 | 703 | 27.7 |

**Appendix II:** Creel survey form used at the fish market

| PALAU FISH LANDING SURVEY | | | | | |
|---|---|---|---|---|---|
| OBSERVER / TEAM | LANDING # TODAY | SURVEY DATE and TIME<br>YY MM DD hh mm AM/PM | TIME LEAVE PORT<br>hh mm AM/PM | RETURN TIME<br>hh mm AM/PM | Trip length<br>hh mm |
| 3D CAMERA #/S | SURVEY LOCATION | SKIPPERS NAME | WEATHER: Sunny raining overcast mixed<br>WIND: Calm Moderate Strong Direction?<br>SWELL: Flat Moderate High | | |
| STATE FISHED<br>EAST WEST | REEF NAME / LOC | REEF TYPE/S : Reef front (Wis) Reef crest ( Elmol or Chis) Inner reef (Ngeraol) Channel/pass<br>Offshore (Ngeuaol or Ikrella Chelmoll ) Lagoon patch reef (Melkesokl) Inshore (Bkula tochel) | | | |

***Catch per unit effort***

| *FISHING METHOD* | TIME FISHING | # PEOPLE | # SPOTS | FISH GROUPS | FISH NOT SOLD (lbs) | VIDEO ALL ? | |
|---|---|---|---|---|---|---|---|
| SPEAR - NIGHT | | | | | | | |
| HANDLINE | | | | | | | |
| TROLLING | | | | | | | |
| GILLNET | | | | | | | |
| SPEAR - DAY | | | | | | | |
| OTHER: | | | | | | | |

***Market data***

| *BASKETS* | NUMBER | WEIGHTS | TOTAL LBS | NOTES |
|---|---|---|---|---|
| MIXED | | | | |
| PARROTFISH | | | | |
| UM | | | | |
| OTHER: | | | | |

**Appendix III:** Monthly market data provided by JR5 central fish market for the period of surveys. Weight in lbs.

| 2015 | PARROTFISH | ASST. FISH | UM | RABBITFISH | WAHOO | TUNA | METENGUI | SEBUS | DUDUL | MAHIMAHI | BILLFISH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MAY** | 7,079.18 | 8,902.76 | 3,208 | 152 | 645.78 | 11 | 0 | 0 | 0 | 0 | 135 |
| **JUNE** | 7,266.20 | 12,398.11 | 3,350.16 | 131 | 548.5 | 428 | 0 | 0 | 74 | 0 | 0 |
| **JULY** | 7,387.19 | 14,807.62 | 3,765.50 | 92 | 75.5 | 952 | 15 | 9 | 255 | 0 | 0 |
| **AUGUST** | 5,240.96 | 11,142.07 | 3,665.51 | 1,159.50 | 114 | 1,405.00 | 16 | 46.5 | 234 | 106 | 88.4 |
| **TOTAL** | **26,973.53** | **47,250.56** | **13,989.17** | **1,534.50** | **1,383** | **2796** | **31** | **55.5** | **563** | **106** | **223.4** |
| **AVERAGE** | **6,743.38** | **11,812.64** | **3,497.29** | **383.63** | **345.82** | **699.00** | **7.75** | **13.88** | **140.75** | **26.50** | **55.85** |