1.1 CNMI FISHERY DESCRIPTIONS

1.1.1 BACKGROUND

The Commonwealth of the Northern Mariana Islands (CNMI) is a chain of islands in the Western Pacific Ocean. Along with the island of Guam, the chain is historically known as the Mariana Islands. The CNMI consists of 14 small islands situated in a north-south direction, stretching a distance of about 500 km. The surrounding waters of the CNMI play an integral role in the everyday lives of its citizens. The ocean is a major source of food and leisure activities for residents and tourists alike. Archeological research has also revealed evidence of fishing activities in the CNMI dating back 3,000 years. Although the composition of fishing activities in the Marianas has changed significantly since then, a common view of its importance remains.

Fisheries during the German occupation

During the German occupational period (1899-1914) a majority of the economic focus in the Northern Marianas was on the copra industry. Few commercial fisheries were noted during this period of time, as the German administration focused efforts on crop production and feral cattle trade (Russell 1999). Chamorro and Carolinians utilized the protected lagoon and open waters with several fishing methods: talaya (cast net), chenchulu (surround net), gigao (fish weir), tokcha (spear), tupak (hook and line), and Carolinians additionally gleaned sea cucumbers for the Asian Markets. Most of these activities were for subsistence purposes, with the catch being distributed and bartered among relatives and acquaintances.

Fisheries during the Japanese occupation

Fisheries development prospered during the Japanese administration (1914-1945), becoming the nation's second largest industry. Small pelagic fishing operations were established and the Garapan port became the main area for drying fish. Large scale fishing activities occurred during the 1930s, shown as Saipan produced 11 percent of total tuna landed in Micronesia (Bowers 2001). However, efforts to develop the tuna fishery shifted to Palau and Federated States of Micronesia (FSM) due to the availability of bait fish in the region. Subsistence fishing still persisted within the lagoon and fringing reefs and was mainly conducted by the natives though a large extraction of sea cucumbers did occur. There were several main fishing methods used during this period: cast net, spear, gill net, surround net, hook and line, and gleaning. During this period, the topshell (*Trochus niloticus*) was also introduced into the Marianas.

Fisheries during the U.S. military occupation

The fishing industry was destroyed during World War 2, but quickly rebuilt afterwards with support from the U.S. military. Okinawans who operated the fishery prior to the war were hired to operate and train locals to fish commercially, targeting pelagic species. A company called Saipan Fishing Company operated during this time and contributed to the early re-development of post-war commercial fisheries in the CNMI (Bowers 2001). Most of the fishing activities were for *Katsuwanus pelamis* (bonito) and other tuna species. However, other resources, such as bigeye scad, reef fish, and lobster, were also harvested during calm weather. The Chamorro and Carolinians continued subsistence fishing in the lagoon after the war. Although limited quantities of monofilament nets were available during this period, they were used to capture lagoon fish and along the reef lines. The use of modern fishing gear such as masks, rubber fins, and flashlights made it much easier to harvest coral reef resources during this time.

Fisheries activities within the past two decades

The CNMI has had numerous changes in its fisheries over the past twenty years. In the mid-1990s, commercial fishing activities increased significantly. Commercial SCUBA fishing became a common method, not only to support local demand for reef fish, but to bolster exports to Guam as well. Large-scale commercial bottomfish fishing in the Northern Islands of the CNMI peaked starting in the mid-1990s through 2002, with landings being both sold locally and exported to Japan. Troll fishing continued to be dominant during this period. An exploratory, deepwater shrimp fishery also developed, but did not last due to internal company issues and gear losses. Around this time, a sea cucumber fishery also began on Rota before migrating to Saipan; ultimately, however, this fishery was found to be unstable and was subsequently halted.

Several fishing companies entered the fisheries only to close down a few years later. The CNMI reached its highest population during the last two decades, most of whom have been migrant workers from Asia. The tourism industry has also been increasing, which contributes to high demand for fresh fish. Subsistence fishing within the nearshore waters of Saipan, Tinian, and Rota has also increased.

In the 2000s, small-scale troll, bottom and reef fish fisheries persisted, with landings sold locally. Federal and state support was provided multiple times to further develop fisheries in the CNMI with intermittent success. An exploratory longline fishery was funded and operated in the CNMI in the mid-2000 for about two years, but eventually closed down due to low productivity of high-value, pelagic fish, among other issues within the business. A few larger (40-80’) bottomfish fishing vessels were also operational during this period, with a majority of them fishing the northern islands and offshore banks. A few of these vessels were recipients of financial assistance to improve their fishing capacities.

Fisheries in the CNMI have generally been relatively small and fluid, with 16-20’ boats fishing within 20 miles from Saipan. Many of these small vessels conduct multiple fishing activities during a single trip. For example, a company that is supported mainly by troll fishing may also conduct bottomfish fishing and spearfishing to supplement their income. Fishing businesses tend to enter and exit the fishery when it is economically beneficial to do so, as they are highly sensitive to changes in the economy, development, population, and regulations. Subsistence fishing continues; however, fishing methods and target species have shifted in step with population demographics and fishery restrictions. Nearshore hook and line, cast net, and spear fishing are common activities, but fishing methods such as gill net, surround net, drag net, and SCUBA-spear have been restricted or outright banned in the CNMI since the early 2000s.

1.1.1.1 BOTTOMFISH FISHERY

The bottomfish fishery has not changed much from its early years in certain aspects. Relatively small (<25 ft.) fishing vessels are still being used to access bottom fishing grounds around Saipan and Tinian, while the larger (>25 ft.) vessels are used to access bottomfish resources in the Northern Islands. Only a handful of these larger bottom fishing vessels are operating within the CNMI. Most of the small bottomfish fishing vessels are owned by commercial purchasers; there are, however, a few subsistence bottomfish fishermen that participate in the fishery intermittently. More recently, improved technologies, such as sophisticated electronics to locate fish and various types of reels replacing handlines, have entered the CNMI bottomfish fishery.

Two distinct types of bottomfish fisheries are identified in the CNMI: shallow-water bottom fishing, which targets fish at depths down to 150 m, and deepwater bottom fishing, which targets fish at depths greater than 150 m. Species targeted by the shallow-water fishery consist of the Redgill Emperor (*Lethrinus rubrioperculatus*), Black Jack (*Caranx lugubris*), Matai (*Epinephelus fasciatus*), Sas (*Lutjanus kasmira*), and Lunartail Grouper (*Variola louti*), among other fish residing at similar depths. Species targeted by the deepwater bottom fishing depths (>150m) include onaga (*Etelis corsucans*), ehu (*E. carbunculus*), yellowtail kalekale (*Pristipomiodes auricilla*), amberjack (*Seriola dumerili*), blueline gindai (*P. argyrogrammicus)*, gindai (*P. zonatus*), opakapaka (*P. filamentosus*), and eightbanded grouper (*Hyporthordus octofasciatus*), among other fish residing at similar depths.

Bottomfish management unit species (BMUS) are not the only species caught in the shallow-bottom fishery. Deep-water bottomfish fishing requires more efficient fishing gears, such as hydraulic reels. Bottomfish fishing trips generally return during the day, but there is an unmeasured amount that occurs outside of survey hours from 2 AM to 10 AM. Fishing trips to the Northern Islands can take two to four days depending on vessel size and refrigeration capacity. These trips are most productive during calm weather months. Successful fishermen targeting deep-water bottomfish tend to fish for one to four years before leaving the fishery, whereas the majority of fishermen targeting shallow-water bottomfish tend to leave the fishery after the first year.

The overall participation of fishermen in the bottomfish fishery tends to occur on a relatively short-term basis (i.e., less than four years). The slight difference between shallow-water and deepwater fishermen likely reflects the greater skill and investment required to participate in the deepwater bottomfish fishery. In addition, deepwater bottomfish fishing tends to include larger ventures that are more buffered from the impulses of individual choice and are usually dependent on a skilled captain and fishermen. Overall, the long-term commitment to hard work, maintenance and repairs, and staff retention appear to be challenging for CNMI bottomfish fishermen to sustain their efforts for more than a few years. A full list of BMUS species is provided in Appendix A.

1.1.1.2 CORAL REEF FISHERY

Coral reef fisheries have been generally steady in recent years relative to previous decades. Small-scale nearshore fisheries in the CNMI continue to be important socially, culturally, recreationally, financially, and for subsistence. Most fishermen are subsistence fishers, with a number of them selling a portion of their catch to roadside commercial purchasers and some of these commercial purchasers employing the fishermen to maintain a constant supply of reef fish. Most of the fishing for coral reef species occurs within the Saipan lagoon and fringing reefs around the islands, targeting mainly finfish and invertebrates. All reef fish catches are sold to local markets or used for personal consumption with a minimal portion exported for off-island residents. Shoreline access is the most common way to harvest coral reef resources. Vessels are generally used during calm weather to fish areas not as accessible other times of the year, with fishing trips to other islands being made when the weather is favorable. Fishing methods have not changed significantly compared to previous years; hook and line, cast netting, spear fishing, and gleaning are methods still being used today. Some of the common families found in the CNMI reef fish markets are Acanthuridae (surgeonfish), scaridae (parrotfish), mullidae (goatfish), serranidae (grouper), labridae (wrasse), holocentridae (soldier/squirrelfish), carangidae (jacks), scombridae (scad), haemulidae (sweetlips), gerridae (mojarra), kyphosidae (rudderfish), and mugilidae (mullet), as well as other non-finfish families.

In 2018, the Council drafted an Amendment 5 to the Mariana Archipelago Fishery Ecosystem Plan (FEP) that reclassified a large number of management unit species (MUS) as Ecosystem Component Species (ECS; WPRFMC 2018). The final rule was published in the *Federal Register* in early 2019 (84 FR 2767, February 8, 2019). This amendment reduces the number of MUS from 227 species and families to 13 in the Mariana Archipelago FEP. All former coral reef ecosystem MUS (CREMUS) and crustacean MUS (CMUS) were reclassified as ECS that do not require annual catch limit (ACL) specifications or accountability measures but are still to be monitored regularly to prioritize conservation and management efforts and to improve efficiency of fishery management in the region. All existing management measures, including reporting and record keeping, prohibitions, and experimental fishing regulations apply to ECS. If an ECS stock becomes a target of a federal fishery in the future, the National Marine Fisheries Service (NMFS) and the Council may consider including that stock as a MUS to actively manage that stock. These species are still regularly monitored via other means (see Sections 1.1.5.3 and 2.2).

1.1.2 FISHERY DATA COLLECTION SYSTEM

A majority of the information collected by the CNMI Division of Fish and Wildlife (DFW) is fishery dependent. Since the early-1980s, attempts were made to establish a data collection program for the nearshore fisheries but failed due to intergovernmental issues. Over recent decades, significant time and effort has been made to further develop nearshore fishery data collection. This effort has resulted in the re-establishment of the shore-based creel survey program by DFW in collaboration with otherfederal agencies. To further improve data collection efforts, the CNMI instituted mandatory data reporting for commercial fisheries. The CNMI is working on improving commercial licensing and data submission processes to meet recent data collection mandates. The CNMI is working with NOAA to further improve this mandate through exploring alternative fishery data collection programs.

1.1.2.1 CREEL SURVEYS

Currently the CNMI maintains both a boat- and shore-based creel survey for the island of Saipan, with plans for expansion to the populated neighboring islands. The programs were established in 2000 and 2005, respectively, in order to strengthen the capacity of DFW in providing sufficient information to the public regarding local fisheries. Other programs, such as the invoicing system and importation monitoring (for commercial purposes), provide supplemental information on harvest and demand for the fishery..

Effective management of Saipan's marine fishery resources requires the collection of fishing effort, methods used, and harvest. The CNMI boat- and shore-based creel surveys are some of the major data collection systems used by DFW to estimate the total annual boat-based participation, effort, and harvest while surveying nearshore fishery resources. These surveys were formerly known as the “CNMI offshore creel survey” but are now referred to as “boat-based” because they cover all fishing done from a boat (including non-registered makeshift boats and kayaks since October 2022). This is an important distinction because where the fishing activity is initiated (i.e., boat vs. shore) determines how that type of activity will be accounted for in the survey systems. For instance, very small boats launched from non-standard launching areas (e.g., from the back of a pickup truck on a beach) are not included in the boat-based creel survey.

The objective of the boat-based creel survey program is to quantify fishing participation, effort, and catch done from on a vessel in CNMI's waters. DFW had an early creel survey data collection program in 1984, and 1990 to 1994, however since the methods were not standardized, the data collected with that early program is not currently being used. The early program was eventually terminated due to a lack of resources. On April 2, 2000, the DFW fishery staff reinitiated the boat-based creel survey program on the island's boat-based fishery following a three-year hiatus. The fishery survey collects trip data (identification of outgoing and incoming vessels), participation data (the number of known fishing boat trailers), and interview data (effort, catch, and economic data) from the three most active launching ramps/docks on the island: Smiling Cove, DFW Ramp, and Fishing Base. DFW Ramp had recently been added as an active launching site as of August 2022 to replace Sugar Dock as it has not been used for quite some time due to the lack of launching access. Essential fishery information is collected and processed from both commercial and noncommercial vessels to help better inform management decisions. Trip data are collected by identifying outgoing and incoming vessels by the vessel identification emblazoned on hulls, by identifying the type of fishing gear if any to distinguish what methods may be used, and by noting departure and arrival times for each vessel.

Participation data are collected via a roving survey in which known fishing boat trailers, known non-fishing boat trailers, and unknown-use boat trailers are counted at all launching ramps/docks at specified times. This includes identifying which charter fishing vessels are present and absent at the Smiling Cove marina. Finally, interview data are collected via access point surveys in which staff interview returning fishers to identify and count number of fishing gear, hours fished, fishing location, what species and how many pieces of each were caught, what fuel and how much was used, and how much ice was used per trip. The data collected are then expanded at a stratum level (quarterly vs. annually, charter vs. non-charter, weekday vs. weekend, etc.) to create estimated landings by gear type for CNMI's boat-based fishery. The shore-based survey currently covers the western lagoon of Saipan. Some pilot surveys were conducted on Saipan's Eastern beaches such as Laolao Bay, Obyan Beach, and Ladder Beach. However, effort to collect data from these areas have been very sporadic. Other accessible areas are not covered at this time due to existing limited resource availability and logistical constraints. With the assistance of the Fisheries Research and Monitoring Division (FRMD) at the Pacific Islands Fisheries Science Center (PIFSC), data processing software and a database were developed to process these survey data.

The shore-based survey now includes all shorelines accessible from public roads on the western coast ofSaipan except no-take Marine Protected Areas (MPAs). With the assistance of the Fisheries Research and Monitoring Division (FRMD) at the Pacific Islands Fisheries Science Center (PIFSC), data processing software and a database were developed to process these survey data.

In May 2005, DFW fishery staff reinitiated the creel survey program for the island's shore-based fishery following an eleven-year hiatus. The western lagoon starts from the northwest (Wing Beach) and extends to the southwest (Agingan Point) of Saipan, encompassing over twenty accessible and highly active shoreline access points. Saipan's shore-based creel survey is also a stratified, randomized data collection program. This program collects two types of data to estimate catch and effort information in the shore-based fishery: participation counts and interviews. The participation counts involve counting the number of people fishing on randomly selected days and their method of fishing along the shoreline. The interviews involve some dialog with fishermen to determine catch, method used, length and weights of fish, species composition, catch disposition, and if any fish were not kept (i.e., bycatch). The data collected from this program have been used to expand and create annual estimated landings for the shore-based fishery in the CNMI.

On August 2015, Saipan was impacted by Typhoon Soudelor and on October 2018, Saipan and Tinian were directly impacted by Super Typhoon Yutu. The damage inflicted by the typhoon delayed both creel surveys, collection of commercial receipt invoices and data entry. About a month after the typhoon, creel surveys were regularly conducted again, and boat-based surveys followed soon thereafter. commercial purchasers prioritized repairing typhoon-related damages to their businesses, and the number of invoices collected decreased as a result.

In March 2020, the CNMI issued community restrictions to address the COVID-19 pandemic concerns. A number of measures, such as curfew restrictions, gathering restrictions, sanitation restrictions, office closures, travel restrictions, as well as fishing restrictions, were implemented during this time. These restrictions were reduced as the COVID -19 situation improved in the CNMI. This also significantly affected commerce within the CNMI as tourism is the main source of income. Fishing activities and businesses gradually opened back up as the situation improved. Participation increased as people entered the fishery due to being displaced by the pandemic and turned to fishing for alternative income. The DFW fishery data collection program activities were also limited by the COVID-19 restrictions. Sample days and hours were limited during the first few months of the restrictions. As restrictions were lifted, sampling effort for all fishery data collection programs increased and coverage improved.

There were 43 boat-based surveys conducted between January 1 and December 31, 2023. A total of 119 interviews were completed with an expanded catch of 184,105 pounds. 694 fishing trips were identified by counting known fishing boat trailers during participation surveys.

1.1.2.2 PURCHASER INVOICE

DFW has been collecting fishery statistics on Saipan's commercial fishing fleet since the mid-1970s. With the assistance of NMFS, DFW also expanded its fisheries monitoring programs to include the other two major inhabited islands in the CNMI: Rota and Tinian. DFW's principal method of collecting domestic commercial fisheries data is an invoicing system. DFW provides numbered two-part invoices to all commercial purchasers of fresh fishery products (including hotels, restaurants, stores, fish markets, and roadside vendors). Commercial purchasers then complete an invoice each time they purchase fish directly from fishers; one copy goes to DFW, and one copy goes to their records. Some advantages of this data collection method are that it is relatively inexpensive to implement and maintain, and it is fairly easy to completely cover the commercial fisheries. DFW can also provide feedback to commercial purchasers and fishers to ensure data accuracy and continued cooperation over time.

There are some disadvantages to the invoicing system, including: (1) dependency on non-DFW personnel to identify the catch and record the data, (2) restrictions on the types of data that can be collected, (3) required education and cooperation of all fish commercial purchasers, and (4) limited recordings of fish actually sold to commercial purchasers. Therefore, a potentially important portion of the total landings typically goes unrecorded. Since 1982, DFW has tried to minimize these disadvantages in several ways by (1) maintaining a close working relationship with commercial purchasers, (2) adding new commercial purchasers to their list and educating them, and (3) implementing a creel survey to help estimate total catch (including recreational and subsistence portions). The current system collects data from commercial purchasers in Saipan, where DFW estimates more than 90 percent of all CNMI commercial landings are made. DFW also estimates that the proportion of total commercial landings that have been recorded in the Saipan database since 1983 is about 90 percent; however, coverage has been relatively mottled over the years. Previous volumes of FSWP reported only recorded landings, but in recent volumes, the data have been adjusted to represent 100 percent coverage and are referenced as “estimated commercial landings” in the tables and figures.

These data elements are collected for all purchases of fishery products; however, identification is often limited to the family taxa, especially for fishes besides pelagic species.

1.1.2.3 BIOSAMPLING

The biosampling database contains general and specific bio-data obtained from individual commercial spearfish catches landed on Saipan from six different commercial purchasers over the course of 2011. The following data was captured for each fishing trip sampled: date, fishing gear type, time/hours fished, location fished, number/names of fishers, lengths/weights of individual fish, number/weight of octopus and squid, number/carapace size/weight/sex of lobster, and whether it was boat- or shore-based fishing trip.

Although sampling effort was intended to be spread evenly among all participating commercial purchasers, smaller commercial purchasers were inherently much more difficult to sample within the time constraints allowed. Therefore, a regular sampling schedule was implemented for the island’s two largest commercial purchasers that included two weekdays and one weekend day each week starting in January-February 2011. Problems encountered in sampling the smaller commercial purchasers included: more days in any given month where no fish were purchased, the work area was not conducive for sampling, and communication problems. The bio-sampling database focuses on nighttime (non-SCUBA) spearfishing activities. Due to purchaser-imposed limitations, other gear types that typically land their catch during normal business hours were not sampled.

1.1.2.4 EXEMPTION NETTING

In 2003, the use of gill nets was prohibited in the CNMI. In 2005, the DFW decided to allow gill netting under special circumstances. Gill netting is now allowed under strict conditions provided by the DFW with their permission such that all gill netting activities are to be monitored and recorded by DFW personnel.

In 2010, a law was passed allowing for the use of gill nets for the purpose of subsistence on the island of Rota. The following year, a regulation allowing subsistence net fishing was passed for the island of Tinian.

For a majority of the permitted gillnet activities, length and weight measurements were taken at the fishing site. Fork lengths were measured in millimeters and weights were measured in grams. If time did not permit for individual measurements, then length measurements were taken for each fish and total weight was taken for each species. Length/weight ratios were used to estimate weights of sampled fish. Information has been collected for activities conducted on the island of Saipan, but no official collection of information has been collected for Rota or Tinian.

1.1.2.5 LIFE HISTORY

The CNMI DFW life history program began in 1996 sampling the redgill emperors (*Lethrinus rubrioperculatus*). Since then, sampling has been conducted on other species, including *A. lineatus*, Myriprestinae (*Myripristis violacea, M. kuntee, M. pralinea, M. bernti, M. murdjan), L. harak, Naso lituratus, Chlorurus sordidus*, and *C. undulatus*. Other life history programs have also developed over the past years. In collaboration with NMFS, DFW personnel collect life history information on *Scarus rubroviolaceus*, *Lethrinus atkinsoni*, and *Parupeneus barbarinus* through funding provided by NOAA-NMFS. The life history survey captures biological information, including reproductive cycle, age at length, and age at maturity. The DFW is continually working to improve the understanding of reef fish life history in the CNMI through these types of programs.

1.1.2.6 MONITORING OF IMPORTED FISH

The DFW Fisheries Data Sections collect fisheries-related importation invoices from the Department of Customs at the end of every month. The data is then entered into a ticket receipt system and reviewed prior to being sent out for compilation by PIFSC. Most of the information entered into the system can only be identified to the family taxa.

1.1.2.7 VESSEL INVENTORY

The most recent records obtained from CNMI Department of Public Safety (DPS) are from 2022. Their records are handwritten and do not exist electronically. 340 vessels (including jet skis) were registered. 107 vessels were registered as commercial fishing vessels. 297 were registered for personal use, although an unknown number was and continue to be used for commercial fishing regardless of their intended use specified on vessel registrations. Others were registered for commercial recreation and government use. This work is also impacted by policies of DPS, which manages vessel licensing. When contacted in 2023, DPS did not provide copies of their vessel inventory for unknown reasons.

1.1.3 META-DATA DASHBOARD STATISTICS

The meta-data dashboard statistics describe the amount of data used or available to calculate the fishery-dependent information. Creel surveys are sampling-based systems that require a random-stratified design applied to pre-scheduled surveys. The number of sampling days, participation runs, and catch interviews can be used to determine if there are sufficient samples to run the expansion algorithm. The trends of these parameters over time may infer survey performance. Monitoring the survey performance is critical for explaining the reliability of the expanded information.

Commercial receipt book information depends on the number of invoices submitted and the number of vendors participating in the program. Variations in these meta-data affect the commercial landing and revenue estimates.

1.1.3.1 CREEL SURVEY META-DATA STATISTICS

Calculations:

Sample days: Count of the total number of unique dates found in the boat log sampling date data in boat-based creel surveys.

Catch Interviews: In boat-based creel surveys, count of the total number of data records found in the interview header data (number of interview headers). This is divided into two categories, interviews conducted during scheduled survey days (Regular) and opportunistic interviews (Opportunistic), which are collected on non-scheduled days.

Table 1. Summary of CNMI boat-based creel survey meta-data

Year	# Sample Days	# Catch Interviews	
		Regular	Opportunistic
2000	44	168	9
2001	67	285	0
2002	75	200	25
2003	90	299	40
2004	77	272	16
2005	78	417	29
2006	71	342	22
2007	62	314	1
2008	55	250	1
2009	64	241	25
2010	65	161	82
2011	67	162	87
2012	72	166	0
2013	71	191	0
2014	71	166	0
2015	57	119	2
2016	65	117	3
2017	66	120	6
2018	54	126	1
2019	33	65	8
2020	58	126	52
2021	69	205	51
2022	51	171	7
2023	41	117	3
10-yr avg.	**57**	**133**	**13**
10-yr SD	**12**	**36**	**19**
20-yr avg.	**62**	**192**	**20**
20-yr SD	**11**	**87**	**27**

1.1.3.2 COMMERCIAL RECEIPT BOOK STATISTICS

Calculations:

Vendors: Count of the number of unique buyer codes found in the commercial purchase header data from the Commercial Receipt Book; BMUS vendors are only from vendors that sold BMUS species.

Invoices: Count of the number of unique invoice numbers found in the commercial header data from the Commercial Receipt Book; BMUS vendors are only from vendors that sold BMUS species.

Table 2. Summary of CNMI commercial receipt book meta-data

Year	# Vendors	# Invoices Collected	# BMUS Vendors	# BMUS Invoices Collected
1983	42	2,929	13	55
1984	45	3,452	11	50
1985	n.d.	n.d.	n.d.	n.d.
1986	n.d.	n.d.	n.d.	n.d.
1987	27	1,908	11	30
1988	16	2,204	7	23
1989	24	2,454	8	51
1990	22	1,917	5	19
1991	30	1,957	3	12
1992	52	2,814	3	4
1993	46	2,749	13	44
1994	53	2,801	16	83
1995	57	3,580	20	147
1996	68	4,463	23	204
1997	54	3,999	14	99
1998	52	5,369	17	137
1999	49	4,649	17	129
2000	47	6,030	16	181
2001	39	4,914	17	379
2002	32	4,759	17	208
2003	24	4,261	12	137
2004	25	3,507	13	98
2005	23	3,945	11	114
2006	21	4,002	10	144
2007	18	3,387	11	210
2008	13	3,054	10	221
2009	6	2,513	6	234
2010	5	1,612	5	134
2011	3	1,198	3	143
2012	19	1,565	11	188
2013	17	2,161	13	202

Year	# Vendors	# Invoices Collected	# BMUS Vendors	# BMUS Invoices Collected
2014	15	1,665	11	117
2015	10	750	3	17
2016	16	2,250	8	165
2017	29	2,266	12	100
2018	34	2,952	13	78
2019	33	2,854	11	91
2020	15	2,231	7	258
2021	17	4,090	8	400
2022	29	3,493	11	443
2023	35	1,697	15	135
10-yr avg.	**23**	**2,425**	**10**	**180**
10-yr SD	**9**	**915**	**3**	**135**
20-yr avg.	**19**	**2,560**	**10**	**175**
20-yr SD	**9**	**956**	**3**	**101**

'n.d.' indicates that data are non-disclosed due to confidentiality rules (i.e., less than three dealers and/or vendors).

1.1.4 FISHERY SUMMARY DASHBOARD STATISTICS

The Fishery Summary Dashboard Statics section consolidates all fishery-dependent information comparing the most recent year with short-term (recent 10 years) and long-term (recent 20 years) average (shown bolded in [brackets]). Trend analysis of the past 10 years will dictate the trends (increasing, decreasing, or no trend). The right-most symbol indicates whether the mean of the short-term and long-term years were above, below, or within one standard deviation of the mean of the full time series.

Legend Key:

↗ - *increasing trend in the time series*
⊕ - *above 1 standard deviation*

↘ - *decreasing trend in the time series*
⊖ - *below 1 standard deviation*

⇔ - *no trend in the time series*
⊙ - *within 1 standard deviation*

10,000 [**1,000**] – *point estimate of fishery statistic* [***difference from short/long term average***]

Table 3. Annual indicators for CNMI bottomfish fisheries describing performance and comparing estimates from 2023 with short- (10-year) and long-term (20-year) averages

Fishery	Fishery statistics	Short-term (10 years)	Long-term (20 years)
Bottomfish	**Total estimated catch (lb)**		
All gears	All BMUS from creel survey data	**10,178[▼69%]** ↗ ⊙	**10,178[▼75%]** ↘ ⊖

Fishery	Fishery statistics	Short-term (10 years)	Long-term (20 years)
(BMUS only)	All BMUS from commercial purchase data	**5,313[▼69%]**	**5,313[▼66%]**
	Catch-per-unit-effort (from boat-based creel surveys)		
Bottomfish fishing (BMUS only)	Bottomfish fishing lb/trip	**18[▼57%]**	**18[▼54%]**
	Bottomfish fishing lb/gr-hr	**1.15[▼69%]**	**1.15[▼62%]**
	Fishing effort (from boat-based creel surveys)		
Bottomfish fishing (BMUS only)	Tallied bottomfish trips	**19[▼5%]**	**19[▼39%]**
	Tallied bottomfish gear hours	**295[▲11%]**	**295[▼41%]**
	Fishing participants (from boat-based creel surveys)		
Bottomfish fishing (BMUS only)	Tallied number of bottomfish fishing vessels	**19[▲19%]**	**19[▼14%]**
	Estimated average number of fishermen per bottomfish fishing trip	**3[▲50%]**	**3[▼40%]**
	Bycatch		
BMUS	# fish caught	**124[▼61%]**	**124[▼78%]**
	# fish discarded/released	**0[no change]**	**0[▼100%]**
	% bycatch	**0[no change]**	**0[▼100%]**

Table 4. Annual indicators for CNMI ECS fisheries describing performance and comparing 2023 estimates with short- (10-year) and long-term (20-year) averages

Fishery	Fishery statistics	Short-term (10 years)	Long-term (20 years)
ECS	**Estimated catch (lb)**		
Prioritized ECS	*Acanthurus lineatus* from creel survey data	**46[▼90%]**	**46[▼85%]**
	Acanthurus lineatus from commercial data	**0[▼100%]**	**0[▼100%]**
	Naso lituratus from creel survey data	**44[▼97%]**	**44[▼96%]**
	Naso lituratus from commercial data	**1,929[▼24%]**	**1,929[▲21%]**
	Naso unicornis from creel survey data	**2,783[▲158%]**	**2,783[▲239%]**
	Naso unicornis from commercial data	**564[▼36%]**	**5,340[▲1%]**

Fishery	Fishery statistics	Short-term (10 years)	Long-term (20 years)
	Scarus ghobban from creel survey data	0[▼100%]	0[▼100%]
	Lethrinus harak from creel survey data	431[▲762%]	431[▲1,624%]
	Lethrinus harak from commercial data	0[no change]	0[no change]
	Siganus argenteus from creel survey data	996[▼45%]	996[▼62%]
	Siganus argenteus from commercial data	548[▼77%]	548[▼80%]
	Mulloidichthys flavolineatus from creel survey data	258[▲10%]	258[▲7%]
	Mulloidichthys flavolineatus from commercial data	0[▼100%]	0[▼100%]

1.1.5 CATCH STATISTICS

The following section summarizes the catch statistics for bottomfish, the top ten landed ECS, and seven prioritized ECS in CNMI as identified by DFW. Estimates of catch are summarized from the creel survey and commercial receipt book data collection programs. Catch statistics provide estimates of annual harvest. Estimates of fishery removals can provide proxies for the level of fishing mortality and a reference level relative to established catch limits.

1.1.5.1 CATCH BY DATA STREAM

This section describes the estimated total catch from the boat-based creel survey programs as well as the commercial landings from the commercial receipt book system. The difference between the creel total and the commercial landings is assumed to be the non-commercial component. However, there are cases where the commercial landing may be higher than the estimated creel total of the commercial receipt book program. In this case, the commercial receipt books can capture the fishery better than the creel surveys. While the reporting of commercial landings for Guam boat-based archipelagic fisheries is often constrained by rules associated with data confidentiality (i.e., commercial data must be sourced by at least three commercial purchasers to be reported), the relative lack of purchaser reports from Guam is likely related to non-participation by commercial purchasers rather than being reflective of a paucity of commercial purchasers.

Calculations: Estimated landings are based on a pre-determined list of species (Appendix A) identified as BMUS regardless of the gear used, for each data collection (creel surveys and the commercial purchase reports).

Table 5. Summary of CNMI BMUS total catch (lb) from expanded boat-based and shore-based creel surveys and the commercial purchase system for all gear types

Year	Boat-Based Creel Survey Estimates	Shore-Based Creel Survey Estimates	Total Creel Survey Estimates	Commercial Landings
1983	-	-	-	3,407
1984	-	-	-	3,463
1985	-	-	-	n.d.
1986	-	-	-	n.d.
1987	-	-	-	1,889
1988	-	-	-	2,413
1989	-	-	-	4,021
1990	-	-	-	1,273
1991	-	-	-	781
1992	-	-	-	158
1993	-	-	-	1,722
1994	-	-	-	5,459
1995	-	-	-	17,564
1996	-	-	-	32,294
1997	-	-	-	21,607
1998	-	-	-	25,529
1999	-	-	-	33,622
2000	67,252	-	67,252	14,751
2001	24,637	-	24,637	24,817
2002	24,603	-	24,603	24,296
2003	12,726	-	12,726	17,144
2004	30,407	-	30,407	11,292
2005	34,311	168	34,479	15,025
2006	35,279	5	35,284	11,837
2007	54,257	648	54,905	14,805
2008	21,118	69	21,187	15,098
2009	65,269	21	65,290	18,313
2010	56,007	2	56,009	13,408
2011	25,799	22	25,821	17,930
2012	137,495	84	137,579	10,591
2013	20,390	-	20,390	16,500
2014	7,740	166	7,906	16,334
2015	10,386	215	10,601	4,121
2016	54,335	36	54,371	18,230
2017	48,007	59	48,066	11,923
2018	650	2	652	7,258

Year	Boat-Based Creel Survey Estimates	Shore-Based Creel Survey Estimates	Total Creel Survey Estimates	Commercial Landings
2019	21,012	2	21,014	15,697
2020	45,547	36	45,583	20,094
2021	73,861	739	74,600	40,903
2022	47,191	192	47,383	32,205
2023	10,064	114	10,178	5,313
10-yr avg.	**31,879**	**156**	**33,075**	**17,208**
10-yr SD	**23,584**	**208**	**22,946**	**11,129**
20-yr avg.	**39,956**	**143**	**40,222**	**15,844**
20-yr SD	**29,928**	**206**	**29,856**	**8,187**

'-' indicates no data are available; 'n.d.' indicates that data are non-disclosed due to confidentiality rules.

1.1.5.2 EXPANDED CATCH ESTIMATES BY FISHING METHOD

Catch information is provided for the top boat-based fishing methods that comprise most of the annual BMUS catch in CNMI.

Calculations: The creel survey catch time series are the sum of the estimated weight for selected gear in all strata for all species all BMUS species.

Table 6. Total catch time series estimates (lb) for all species and BMUS only using CNMI expanded boat-based creel survey data for bottomfish fishing gears

Year	Bottomfish		Spearfishing (Snorkel)	
	All	BMUS	All	BMUS
2000	99,106	62,990	27,918	4,262
2001	40,556	24,574	8,693	63
2002	37,621	23,945	9,990	159
2003	15,406	12,547	5,528	178
2004	40,060	30,407	7,452	-
2005	48,699	34,266	6,567	46
2006	61,157	34,951	8,553	15
2007	83,677	54,059	11,849	198
2008	51,075	19,744	15,516	1,334
2009	99,523	64,979	18,801	217
2010	82,211	56,007	5,814	-
2011	60,432	25,799	7,289	-
2012	157,445	137,495	8,513	-
2013	34,954	20,390	2,456	-
2014	15,291	7,740	2,257	-
2015	17,554	10,374	4,820	-
2016	56,983	53,906	-	-
2017	50,177	47,883	-	-

Year	Bottomfish		Spearfishing (Snorkel)	
	All	BMUS	All	BMUS
2018	4,347	90	4,087	-
2019	25,556	16,831	10,486	-
2020	73,773	45,358	6,892	189
2021	89,963	70,013	31,608	32
2022	68,088	46,582	33,895	374
2023	20,075	9,673	16,019	192
10-yr avg.	**42,181**	**30,845**	**11,006**	**79**
10-yr SD	**27,859**	**23,147**	**11,814**	**123**
20-yr avg.	**57,052**	**39,327**	**10,144**	**130**
20-yr SD	**34,719**	**29,931**	**9,003**	**295**

'-' indicates no data are available.

1.1.5.3 TOP AND PRIORITIZED ECS IN BOAT-BASED FISHERY CATCH

Catch can act as an indicator of fishery performance. Variations in the catch can be attributed to several factors, and there is no single explanatory variable for the observed trends. A one-year reflection of the top ten harvested species (by weight) is included to monitor which ECS are being caught the most annually. Additionally, CNMI DFW selected seven species that were reclassified as ECS that are still of priority to CNMI DFW for regular monitoring, and complete catch time series of these species are included in the report as well.

Calculations: Catch tallied from the boat-based expanded species composition data combining gear types for all species excluding BMUS and pelagic MUS species.

Table 7a. Top ten landed species (lb) in CNMI ECS fisheries from expanded boat-based creel survey data in 2023

Common Name	Scientific Name	Catch
Bigeye scad	*Selar crumenophthalmus*	6,851
Surgeonfish (misc.)	Acanthuridae (family)	3,029
Bluespine unicornfish	*Naso unicornis*	2,783
Yellowtail kalikali	*Pristipomoides auricilla*	2,261
Gibbus parrotfish	*Chlorurus microrhinos*	2,235
Pacific longnose parrotfish	*Hipposcarus longiceps*	1,357
Gold spotted rabbitfish	*Siganus punctatus*	1,273
Yellowmargin triggerfish	*Pseudobalistes flavimarginatus*	1,224
Blackspot emperor	*Lethrinus harak*	996
Longnose emperor	*Lethrinus olivaceus*	772

Calculations: Catch tallied from commercial receipt data combining gear types for all species excluding BMUS and pelagic MUS species.

Table 7b. Top ten landed species (lb) in CNMI ECS fisheries from commercial landings data in 2023

Common Name	Scientific Name	Catch
Bigeye scad	*Selar crumenophthalmus*	9,687
Parrot/palakse/la (misc.)	Scaridae (family)	6,629
Emperor/mafute (misc.)	Lethrinidae (family)	5,224
Surgeonfish (misc.)	Acanthuridae (family)	2,215
Jacks (misc.)	Carangidae (family)	1,181
Rabbitfishes	*Siganus* spp.	1,140
Unicornfish (misc.)	*Naso* spp.	1,013
Rudderfish/guili	*Kyphosus* spp.	952
Goatfish/satmoneti (misc.)	Mullidae (family)	929
Grouper (misc.)	Serranidae (family)	702

Calculations: Catch tallied from boat-based expanded species composition data for species identified as priority ECS by DFW (Appendix A).

Table 8a. Catch (lb) from expanded boat-based creel survey data for prioritized species in CNMI ECS fisheries

Year	*Acanthurus lineatus*	*Naso lituratus*	*Naso unicornis*	*Scarus ghobban*	*Lethrinus harak*	*Siganus argenteus*	*Mulloidichthys flavolineatus*
2000	-	1,189	43	-	-	-	955
2001	-	849	222	-	-	-	136
2002	-	2,238	981	-	-	-	1,034
2003	345	1,125	965	-	-	136	227
2004	601	458	323	-	-	-	11
2005	339	451	250	-	-	272	-
2006	249	375	1,662	-	-	2,676	28
2007	200	1,139	1,125	-	-	4,640	114
2008	-	636	135	-	-	7,318	317
2009	-	3,555	524	-	-	8,996	1,385
2010	-	600	-	-	-	1,063	615
2011	40	81	1,611	-	-	1,648	-
2012	155	190	-	-	-	6,941	-
2013	-	77	-	-	-	1,224	-
2014	34	223	-	-	-	1,819	736
2015	87	383	64	-	48	386	29
2016	-	-	-	-	-	408	-
2017	-	-	-	-	-	45	-
2018	-	412	-	-	-	1,896	489
2019	-	346	-	-	-	1,979	-
2020	113	1,382	2,186	-	-	5,387	-
2021	3,363	5,735	1,051	80	16	3,297	284

Year	*Acanthurus lineatus*	*Naso lituratus*	*Naso unicornis*	*Scarus ghobban*	*Lethrinus harak*	*Siganus argenteus*	*Mulloidichthys flavolineatus*
2022	872	4,788	4,712	13	-	1,782	548
2023	46	44	2,783	-	431	996	258
10-year avg.	**452**	**1,331**	**1,080**	**9**	**50**	**1,800**	**234**
10-year SD	**1,057**	**2,121**	**1,639**	**25**	**135**	**1,592**	**275**
20-year avg.	**305**	**1,044**	**821**	**5**	**25**	**2,639**	**241**
20-year SD	**755**	**1,650**	**1,245**	**18**	**96**	**2,643**	**361**

'-' indicates no data are available.

Calculations: Catch tallied from commercial purchase data for species identified as priority ECS by DFW (Appendix A). From the prioritized ECS list, *Scarus ghobban* is not included because there is no specific code for that species in the CNMI commercial coding system.

Table 8b. Catch (lb) from commercial purchase data for prioritized species in CNMI ECS fisheries

Year	*Acanthurus lineatus*	*Naso lituratus*	*Naso unicornis*	*Lethrinus harak*	*Siganus argenteus*	*Mulloidichthys flavolineatus*
1983	0	0	0	0	7,644	0
1983	0	0	0	0	7,644	0
1984	0	0	0	0	9,792	0
1985	n.d.	n.d.	n.d.	n.d.	3,826	n.d.
1986	n.d.	n.d.	n.d.	n.d.	7,271	n.d.
1987	0	0	0	0	4,061	0
1988	0	0	0	0	6,653	0
1989	0	0	0	0	8,434	0
1990	0	0	0	0	5,678	0
1991	0	0	0	0	3,867	0
1992	0	0	0	0	3,151	0
1993	0	0	0	0	1,603	0
1994	0	0	0	0	2,181	0
1995	0	0	0	0	904	0
1996	0	1,434	0	0	1,338	0
1997	0	3,173	0	0	1,093	0
1998	0	106	0	0	5,956	0
1999	0	1,756	0	0	6,442	0
2000	0	4,883	0	0	12,677	0
2001	0	4,500	0	0	8,408	0
2002	0	1,041	0	0	9,141	0
2003	0	143	0	0	7,161	0
2004	0	2	0	0	3,714	0
2005	0	64	0	0	2,571	0
2006	0	70	0	0	8,354	0
2007	0	426	0	0	5,909	0

Year	*Acanthurus lineatus*	*Naso lituratus*	*Naso unicornis*	*Lethrinus harak*	*Siganus argenteus*	*Mulloidichthys flavolineatus*
2008	0	323	0	0	2,599	0
2009	0	313	0	0	1,312	0
2010	717	1,190	462	0	1,880	0
2011	0	2,804	1,804	0	2,313	0
2012	0	451	0	0	1,467	0
2013	0	759	0	0	2,331	0
2014	0	1,827	0	0	2,329	0
2015	0	1,380	0	0	1,569	0
2016	0	1,018	0	0	2,319	0
2017	0	1,664	0	0	3,063	18
2018	0	415	0	0	1,008	0
2019	0	320	0	0	293	0
2020	0	2,887	0	0	390	0
2021	33	6,478	2,962	0	5,883	0
2022	498	7,594	5,340	0	5,949	0
2023	0	1,929	564	0	548	0
10-yr avg.	**53**	**2,551**	**887**	**0**	**2,335**	**2**
10-yr SD	**157**	**2,493**	**1,818**	**0**	**2,100**	**6**
20-yr avg.	**62**	**1,596**	**557**	**0**	**2,790**	**1**
20-yr SD	**190**	**2,059**	**1,355**	**0**	**2,159**	**4**

'n.d.' indicates that data are non-disclosed due to confidentiality rules.

1.1.6 CATCH-PER-UNIT-EFFORT (CPUE) STATISTICS

This section summarizes the estimates for CPUE in the boat-based BMUS fisheries. The boat-based fisheries include the bottomfish fishing (handline gear) and spearfishing (snorkel). CPUE is reported as pounds per gear hour in the boat-based fishery.

Calculations**:** CPUE is calculated from interview data by gear type using ∑catch /∑(number of gears used*number of hours fished) or ∑catch /∑trips for boat-based data. If the value is blank (i.e., zero), then there was no interview collected for that method. Landings from interviews without fishing hours or number of gears are excluded from the calculations.

All - lb/trip: All catch and trips are tallied from landings by gear level, including non-BMUS species.

All - lb/gr-hr.: All catch and trips are tallied from trips with data on the number of gears used and numbers of hours fished, including non-BMUS species.

BMUS - lb/trip: Only BMUS catch and trips that landed BMUS species are tallied from landings by gear level.

BMUS - lb/gr-hr.: Only BMUS catch and trips that landed BMUS are tallied from trips with data on the number of gears used and numbers of hours fished.

Table 9. Non-expanded CPUE (lb/trip and lb/gear hour) for bottomfish fishing gears in the CNMI boat-based fishery for all species and BMUS only

Year	Bottomfish				Spearfishing (Snorkel)			
	All		BMUS		All		BMUS	
	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr
2000	50	4.44	55	4.76	35	2.43	64	5.33
2001	17	1.64	21	1.89	19	1.48	2	0.11
2002	28	2.22	32	2.35	20	1.55	3	0.38
2003	21	1.76	21	1.64	29	2.07	4	0.29
2004	25	2.03	20	1.55	15	0.91	-	-
2005	26	2.01	26	1.72	21	1.82	1	0.15
2006	18	1.43	17	1.22	12	1.25	1	0.10
2007	28	2.65	28	2.42	15	1.05	2	0.12
2008	16	1.03	13	0.88	21	1.19	6	0.23
2009	19	0.77	34	1.47	21	1.39	3	0.08
2010	12	0.40	11	0.39	15	1.32	-	-
2011	11	0.34	16	0.54	38	2.76	-	-
2012	108	8.83	156	9.85	13	1.03	-	-
2013	46	4.30	44	3.59	20	1.33	-	-
2014	18	1.87	32	3.63	33	1.89	-	-
2015	34	2.77	43	3.00	19	3.26	-	-
2016	69	5.28	78	5.68	-	-	-	-
2017	81	8.16	115	12.97	-	-	-	-
2018	5	0.41	1	0.14	9	0.88	-	-
2019	26	2.19	23	2.42	10	0.83	-	-
2020	28	2.03	29	1.89	14	0.84	2	0.09
2021	39	2.73	41	2.51	41	2.11	2	0.05
2022	40	4.19	38	3.84	42	3.03	6	0.58
2023	19	1.47	18	1.15	27	2.11	2	0.09
10-yr avg.	**36**	**3.11**	**42**	**3.72**	**24**	**1.87**	**3**	**0.20**
10-yr SD	**22**	**2.12**	**31**	**3.40**	**12**	**0.90**	**2**	**0.22**
20-yr avg.	**33**	**2.74**	**39**	**3.04**	**21**	**1.61**	**3**	**0.17**
20-yr SD	**25**	**2.31**	**36**	**3.12**	**10**	**0.75**	**2**	**0.15**

'-' indicates no data are available.

1.1.7 EFFORT STATISTICS

This section summarizes the effort trends in the CNMI bottomfish fishery. Fishing effort trends provide insights on the level of fishing pressure through time. Effort information is provided for the top boat-based fishing methods that comprise most of the annual catch.

Calculations: Effort estimates (in both trips and gear hours) are calculated from boat-based interview data. Trips are tallied according to the interview data in boat-based creel surveys. Gear hours are generated by summing the data on number of gears used*number of hours fished collected from interviews by gear type. For the boat-based estimates, data collection started in 2000.

All - Trips: All trips tallied by gear type.

All - Gear-hr: Gear hours tallied by gear type.

BMUS - Trips: Trips that landed BMUS tallied by gear type.

BMUS - Gr-hr: Gear hours tallied by gear type for trips landed BMUS with data on both number of gears used and numbers of hours fished.

Table 10. Non-expanded effort (trips and gear hours) for bottomfish fishing gears in the CNMI boat-based fishery for all species and BMUS only

Year	Bottomfish				Spear Snorkel			
	All		BMUS		All		BMUS	
	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr
2000	35	392	24	276	13	186	1	12
2001	50	529	20	221	14	181	1	18
2002	40	505	22	299	12	156	1	8
2003	34	403	25	323	8	112	2	28
2004	53	656	45	579	17	274	0	0
2005	124	1,600	85	1,285	25	286	3	27
2006	101	1,248	59	810	27	253	1	10
2007	81	852	48	552	32	464	4	66
2008	57	881	23	351	9	159	3	78
2009	100	1,901	34	488	19	280	2	24
2010	116	3,510	63	1,743	5	56	0	0
2011	134	4,439	37	1,097	4	55	0	0
2012	26	318	16	253	10	124	0	0
2013	29	309	16	197	5	74	0	0
2014	17	160	6	52	3	53	0	0
2015	14	170	7	100	4	23	0	0
2016	20	263	16	219	0	0	0	0
2017	13	127	7	61	0	0	0	0
2018	12	140	2	14	4	41	0	0
2019	13	156	9	85	2	23	0	0
2020	51	710	30	463	8	130	2	35
2021	101	1,349	67	995	21	364	2	76

Year	Bottomfish				Spear Snorkel			
	All		BMUS		All		BMUS	
	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr
2022	51	486	37	368	17	235	2	19
2023	31	392	19	295	12	151	2	34
10-yr avg.	**32**	**395**	**20**	**265**	**7**	**102**	**1**	**16**
10-yr SD	**27**	**365**	**19**	**282**	**7**	**114**	**1**	**24**
20-yr avg.	**57**	**983**	**31**	**500**	**11**	**152**	**1**	**18**
20-yr SD	**41**	**1128**	**23**	**455**	**9**	**130**	**1**	**26**

1.1.8 PARTICIPANTS

This section summarizes the estimated participation in the bottomfish fishery. The information presented here can be used in the impact analysis of potential amendments in the FEPs associated with the bottomfish fisheries. The trend in participation over time can also be used as an indicator for fishing pressure.

Calculations: For boat-based data, the estimated number of unique vessels is calculated by tallying the number of vessels recorded in the interview data via vessel registration or name.

All: Total unique vessels by gear type.

BMUS: Unique vessels from trips that landed BMUS by gear type.

Table 11a. Non-expanded number of unique vessels for bottomfish fishing gears in the CNMI boat-based fishery for all species and BMUS only

Year	Bottomfish		Spearfishing (Snorkel)	
	All	BMUS	All	BMUS
2000	24	18	12	1
2001	35	15	10	1
2002	25	15	11	1
2003	22	15	6	2
2004	29	24	13	0
2005	67	51	22	3
2006	60	42	18	1
2007	58	36	26	4
2008	40	22	9	3
2009	55	27	16	2
2010	26	19	5	0
2011	31	15	4	0
2012	23	15	9	0
2013	25	15	4	0
2014	14	5	3	0
2015	12	6	4	0
2016	16	13	0	0

Year	Bottomfish		Spearfishing (Snorkel)	
	All	BMUS	All	BMUS
2017	12	6	0	0
2018	11	2	3	0
2019	12	8	2	0
2020	44	27	8	2
2021	87	58	17	2
2022	31	20	13	2
2023	29	19	12	2
10-yr avg.	**27**	**16**	**6**	**1**
10-yr SD	**23**	**16**	**6**	**1**
20-yr avg.	**34**	**22**	**9**	**1**
20-yr SD	**21**	**15**	**7**	**1**

Calculations: For boat-based data, the estimated number of fishermen per trip is calculated by filtering interviews that recorded the number of fishers, and then ∑fishers/∑trips.

All: Average fishers from all trips by gear type.

BMUS: Average fishers from trips that landed BMUS by gear type.

Table 11b. Non-expanded average number of fishers per trip for bottomfish fishing gears in the CNMI boat-based fishery for all species and BMUS only

Year	Bottomfish		Spearfishing (Snorkel)	
	All	BMUS	All	BMUS
2000	4	3	4	8
2001	3	3	3	2
2002	4	4	3	2
2003	5	5	3	2
2004	4	5	4	0
2005	5	5	3	2
2006	4	4	3	3
2007	3	3	3	3
2008	6	6	4	4
2009	10	6	4	3
2010	21	19	2	0
2011	21	17	3	0
2012	2	2	4	0
2013	2	2	2	0
2014	2	2	3	0
2015	2	2	2	0
2016	2	2	0	0
2017	2	2	0	0
2018	3	5	3	0

Year	Bottomfish		Spearfishing (Snorkel)	
	All	BMUS	All	BMUS
2019	2	2	3	0
2020	2	2	3	4
2021	2	2	4	6
2022	2	2	3	3
2023	3	3	3	3
10-yr avg.	**2**	**2**	**2**	**2**
10-yr SD	**0**	**1**	**1**	**2**
20-yr avg.	**5**	**5**	**3**	**2**
20-yr SD	**6**	**5**	**1**	**2**

1.1.9 BYCATCH ESTIMATES

This section focuses on Magnuson-Stevens Fishery Conservation and Management Act (MSA) § 303(a)(11), which requires that all FMPs establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery, and include conservation and management measures that, to the extent practicable, minimize bycatch and bycatch mortality. The MSA § 303(a)(11) standardized reporting methodology is commonly referred to as a ''Standardized Bycatch Reporting Methodology'' (SBRM) and was added to the MSA by the Sustainable Fisheries Act of 1996 (SFA). The Council implemented omnibus amendments to FMPs in 2003 to address MSA bycatch provisions and established SBRMs at that time.

The following are recent bycatch estimates for the boat-based BMUS and non-BMUS fisheries. The bycatch estimates presented here are self-reported by fishers during creel survey interviews, and thus, the data are likely biased downward.

Calculations: The number caught is the sum of the total number of individuals found in the raw data including bycatch. The number discarded or released is number of individuals marked as bycatch. Percent bycatch is the sum of all released divided by the number caught.

Table 12. Non-expanded catch and bycatch in the CNMI boat-based BMUS and non-BMUS fisheries

Year	BMUS			Non-BMUS			BMUS + Non-BMUS		
	# Caught	# Discard / Release	% Bycatch	# Caught	# Discard / Release	% Bycatch	# Caught	# Discard / Release	% Bycatch
2000	493	12	2.43	325	9	2.77	818	21	2.57
2001	268	0	0.00	663	1	0.15	931	1	0.11
2002	474	0	0.00	430	14	3.26	904	14	1.55
2003	627	3	0.48	250	33	13.20	877	36	4.10
2004	756	0	0.00	623	20	3.21	1,379	20	1.45
2005	2,206	4	0.18	1,019	0	0.00	3,225	4	0.12
2006	874	0	0.00	971	3	0.31	1,845	3	0.16
2007	1,325	0	0.00	785	0	0.00	2,110	0	0.00
2008	241	0	0.00	917	0	0.00	1,158	0	0.00

Year	BMUS			Non-BMUS			BMUS + Non-BMUS		
	# Caught	# Discard / Release	% Bycatch	# Caught	# Discard / Release	% Bycatch	# Caught	# Discard / Release	% Bycatch
2009	596	0	0.00	1,183	0	0.00	1,779	0	0.00
2010	614	0	0.00	860	0	0.00	1,474	0	0.00
2011	482	0	0.00	1,252	0	0.00	1,734	0	0.00
2012	456	0	0.00	326	0	0.00	782	0	0.00
2013	519	0	0.00	338	0	0.00	857	0	0.00
2014	57	0	0.00	159	0	0.00	216	0	0.00
2015	102	0	0.00	94	0	0.00	196	0	0.00
2016	636	0	0.00	85	0	0.00	721	0	0.00
2017	120	0	0.00	194	0	0.00	314	0	0.00
2018	6	0	0.00	101	0	0.00	107	0	0.00
2019	139	0	0.00	105	0	0.00	244	0	0.00
2020	516	0	0.00	692	0	0.00	1,208	0	0.00
2021	913	0	0.00	568	2	0.35	1,481	2	0.14
2022	561	0	0.00	439	0	0.00	1,000	0	0.00
2023	124	0	0.00	229	0	0.00	353	0	0.00
10-yr avg.	**317**	**0**	**0.00**	**267**	**0**	**0.04**	**584**	**0**	**0.01**
10-yr SD	**296**	**0**	**0.00**	**209**	**1**	**0.11**	**463**	**1**	**0.04**
20-yr avg.	**562**	**0**	**0.01**	**547**	**1**	**0.19**	**1,109**	**1**	**0.09**
20-yr SD	**501**	**1**	**0.04**	**382**	**4**	**0.70**	**779**	**4**	**0.32**

1.1 PROTECTED SPECIES

This section of the report summarizes information on protected species interactions in fisheries managed under the Mariana FEP. Protected species covered in this report include sea turtles, seabirds, marine mammals, sharks, and corals. Most of these species are protected under the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and/or the Migratory Bird Treaty Act (MBTA). A list of protected species found in or near Mariana Archipelago waters and a list of critical habitat designations in the Pacific Ocean are included in Appendix B.

1.1.1 INDICATORS FOR MONITORING PROTECTED SPECIES INTERACTION

This report monitors the status of protected species interactions in the Marianas FEP fisheries using proxy indicators such as fishing effort, and changes in gear types as these fisheries do not have observer coverage. Creel surveys and logbook programs are not expected to provide reliable data about protected species interactions. Discussion of protected species interactions is focused on fishing operations in federal waters and associated transit through territorial waters.

1.1.2 FEP CONSERVATION MEASURES

Bottomfish, precious coral, coral reef and crustacean fisheries managed under this FEP have no specific regulations in place to mitigate protected species interactions. Destructive gear such as bottom trawls, bottom gillnets, explosives, and poisons are prohibited under this FEP, and these prohibitions benefit protected species by preventing potential interactions with non-selective fishing gear.

1.1.2.1 ESA CONSULTATIONS

ESA consultations were conducted by NMFS and the U.S. Fish and Wildlife Service (USFWS; for species under their jurisdiction) to ensure ongoing fisheries operations managed under the Marianas FEP are not jeopardizing the continued existence of any ESA-listed species or adversely modifying critical habitat. The results of these consultations conducted under section 7 of the ESA are briefly described below and summarized in Table 1.

NMFS concluded in an informal consultation dated April 29, 2015 that all fisheries managed under the Mariana Archipelago FEP are not likely to adversely affect the Indo-West Pacific DPS of scalloped hammerhead shark or ESA-listed reef-building corals.

Table 1. Summary of ESA consultations for Mariana Archipelago FEP Fisheries

Fishery	Consultation date	Consultation type[a]	Outcome[b]	Species
All fisheries	4/29/2015	LOC	NLAA	Reef-building corals, scalloped hammerhead shark (Indo-west Pacific DPS)
Bottomfish (CNMI & Guam)	3/8/2008	BiOp	NLAA	Loggerhead sea turtle
	6/3/2008	LOC	NLAA	Green sea turtle, olive ridley sea turtle, hawksbill sea turtle, leatherback sea turtle, blue whale, fin whale, humpback whale, sei whale sperm whale
	8/26/2022	BiOp	LAA, non-jeopardy	Oceanic whitetip shark
			NLAA	
Coral reef ecosystem (CNMI & Guam)	3/7/2002	LOC	NLAA	Loggerhead sea turtle, leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, sei whale, sperm whale
	5/22/2002	LOC (USFWS)	NLAA	Green, hawksbill, leatherback, loggerhead and olive ridley turtles, Newell's shearwater, short-tailed albatross, Laysan duck, Laysan finch, Nihoa finch, Nihoa millerbird, Micronesian megapode, 6 terrestrial plants
	6/3/2008	LOC	NLAA	Green sea turtle, olive ridley sea turtle, hawksbill sea turtle, leatherback sea turtle, blue whale, fin whale, humpback whale, sei whale, sperm whale
	9/18/2018	No effect memo	No effect	Oceanic whitetip shark, giant manta ray
Crustaceans (CNMI & Guam)	9/28/2007	LOC	NLAA	Green sea turtle, loggerhead sea turtle, olive ridley sea turtle, hawksbill sea turtle, leatherback sea turtle, blue whale, humpback whale, sei whale, sperm whale
	9/18/2018	No effect memo	No effect	Oceanic whitetip shark, giant manta ray
Precious corals (CNMI & Guam)	10/4/1978	BiOp	Does not constitute threat	Sperm whale, leatherback sea turtle
	9/18/2018	No effect memo	No effect	Oceanic whitetip shark, giant manta ray

Fishery	Consultation date	Consultation type[a]	Outcome[b]	Species
Precious corals (Guam)	12/20/2000	LOC	NLAA	Humpback whale, green sea turtle, hawksbill sea turtle

[a] BiOp = Biological Opinion; LOC = Letter of Concurrence; BE = Biological Evaluation
[b] LAA = likely to adversely affect; NLAA = not likely to adversely affect.

1.1.2.1.1 Bottomfish Fishery

In a Biological Opinion issued on March 8, 2002, NMFS concluded that the ongoing operation of the Western Pacific Region's bottomfish and seamount fisheries was not likely to jeopardize the continued existence of any threatened or endangered species under NMFS's jurisdiction or destroy or adversely modify any critical habitat. In an informal consultation on June 3, 2008, NMFS concluded that Mariana Archipelago bottomfish fisheries are not likely to adversely affects four sea turtle species (leatherback, olive ridley, green, and hawksbill turtles) and five marine mammal species (humpback, blue, fin, sei, and sperm whales).

On August 26, 2022, NMFS completed a new BiOp that was initiated in response to the ESA listing of the oceanic whitetip shark, chambered nautilus, and giant manta ray. This BiOp did not re-evaluate species previously consulted on because NMFS determined that reinitiation has not been triggered for those species in a Biological Evaluation dated June 5, 2019. NMFS determined that both the Guam and CNMI bottomfish fishery are not likely to adversely affect giant manta rays or chambered nautilus. For oceanic whitetip sharks, NMFS determined that the continued operation of both the Guam and CNMI bottomfish activities would adversely affect the threatened sharks, but determined that the activities are not likely to jeopardize their continued existence. Both bottomfish fisheries incidentally take oceanic whitetip sharks. To monitor the amount of take NMFS established an Incidental Take Statement (ITS) for each fishery as one shark over any five consecutive years for Guam and four sharks over any five consecutive years for CNMI. If the ITS is exceeded, NMFS will reinitiate formal consultation.

1.1.2.1.2 Crustacean Fishery

In an informal consultation completed on September 28, 2007, NMFS concluded that Mariana Archipelago crustacean fisheries are not likely to adversely affect five sea turtle species (loggerhead, leatherback, olive ridley, green, and hawksbill turtles) and five marine mammal species (humpback, blue, fin, sei, and sperm whales).

On September 18, 2018, NMFS concluded that Mariana Archipelago crustacean fisheries will have no effect on the oceanic whitetip shark and giant manta ray.

1.1.2.1.3 Coral Reef Fishery

In an informal consultation completed by NMFS on March 7, 2002, NMFS concluded that fishing activities conducted under the Coral Reef Ecosystems FMP are not likely to adversely affect endangered or threatened species or critical habitat under NMFS's jurisdiction. On May 22, 2002, the USFWS concurred with the determination of NMFS that the activities conducted under the Coral Reef Ecosystems FMP are not likely to adversely affect listed species under USFWS's exclusive jurisdiction (i.e., seabirds) and listed species shared with NMFS (i.e., sea turtles).

In an informal consultation completed on June 3, 2008, NMFS concluded that the Mariana Archipelago coral reef fisheries are not likely to adversely affect four sea turtle species (leatherback, olive ridley, green, and hawksbill turtles) and five marine mammal species (humpback, blue, fin, sei, and sperm whales).

On September 18, 2018, NMFS concluded that Mariana Archipelago coral reef fisheries will have no effect on the oceanic whitetip shark and giant manta ray.

1.1.2.1.4 Precious Coral Fishery

In a Biological Opinion issued on October 4, 1978, NMFS concluded that the ongoing operation of the Western Pacific Region's precious coral fisheries was not likely to jeopardize the continued existence of any threatened or endangered species under NMFS's jurisdiction or destroy or adversely modify critical habitat. In an informal consultation completed on December 20, 2000, NMFS concluded that Mariana Archipelago precious coral fisheries are not likely to adversely affect humpback whales, green turtles, or hawksbill turtles.

On September 18, 2018, NMFS concluded that Mariana Archipelago precious coral fisheries will have no effect on the oceanic whitetip shark and giant manta ray.

1.1.2.2 NON-ESA MARINE MAMMALS

The MMPA requires NMFS to annually publish a List of Fisheries (LOF) that classifies commercial fisheries in one of three categories based on the level of mortality and serious injury of marine mammals associated with that fishery. According to the 2024 LOF (89 FR 12257, February 16, 2024) the Guam and CNMI bottomfish fisheries operating under the Marianas FEP are classified as Category III fisheries (i.e., a remote likelihood of or no known incidental mortality and serious injury of marine mammals).

1.1.3 STATUS OF PROTECTED SPECIES INTERACTIONS IN THE MARIANAS FEP FISHERIES

1.1.3.1 BOTTOMFISH FISHERIES

1.1.3.1.1 Sea Turtle, Marine Mammal, and Seabird Interactions

There are no observer data available for the Guam and CNMI bottomfish fisheries. However, based on current ESA consultations, these fisheries are not expected to interact with any ESA-listed sea turtle, marine mammal, or seabird species in federal waters around Guam or CNMI. NMFS has also concluded that the Mariana Archipelago commercial bottomfish fisheries will not affect marine mammals in any manner not considered or authorized under the MMPA.

Based on fishing effort and other characteristics described in Chapter 1 of this report, no notable changes have been observed in the fishery. There is no other information to indicate that impacts to sea turtle, marine mammal, or seabird species from this fishery have changed in recent years.

1.1.3.1.2 Elasmobranch Interactions

As indicated in Section 1.1.2.1, ESA consultation for newly listed elasmobranch species was completed in 2022. To meet the requirements of the new BiOp for the Marianas bottomfish fisheries, ITS for oceanic whitetip sharks will be monitored on an annual basis to serve as a check for the reinitiation trigger. Available information on elasmobranch interactions in the Guam and CNMI bottomfish fishery are included here.

There is limited data on fishery interactions with oceanic white tip sharks in Pacific Island bottomfish fisheries. Where data exists, some datasets identified oceanic whitetip shark captures to the species level, while others categorized oceanic whitetip sharks and whitetip reef sharks as “whitetip shark.” Guam and CNMI bottomfish boat-based creel surveys indicate that fishermen catch whitetip reef sharks more frequently than oceanic whitetip sharks.

From 1982 to 2017, Guam DAWR recorded 39 whitetip reef sharks and 3 oceanic whitetip sharks in the Guam boat-based creel survey (NMFS 2019). No additional interactions with oceanic whitetip sharks have been reported since 2013 for the Guam bottomfish fishery.

There have been no records of oceanic whitetip sharks in the CNMI boat-based creel surveys administered by CNMI DFW since the start of the dataset in 2000. The federal commercial bottomfish logbook form in the CNMI has a write-in space for recording catch by species under the shark category. Between 2009, when logbooks were implemented, and 2017, fishermen recorded 33 sharks as “whitetip shark”, which may be whitetip reef sharks or oceanic whitetip sharks. Based on catch composition associated with the whitetip shark captures, most records were associated with shallow-water fish species captures, which are more likely to be whitetip reef sharks. Twelve of the 33 whitetip shark captures were associated with deep-water bottomfish species, which could potentially be oceanic whitetip sharks (NMFS 2019). No additional interactions with oceanic whitetip sharks or unidentified whitetip sharks have been reported in the last five years in the CNMI bottomfish fishery.

Table 2. The number of oceanic whitetip shark interactions expected, including unidentified sharks, as calculated by the 2022 BiOp, representing the ITS, with the reported number of interactions based on the best scientific data as described above.

Territory	**ITS**	**Reported number in the last five consecutive calendar years**
Guam	1	0
CNMI	4	0

While bottomfish fishing surveys in the main Hawaiian Islands (PIFSC unpublished survey) and Guam (Kendall Enterprise Inc. 2014) show records of whitetip reef shark captures, there have not been any oceanic whitetip sharks recorded in bottomfish surveys or other PIFSC research activities. In addition to the bottomfish surveys, PIFSC researchers have conducted limited bottomfish fishing in the Pacific Islands region for life history research purposes since 2007. They typically fish once to twice a year and land a maximum of 1,200 kg of bottomfish each time they fish. In the last five years (2013-2018), there was one trip each to Johnston Atoll, the CNMI, Guam, and American Samoa, and Samoa. There are no records of researchers catching oceanic whitetip sharks while conducting these activities. There was one record in Guam of an oceanic whitetip shark depredating hooked fish but did not become hooked or entangled on the line (NMFS 2019).

1.1.3.2 CORAL REEF FISHERIES

There are no observer data available for the Guam and CNMI coral reef fisheries. However, based on current ESA consultations, these fisheries are not expected to interact with any ESA-listed species in federal waters around Guam or CNMI. NMFS has also concluded that the Mariana Archipelago commercial coral reef fisheries will not affect marine mammals in any manner not considered or authorized under the MMPA.

Based on fishing effort and other characteristics described in Chapter 1 of this report, no notable changes have been observed in the fishery. There is no other information to indicate that impacts to protected species from this fishery have changed in recent years.

1.1.3.3 CRUSTACEAN AND PRECIOUS CORAL FISHERIES

There are currently no crustacean or precious coral fisheries operating in federal waters around Guam or CNMI. However, based on current ESA consultations, crustacean fisheries are not expected to interact with any ESA-listed species in federal waters around Guam or CNMI. NMFS has also concluded that the Mariana Archipelago crustacean and precious coral commercial fisheries will not affect marine mammals in any manner not considered or authorized under the MMPA.

1.1.4 IDENTIFICATION OF EMERGING ISSUES

Table 3 summarizes current candidate ESA species, recent listing status, and post-listing activity (critical habitat designation and recovery plan development). Impacts from FEP-managed fisheries on any new listings and critical habitat designations will be considered in future versions of this report.

Table 3. Status of candidate ESA species, recent ESA listing processes, and post-listing activities

Species		Listing Process			Post-Listing Activity	
Common Name	**Scientific Name**	**90-Day Finding**	**12-Month Finding / Proposed Rule**	**Final Rule**	**Critical Habitat**	**Recovery Plan**
Oceanic whitetip shark	*Carcharhinus longimanus*	Positive (81 FR 1376, 1/12/2016)	Positive, threatened (81 FR 96304, 12/29/2016)	Listed as threatened (83 FR 4153, 1/30/18)	Designation not prudent; no areas within U.S. jurisdiction that meet definition of critical habitat (85 FR 12898, 3/5/2020)	Draft Recovery Plan published January 25, 2023 (88 FR 4817)
Giant manta ray	*Manta birostris*	Positive (81 FR 8874, 2/23/2016)	Positive, threatened (82 FRN 3694, 1/12/2017)	Listed as threatened (83 FR 2916, 1/22/18)	Designation not prudent; no areas within U.S. jurisdiction that meet definition of critical habitat (84 FR 66652, 12/5/2019)	Recovery outline published 12/4/19 to serve as interim guidance until full recovery plan is developed; recovery planning workshop planned for 2021.
Corals	N/A	Positive for 82 species (75 FR 6616, 2/10/2010)	Positive for 66 species (77 FR 73219, 12/7/2012)	20 species listed as threatened (79 FR 53851, 9/10/2014)	Critical habitat proposed (85 FR 76262, 11/27/2021, withdrawn), Critical habitat proposed (88 FR 83644, November 30, 2023)	In development, interim recovery outline in place; recovery workshops convened in May 2021.
Giant Clams	*Hippopus, H. porcellanus, Tridacna costata, T. derasa, T. gigas, T. Squamosa,* and *T. tevoroa*	Positive (82 FR 28946, 06/26/2017)	TBA (status review ongoing)	TBA	N/A	N/A

Species		Listing Process			Post-Listing Activity	
Common Name	Scientific Name	90-Day Finding	12-Month Finding / Proposed Rule	Final Rule	Critical Habitat	Recovery Plan
Green sea turtle	*Chelonia mydas*	Positive (77 FR 45571, 8/1/2012)	Identification of 11 DPSs, endangered and threatened (80 FR 15271, 3/23/2015)	11 DPSs listed as endangered and threatened (81 FR 20057, 4/6/2016)	Critical habitat proposed (88 FR 46572, 07/19/2023)	TBA
Humpback whale	*Megaptera novaeangliae*	Positive 90-day finding on petition to classify the North Pacific population as DPS and delist the DPS (78 FR 53391, 8/29/2013)	Revision of species-wide listing and listing of four DPSs as threatened or endangered (80 FR 22304)	Revision of species wide listing; Western North Pacific DPS listed as endangered (81 FR 62259, 9/8/2016)	No critical habitat designated for waters around the Mariana Archipelago (86 FR 21082, 4/21/21)	In development for Western North Pacific DPS; anticipated publication of draft documents & public comment period in 2023
Shortfin Mako Shark	*Isurus oxyrinchus*	Positive (86 FR 19863, 04/15/2021	Not warranted (87 FR 68236, 11/14/2022)	N/A	N/A	N/A

1.1.5 IDENTIFICATION OF RESEARCH, DATA, AND ASSESSMENT NEEDS

The following research, data, and assessment needs for insular fisheries were identified by the Council's Plan Team:

- Improve species identification of commercial and non-commercial fisheries data (e.g., outreach, use FAO species codes) to improve understanding of potential protected species impacts.
- Define and evaluate innovative approaches to derive robust estimates of protected species interactions in insular fisheries.
- Conduct genetic and telemetry research to improve understanding of population structure and movement patterns for listed elasmobranchs.
- Estimates of post release survival for incidental protected species.

2.3

2.3 LIFE HISTORY AND LENGTH DERIVED PARAMETERS

The annual stock assessment and fishery evaluation (SAFE) report will serve as the repository of available life history information for the Western Pacific region. Life history data particularly age, growth, reproduction, and mortality information inform stock assessments on fish productivity and population dynamics. Some assessments, particularly for data poor stocks, utilize information from other areas that introduces biases and increase uncertainties in the population estimates. An archipelago specific life history parameter ensures accuracy in the input parameters used in the assessment.

The NMFS PIFSC Biosampling Program allows for the collection of life history samples like otoliths and gonads from priority species in the bottomfish and coral reef fisheries. A significant number of samples are also collected during research cruises. These life history samples, once processed and examined, will contribute to the body of scientific information for the two data-poor fisheries in the region (coral reef fish and bottomfish). The life history information available from the region will be monitored by the Archipelagic Plan Team and will be tracked through this section of the report.

This section will be divided into two fisheries: 1) prioritized coral reef ecosystem component species, and 2) management unit species (MUS). The prioritized coral reef species list was developed by the CNMI Department of Fish and Wildlife (DFW) and the Guam Division of Aquatic and Wildlife Resources (DAWR) in 2019. The MUS are the species that are listed in the federal ecosystem plan and are managed on a federal level. Within each fishery, the available life history information will be described under the age, growth, and reproductive maturity section. The section labelled fish length derived parameters summarizes available information derived from sampling the fish catch or the markets. Length-weight conversion coefficients provide area-specific values to convert length from fishery-dependent and fishery-independent data collection to weight or biomass.

2.3.1 CNMI CORAL REEF ECOSYSTEM COMPONENTS LIFE HISTORY

2.3.1.1 AGE, GROWTH, AND REPRODUCTIVE MATURITY

Description: Age determination is based on counts of yearly growth marks (annuli) and/or daily growth increments (DGIs) internally visible within transversely cut, thin sections of sagittal otoliths. Validated age determination is based on several methods including an environmental signal (bomb radiocarbon ^{14}C) produced during previous atmospheric thermonuclear testing in the Pacific and incorporated into the core regions of sagittal otolith and other aragonite-based calcified structures such as hermatypic corals. This technique relies on developing a regionally based aged coral core reference series for which the rise, peak, and decline of ^{14}C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the ^{14}C otolith core values back in time from its capture date to where it intersects with the known age ^{14}C coral reference series. Fish growth is estimated by fitting the length-at-age data to a growth function, typically the von Bertalanffy growth function (VBGF). This function typically uses three coefficients (L_{∞}, k, and t_0), which together characterize the shape of the length-at-age growth relationship.

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex and these data are fitted to a three- or four-parameter logistic function to determine the best fit of these data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region) - such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes - standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and age at 50% sex reversal ($A\Delta_{50}$) can be derived by referencing the VBGF for that species and using the corresponding L_{50} and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age & growth and reproductive maturity are concurrently determined, estimates of A_{50} and $A\Delta_{50}$ are derived directly by fitting the percent of mature samples for each age (one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a particular species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Category: Biological

Timeframe: N/A

Jurisdiction: CNMI

Spatial Scale: Archipelagic

Data Source: Sources of data are directly derived from research cruises sampling and market samples collected by the CNMI contracted bio-sampling team which samples the catch of fishermen and local fish vendors. Laboratory analyses and data generated from these analyses reside with the PIFSC Life History Program (LHP). Refer to the “Reference” column in

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. These parameters are also used as direct inputs into stock assessments. Currently, the assessment of coral reef fish resources in CNMI is data limited. Knowledge of these life history parameters support current efforts to characterize the resilience of these resources and provide important biological inputs for future stock assessment efforts and enhance our understanding of the species’ likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 1 for specific details on data sources by species.

Parameter Definitions:

T_{max} (maximum age) – The maximum observed age revealed from an otolith-based age determination study. T_{max} values can be derived from ages determined by annuli counts of sagittal otolith sections and/or bomb radiocarbon (^{14}C) analysis of otolith core material. Units are years.

L_∞ (asymptotic length) – One of three coefficients of the VBGF that measures the mean maximum length at which the growth curve plateaus and no longer increases in length with increasing age. This coefficient reflects the estimated mean maximum length and not the observed maximum length. Units are centimeters.

k (growth coefficient) – One of three coefficients of the VBGF that measures the shape and steepness by which the initial portion of the growth function approaches its mean maximum length (L_∞).

t_0 (hypothetical age at length zero) – One of three coefficients of the VBGF whose measure is highly influenced by the other two VBGF coefficients (k and L_∞) and typically assumes a negative value when specimens representing early growth phases) are not available for age determination. This parameter can be fixed at 0. Units are years.

M (natural mortality) – This is a measure of the mortality rate for a fish stock and is considered to be directly related to stock productivity (i.e., high M indicates high productivity and low M indicates low stock productivity). M can be derived through use of various equations that link M to T_{max} and the VBGF coefficients (k and L_∞) or by calculating the value of the slope from a regression fit to a declining catch curve (regression of the natural logarithm of abundance versus age class) derived from fishing an unfished or lightly fished population.

A_{50} (age at 50% maturity) – Age at which 50% of the sampled stock under study has attained reproductive maturity. This parameter is best determined based on studies that concurrently determine both age (otolith-based age data) and reproductive maturity status (logistic function fitted to percent mature by age class with maturity determined via microscopic analyses of gonad histology preparations). A more approximate means of estimating A_{50} is to use an existing L_{50} estimate to find the corresponding age (A_{50}) from an existing VBGF curve. Units are years.

$A\Delta_{50}$ (age of sex switching) – Age at which 50% of the immature and adult females of the sampled stock under study is undergoing or has attained sex reversal. This parameter is best determined based on studies that concurrently determines both age (otolith-based age data) and reproductive sex reversal status (logistic function fitted to percent sex reversal by age class with sex reversal determined via microscopic analyses of gonad histology preparations). A more approximate means of estimating $A\Delta_{50}$ is to use an existing $L\Delta_{50}$ estimate to find the corresponding age ($A\Delta_{50}$) from the VBGF curve. Units are years.

L_{50} (length at which 50% of a fish population are capable of spawning) – Length at which 50% of the females of a sampled stock under study has attained reproductive maturity; this is the length associated with A_{50} estimates. This parameter is derived using a logistic function to fit the percent mature data by length class with maturity status best determined via microscopic analyses of gonad histology preparations. L_{50} information is typically more available than A_{50} since L_{50} estimates do not require knowledge of age and growth. Units are centimeters.

***L*Δ₅₀ (length of sex switching)** – Length at which 50% of the immature and adult females of the sampled stock under study is undergoing or has attained sex reversal; this is the length associated with $A\Delta_{50}$ estimates. This parameter is derived using a logistic function to fit the percent sex reversal data by length class with sex reversal status best determined via microscopic analyses of gonad histology preparations. $L\Delta_{50}$ information is typically more available than $A\Delta_{50}$ since $L\Delta_{50}$ estimates do not require knowledge of age and growth. Units are centimeters.

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. These parameters are also used as direct inputs into stock assessments. Currently, the assessment of coral reef fish resources in CNMI is data limited. Knowledge of these life history parameters support current efforts to characterize the resilience of these resources and provide important biological inputs for future stock assessment efforts and enhance our understanding of the species' likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 1. Available age, growth, reproductive maturity, and natural mortality information for prioritized coral reef ecosystem component species in CNMI

Species	Age, growth, and reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Acanthurus lineatus	20[c]	20.5[c]	0.24[c]	-3.2[c]		6.2[c]		18.8[c]		Leon Guerrero (2023)
Lethrinus harak	f=9[d] m=9[d]	f=37.2[d] m=27.3[d]	f=0.14[d] m=0.38[d]	f=-2.92[d] m=-1.11[d]		f=2.6[d] m=2.4[d]	f=0.43[d] m=0.44[d]	f=19.6[d] m=18.7[d]		Trianni (2016)
Mulloidichthys flavolineatus	f=5[c] M=4[c]	f=25.55[c] m=21.80[c]	f=1.24[c] m=1.69[c]					f=15.8[c] m=16.1[c]		Reed et al. (2020)
Naso lituratus									NA	
Naso unicornis	20[d]	42.7-51.7[d]	0.22-0.34	-(0.32) - (-0.85)[d]	0.17-0.41[d]			23.8[b]	NA	Taylor et al. (2019)
Scarus rubroviolaceus										
Scarus ghobban										
Siganus argenteus	7[d]	274[d]	0.9[d]	-0.3[d]	0.56[d]	1.3[d]	NA	218[d]	NA	Taylor et. al. (2016)

[a] signifies estimate pending further evaluation in an initiated and ongoing study.
[b] signifies a preliminary estimate taken from ongoing analyses.
[c] signifies an estimate documented in an unpublished report or draft manuscript.
[d] signifies an estimate documented in a finalized report or published journal article (including in press).

Parameter estimates are for females unless otherwise noted (f=females, m=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm fork length (FL); k is in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications ([d]) are denoted in the "Reference" column.

2.3.1.2 FISH LENGTH DERIVED PARAMETERS

Description: The NMFS Commercial Fishery Biosampling Program started in 2010. This program has two components: first is the Field/Market Sampling Program, and the second is the Lab Sampling Program, details of which are described in a separate section of this report. The goals of the Field/Market Sampling Program are:

- Broad scale look at commercial landings (by fisher/trip, gear, and area fished);
- Length and weight frequencies of whole commercial landings per fisher-trip (with an effort to also sample landings not sold commercially);
- Accurate species identification;
- Develop accurate local length-weight curves.

In CNMI, the Biosampling Program was focused on the commercial coral reef spear fishery with occasional sampling of the bottomfish fishery occurring locally and less frequently at the northern islands. However, in 2020 the Program switched focus to the MUS. Sampling is conducted in partnership with the fish vendors and fishermen. The Market Sampling information includes (but not limited to): 1) fish length; 2) fish weight; 3) species identification; and 4) basic effort information. Specific for CNMI, the program collects Daily Vendor Logs for reef fish that includes basic catch and effort information.

Category: Biological

Timeframe: N/A

Jurisdiction: CNMI

Spatial Scale: Archipelagic

Data Source: NMFS Biosampling Program

Parameter definitions:

n* – *sample size is the total number of fish sampled for length for each species recorded in the Bio-Sampling Program database.

L_{max} – *maximum fish length* is the largest individual per species recorded in the Bio-Sampling Program database from the commercial spear fishery. This value is derived from measuring the length of individual samples for species occurring in the spear fishery. Units are centimeters.

a and b* – *length-weight coefficients are the coefficients derived from the regression line fitted to all length and weight measured by species in the commercial spear fishery. These values are used to convert length information to weight. Values are influenced by the life history characteristics of the species, geographic location, population status, and nature of the fisheries from which the species are harvested.

Rationale: Length derived information is an important component of fisheries monitoring and data poor stock assessment approaches. Maximum length (L_{max}) is used to derive missing species- and location-specific life history information (Nadon et al. 2015; Nadon and Ault 2016; Nadon 2019). The length-weight coefficients (*a* and *b* values) are used to convert length to weight for fishery-dependent and fishery-independent data collection where length is typically recorded but weight is the factor being used for management. This section of the report presents the best available information for the length derived variables for the CNMI coral reef ecosystem component fisheries.

Table 2. Available length derived information for prioritized coral reef ecosystem component species in CNMI

Species	Length derived parameters				Reference
	n	L_{max}	*a*	*b*	
Acanthurus lineatus	5,864	23.5	0.0413	2.85	Mathews and Schemmel (in prep.)
Lethrinus harak	778	33.6	0.019	3.00	Mathews and Schemmel (in prep.)
Mulloidichthys flavolineatus	2,851	31.4	0.0139	3.05	Mathews and Schemmel (in prep.)
Naso lituratus	5,293	30.1	0.0165	3.11	Mathews and Schemmel (in prep.)
Naso unicornis	4,638	53.6	0.0272	2.91	Mathews and Schemmel (in prep.)
Scarus rubroviolaceus	1,893	52.6	0.00871	3.25	Mathews and Schemmel (in prep.)
Scarus ghobban	1,685	38.1	0.0127	3.12	Mathews and Schemmel (in prep.)
Siganus argenteus	4,103	34.3	0.0128	3.11	Mathews and Schemmel (in prep.)

2.3.2 CNMI MANAGEMENT UNIT SPECIES LIFE HISTORY

2.3.2.1 AGE, GROWTH, AND REPRODUCTIVE MATURITY

Description: Age determination is based on counts of yearly growth marks (annuli) and/or DGIs internally visible within transversely cut, thin sections of sagittal otoliths. Validated age determination is based on several methods including an environmental signal (bomb radiocarbon ^{14}C) produced during previous atmospheric thermonuclear testing in the Pacific and incorporated into the core regions of sagittal otolith and other aragonite-based calcified structures such as hermatypic corals. This technique relies on developing a regionally based aged coral core reference series for which the rise, peak, and decline of ^{14}C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the ^{14}C otolith core values back in time from its capture date to where it intersects with the known age ^{14}C coral reference series. Fish growth is estimated by fitting the length-at-age data to a VBGF. This function typically uses three coefficients (L_∞, k, and t_0), which together characterize the shape of the length-at-age growth relationship.

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex, and these data are fitted to a three- or four-parameter logistic function to determine the best fit for the data based on statistical analyses. The mid-point of the fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region), such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes, standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three- or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and age at 50% sex reversal ($A\Delta_{50}$) can be derived by referencing the VBGF for that species and using the corresponding L_{50} and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age and growth and reproductive maturity are concurrently determined, estimates of A_{50} and $A\Delta_{50}$ are derived directly by fitting the percent of mature samples for each age (i.e., one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Category: Biological

Timeframe: N/A

Jurisdiction: CNMI

Spatial Scale: Archipelagic

Data Source: Sources of data are directly derived from research cruises sampling and market samples collected by the CNMI contracted bio-sampling team which samples the catch of fishermen and local fish vendors. Laboratory analyses and data generated from these analyses reside with the PIFSC LHP. Refer to the "Reference" column in **Rationale:** These nine life-history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. Currently, the assessment of coral reef fish resources in CNMI is data limited. Knowledge of these life-history parameters support current efforts to characterize the resilience of these resources, provide important biological inputs for future stock assessment efforts, and enhance our understanding of the species' likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 3 for specific details on data sources by species.

Parameter Definitions: Identical to Section 2.3.2.1

Rationale: These nine life-history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. Currently, the assessment of coral reef fish resources in CNMI is data limited. Knowledge of these life-history parameters support current efforts to characterize the resilience of these resources, provide important biological inputs for future stock assessment efforts, and enhance our understanding of the species' likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 3. Available age, growth, reproductive maturity, and natural mortality information for MUS in CNMI

Species	Age, growth, and reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Aphareus rutilans							NA		NA	
Caranx ignobilis										
Caranx lugubris										
Etelis carbunculus[1]							NA		NA	
Etelis coruscans							NA		NA	
Lethrinus rubrioperculatus	8[d]	31.5[d]	0.80[d]	-0.52[d]				23.2[d]	29.0[d]	Trianni (2011)
Lutjanus kasmira							NA		NA	
Pristipomoides auricilla[2]	18[d]	32.5[d]	0.60[d]		0.18[d]		NA		NA	O'Malley et al. (2019)
Pristipomoides filamentosus[2]	31[c]	54.6[c]	0.19[c]			f=5.0[d] m=2.8[d]	NA	f=41.2[d] m=27.6[d]	NA	Villagomez (2019)
Pristipomoides flavipinnis							NA		NA	
Pristipomoides sieboldii							NA		NA	
Pristipomoides zonatus	X[a]	X[a]	X[a]	X[a]			NA		NA	LHP (in prep)
Variola louti										

[1] *E. carbunculus* is now known to be comprised of two distinct, non-interbreeding lineages (Andrews et al. 2016). Both species occur in the Mariana Archipelago and are likely both captured by fishermen but reported as one species.
[2] Estimates are for the southern portion of the Mariana Archipelago.
[a] signifies estimate pending further evaluation in an initiated and ongoing study.
[b] signifies a preliminary estimate taken from ongoing analyses.
[c] signifies an estimate documented in an unpublished report or draft manuscript.
[d] signifies an estimate documented in a finalized report or published journal article (including in press).

Parameter estimates are for females unless otherwise noted (f=females, m=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm FL; k is in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications ([d]) are denoted in the "Reference" column.

2.3.2.2 FISH LENGTH DERIVED PARAMETERS

<u>Description</u>: The NMFS Commercial Fishery Biosampling Program started in 2010. This program has two components: first is the Field/Market Sampling Program and the second is the

Lab Sampling Program, details of which are described in a separate section of this report. The goals of the Field/Market Sampling Program are:

- Broad scale look at commercial landings (by fisher/trip, gear, and area fished);
- Length and weight frequencies of whole commercial landings per fisher-trip (with an effort to also sample landings not sold commercially);
- Accurate species identification;
- Develop accurate local length-weight curves.

In the CNMI, the Biosampling Program was focused on the commercial coral reef spear fishery with occasional sampling of the bottomfish fishery occurring locally and less frequently at the northern islands. However, in 2020 the Program switched focus to the MUS. Sampling is conducted in partnership with the fish vendors and fishermen. The Market Sampling information includes (but not limited to): 1) fish length; 2) fish weight; 3) species identification; and 4) basic effort information. Specific for CNMI, the program collects Daily Vendor Logs for reef fish that includes basic catch and effort information.

Category: Biological

Timeframe: N/A

Jurisdiction: CNMI

Spatial Scale: Island

Data Source: NMFS Biosampling Program

Parameter Definitions: Identical to Section 2.3.1.2

Rationale: Length derived information is an important component of fisheries monitoring and data poor stock assessment approaches. Maximum length (L_{max}) is used to derive missing species- and location-specific life history information (Nadon et al. 2015; Nadon and Ault 2016; Nadon 2019). The length-weight coefficients (*a* and *b* values) are used to convert length to weight for fishery-dependent and fishery-independent data collection where length is typically recorded but weight is the factor being used for management. This section of the report presents the best available information for the length derived variables for the CNMI MUS fisheries.

Table 4. Available length derived information for MUS in the CNMI

Species	**Length-Derived Parameters**				**Reference**
	n	***L_{max}***	***a***	***b***	
Aphareus rutilans	434	109	0.0358	2.76	Mathews and Schemmel (in prep.)
Caranx ignobilis	6	109.2	0	0	Mathews and Schemmel (in prep.)
Caranx lugubris	397	82.5	0.0248	2.95	Mathews and Schemmel (in prep.)
Etelis carbunculus[1]	2,087	53.5	0.0157	3.03	Mathews and Schemmel (in prep.)
Etelis coruscans	1,485	99.5	0.0525	2.69	Mathews and Schemmel (in prep.)

Species	Length-Derived Parameters				Reference
	n	***L_{max}***	***a***	***b***	
Lethrinus rubrioperculatus	1,611	38.1	0.018	3	Mathews and Schemmel (in prep.)
Lutjanus kasmira	882	35.7	0.0112	3.16	Mathews and Schemmel (in prep.)
Pristipomoides auricilla	1,979	40.3	0.0207	2.98	Mathews and Schemmel (in prep.)
Pristipomoides filamentosus	341	65.3	0.033	2.82	Mathews and Schemmel (in prep.)
Pristipomoides flavipinnis	548	51.5	0.0145	3.06	Mathews and Schemmel (in prep.)
Pristipomoides sieboldii	439	44	0.0151	3.04	Mathews and Schemmel (in prep.)
Pristipomoides zonatus	875	45.4	0.0181	3.04	Mathews and Schemmel (in prep.)
Variola louti	15	44.5	0	0	Mathews and Schemmel (in prep.)

[1] *E. carbunculus* is now known to be comprised of two distinct, non-interbreeding lineages (Andrews et al. 2016). Both species occur in the Mariana Archipelago and are likely both captured by fishermen but reported as one species.

2.3.3 GUAM CORAL REEF ECOSYSTEM COMPONENTS LIFE HISTORY

2.3.3.1 AGE, GROWTH, AND REPRODUCTIVE MATURITY

Description: Age determination is based on counts of yearly growth marks (annuli) and/or DGIs internally visible within transversely cut, thin sections of sagittal otoliths. Validated age determination is based on several methods including an environmental signal (bomb radiocarbon ^{14}C) produced during previous atmospheric thermonuclear testing in the Pacific and incorporated into the core regions of sagittal otolith and other aragonite-based calcified structures such as hermatypic corals. This technique relies on developing a regionally based aged coral core reference series for which the rise, peak, and decline of ^{14}C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the ^{14}C otolith core values back in time from its capture date to where it intersects with the known age ^{14}C coral reference series. Fish growth is estimated by fitting the length-at-age data to a VBGF. This function typically uses three coefficients (L_∞, k, and t_0), which together characterize the shape of the length-at-age growth relationship.

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex and these data are fitted to a three- or four-parameter logistic function to determine the best fit of these data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region) - such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes - standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and age at 50% sex reversal ($A\Delta_{50}$) can be derived by referencing the VBGF for that species and using the corresponding L_{50} and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age & growth and reproductive maturity are concurrently determined, estimates of A_{50} and $A\Delta_{50}$ are derived directly by fitting the percent of mature samples for each age (one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a particular species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Category: Biological

Timeframe: N/A

Jurisdiction: Guam

Spatial Scale: Archipelagic

<u>Data Source</u>: Sources of data are directly derived from research cruises sampling and market samples collected by the Guam contracted bio-sampling team which samples the catch of fishermen and local fish vendors. Laboratory analyses and data generated from these analyses reside with the PIFSC LHP. Refer to the "Reference" column in **<u>Rationale</u>:** These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. These parameters are also used as direct inputs into stock assessments. Currently, the assessment of coral reef fish resources in Guam is data-limited. Knowledge of these life history parameters support current efforts to characterize the resilience of these resources and provide important biological inputs for future stock assessment efforts and enhance our understanding of the species' likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 5 for specific details on data sources by species.

Parameter Definitions:

***T_{max}* (maximum age)** – The maximum observed age revealed from an otolith-based age determination study. T_{max} values can be derived from ages determined by annuli counts of sagittal otolith sections and/or bomb radiocarbon (^{14}C) analysis of otolith core material. Units are years.

***L_∞* (asymptotic length)** – One of three coefficients of the VBGF that measures the mean maximum length at which the growth curve plateaus and no longer increases in length with increasing age. This coefficient reflects the estimated mean maximum length and not the observed maximum length. Units are centimeters.

***k* (growth coefficient)** – One of three coefficients of the VBGF that measures the shape and steepness by which the initial portion of the growth function approaches its mean maximum length (L_∞).

t_0 (hypothetical age at length zero) – One of three coefficients of the VBGF whose measure is highly influenced by the other two VBGF coefficients (*k* and L_∞) and typically assumes a negative value when specimens representing early growth phases) are not available for age determination. This parameter can be fixed at 0. Units are years.

***M* (natural mortality)** – This is a measure of the mortality rate for a fish stock and is considered to be directly related to stock productivity (i.e., high *M* indicates high productivity and low *M* indicates low stock productivity). *M* can be derived through use of various equations that link *M* to T_{max} and the VBGF coefficients (*k* and L_∞) or by calculating the value of the slope from a regression fit to a declining catch curve (regression of the natural logarithm of abundance versus age class) derived from fishing an unfished or lightly fished population.

A_{50} (age at 50% maturity) – Age at which 50% of the sampled stock under study has attained reproductive maturity. This parameter is best determined based on studies that concurrently determine both age (otolith-based age data) and reproductive maturity status (logistic function fitted to percent mature by age class with maturity determined via microscopic analyses of gonad histology preparations). A more approximate means of estimating A_{50} is to use an existing L_{50} estimate to find the corresponding age (A_{50}) from an existing VBGF curve. Units are years.

$A\Delta_{50}$ (age of sex switching) – Age at which 50% of the immature and adult females of the sampled stock under study is undergoing or has attained sex reversal. This parameter is best determined based on studies that concurrently determines both age (otolith-based age data) and reproductive sex reversal status (logistic function fitted to percent sex reversal by age class with sex reversal determined via microscopic analyses of gonad histology preparations). A more approximate means of estimating $A\Delta_{50}$ is to use an existing $L\Delta_{50}$ estimate to find the corresponding age ($A\Delta_{50}$) from the VBGF curve. Units are years.

L_{50} (length at which 50% of a fish population are capable of spawning) – Length at which 50% of the females of a sampled stock under study has attained reproductive maturity; this is the length associated with A_{50} estimates. This parameter is derived using a logistic function to fit the percent mature data by length class with maturity status best determined via microscopic analyses of gonad histology preparations. L_{50} information is typically more available than A_{50} since L_{50} estimates do not require knowledge of age and growth. Units are centimeters.

$L\Delta_{50}$ (length of sex switching) – Length at which 50% of the immature and adult females of the sampled stock under study is undergoing or has attained sex reversal; this is the length associated with $A\Delta_{50}$ estimates. This parameter is derived using a logistic function to fit the percent sex reversal data by length class with sex reversal status best determined via microscopic analyses of gonad histology preparations. $L\Delta_{50}$ information is typically more available than $A\Delta_{50}$ since $L\Delta_{50}$ estimates do not require knowledge of age and growth. Units are centimeters.

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. These parameters are also used as direct inputs into stock assessments. Currently, the assessment of coral reef fish resources in Guam is data-limited. Knowledge of these life history parameters support current efforts to characterize the resilience of these resources and provide important biological inputs for future stock assessment efforts and enhance our understanding of the species' likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 5. Available age, growth, reproductive maturity, and natural mortality information for prioritized coral reef ecosystem component species in Guam

Species	Age, growth, and reproductive maturity parameters							Reference
	T_{max}	L_∞	k	t_0	A_{50}	L_{50}	$L\Delta_{50}$	
Caranx melampygus	X[a]	X[a]	X[a]	X[a]	X[a]	X[a]	X[a]	LHP (in progress)
Chlorurus frontalis	11[d]	37.2[d]	0.71[d]	-0.058[d]	1.55[d]	24.0[d]	34.3[d]	Taylor and Choat (2014)
Epinephelus fasciatus								
Lethrinus harak								
Lethrinus olivaceus								
Lutjanus fulvus								
Naso unicornis	23[d]	49.3[d]	0.22[d]	-0.048[d]	f=4.0[d] m=3.2[d]	f=29.2[d] m=27.1[d]		Taylor et al. (2014)
Scarus rubroviolaceus	6[d]	37.6[d]	0.66[d]	-0.062[d]	1.91[d]	27.1[d]	32.9[d]	Taylor and Choat (2014)
Siganus spinus								

[a] signifies estimate pending further evaluation in an initiated and ongoing study.
[b] signifies a preliminary estimate taken from ongoing analyses.
[c] signifies an estimate documented in an unpublished report or draft manuscript.
[d] signifies an estimate documented in a finalized report or published journal article (including in press).

Parameter estimates are for females unless otherwise noted (f=females, m=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm FL; k is in units of $year^{-1}$; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications ([d]) are denoted in the "Reference" column.

2.3.3.2 FISH LENGTH DERIVED PARAMETERS

Description: The NMFS Commercial Fishery Biosampling Program started in 2009. This program has two components: first is the Field/Market Sampling Program, and the second is the

Lab Sampling Program, details of which are described in a separate section of this report. The goals of the Field/Market Sampling Program are:

- Broad scale look at commercial landings (by fisher/trip, gear, and area fished);
- Length and weight frequencies of whole commercial landings per fisher-trip (with an effort to also sample landings not sold commercially);
- Accurate species identification;
- Develop accurate local length-weight curves.

In Guam, the Biosampling Program was focused on the commercial coral reef spear fishery with occasional sampling of the bottomfish fishery occurring locally and less frequently at the northern islands. However, in 2020 the Program switched focus to the MUS. Sampling is conducted in partnership with the fish vendors and fishermen. The Market Sampling information includes (but not limited to): 1) fish length; 2) fish weight; 3) species identification; and 4) basic effort information.

Category: Biological

Timeframe: N/A

Jurisdiction: Guam

Spatial Scale: Archipelagic

Data Source: NMFS Biosampling Program

Parameter Definitions:

n* – *sample size is the total number of fish sampled for length for each species recorded in the Bio-Sampling Program database.

L_{max} – *maximum fish length* is the largest individual per species recorded in the Bio-Sampling Program database from the commercial spear fishery. This value is derived from measuring the length of individual samples for species occurring in the spear fishery. Units are centimeters.

a and b* – *length-weight coefficients are the coefficients derived from the regression line fitted to all length and weight measured by species in the commercial spear fishery. These values are used to convert length information to weight. Values are influenced by the life history characteristics of the species, geographic location, population status, and nature of the fisheries from which the species are harvested.

Rationale: Length derived information is an important component of fisheries monitoring and data poor stock assessment approaches. Maximum length (L_{max}) is used to derive missing species- and location-specific life history information (Nadon et al. 2015, Nadon and Ault 2016, Nadon 2019). The length-weight coefficients (*a* and *b* values) are used to convert length to weight for fishery-dependent and fishery-independent data collection where length is typically recorded but weight is the factor being used for management. This section of the report presents the best available information for the length derived variables for the Guam coral reef fisheries.

Table 6. Available length derived information for prioritized coral reef ecosystem component species in Guam

Species	Length-Derived Parameters	Reference

	n	L_{max}	*a*	*b*	
Caranx melampygus	1,404	75.6	0.0237	2.93	Mathews and Schemmel (in prep.)
Chlorurus frontalis	516	48.5	0.0169	3.09	Mathews and Schemmel (in prep.)
Epinephelus fasciatus	2,411	31.3	0.0135	3.04	Mathews and Schemmel (in prep.)
Lethrinus harak	599	30.0	0.0260	2.92	Mathews and Schemmel (in prep.)
Lethrinus olivaceus	681	72.2	0.0189	2.94	Mathews and Schemmel (in prep.)
Lutjanus fulvus	408	34.4	0.0165	3.06	Mathews and Schemmel (in prep.)
Naso unicornis	8,447	57.2	0.0280	2.91	Mathews and Schemmel (in prep.)
Scarus rubroviolaceus	2,236	47.8	0.0116	3.18	Mathews and Schemmel (in prep.)
Siganus spinus	1,563	27.0	0.0297	2.85	Mathews and Schemmel (in prep.)

2.3.4 GUAM MANAGEMENT UNIT SPECIES LIFE HISTORY

2.3.4.1 AGE, GROWTH, AND REPRODUCTIVE MATURITY

Description: Age determination is based on counts of yearly growth marks (annuli) and/or DGIs internally visible within transversely cut, thin sections of sagittal otoliths. Validated age determination is based on several methods including an environmental signal (bomb radiocarbon ^{14}C) produced during previous atmospheric thermonuclear testing in the Pacific and incorporated into the core regions of sagittal otolith and other aragonite-based calcified structures such as hermatypic corals. This technique relies on developing a regionally based aged coral core reference series for which the rise, peak, and decline of ^{14}C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the ^{14}C otolith core values back in time from its capture date to where it intersects with the known age ^{14}C coral reference series. Fish growth is estimated by fitting the length-at-age data to a growth curve, typically a VBGF. This function typically uses three coefficients (L_∞, k, and t_0), which together characterize the shape of the length-at-age growth relationship.

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex and these data are fitted to a three- or four-parameter logistic function to determine the best fit of these data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region) - such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes - standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and age at 50% sex reversal ($A\Delta_{50}$) can be derived by referencing the VBGF for that species and using the corresponding L_{50} and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age & growth and reproductive maturity are concurrently determined, estimates of A_{50} and $A\Delta_{50}$ are derived directly by fitting the percent of mature samples for each age (one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a particular species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Category: Biological

Timeframe: N/A

Jurisdiction: Guam

Spatial Scale: Archipelagic

Data Source: Sources of data are directly derived from research cruises sampling and market samples collected by the Guam-contracted bio-sampling team which samples the catch of fishermen and local fish vendors. Laboratory analyses and data generated from these analyses reside with the PIFSC LHP. Refer to the "Reference" column in Table 7 for specific details on data sources by species.

Parameter Definitions: Identical to Section 2.3.3.1

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. Currently, the assessment of coral reef fish resources in Guam is data-limited. Knowledge of these life history parameters support current efforts to characterize the resilience of these resources and also provide important biological inputs for future stock assessment efforts and enhance our understanding of the species' likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Parameter estimates are for females unless otherwise noted (f=females, m=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm FL; k is in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications ([d]) are denoted in the "Reference" column.

Table 7. Available age, growth, reproductive maturity, and natural mortality information for MUS in Guam

Species	Age, growth, and reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Aphareus rutilans							NA		NA	
Caranx ignobilis							NA		NA	
Caranx lugubris							NA		NA	
Etelis carbunculus[1]							NA		NA	
Etelis coruscans							NA		NA	
Lethrinus rubrioperculatus							NA		NA	
Lutjanus kasmira							NA		NA	
Pristipomoides auricilla[2]	18[d]	32.5[d]	0.60[d]		0.18[d]		NA		NA	O'Malley et al. (2019)
Pristipomoides filamentosus[2]	31[c]	54.6[c]	0.19[c]			f=5.0[c] m=2.8[c]	NA	f=41.2[c] m=27.6[c]	NA	Villagomez (2019)
Pristipomoides flavipinnis							NA		NA	
Pristipomoides sieboldii							NA		NA	
Pristipomoides zonatus	f=19[d] m=30[d]	f=35.5[c] m=38.9[c]	f=0.28[c] m=0.28[c]	f=-0.543[c] m=-.019[c]	0.22[d]	f=3.4[c] m=2.8[c]	NA	f=23.6[c] m=24.2[c]	NA	Schemmel et al. (2021); Schemmel et al. (in prep.)
Variola louti	f=12[d] m=17[d]	43.7[d]	0.28[d]	-0.2[d]	0.37[d]	2.6[d]	6.1[d]	26.0[d]	35.5[d]	Schemmel et al. (in press)

[1] *E. carbunculus* is now known to be comprised of two distinct, non-interbreeding lineages (Andrews et al. 2016). Both species occur in the Samoa Archipelago and were likely both captured by fishermen in the 1980s but reported as one species.
[2] Estimates are for the southern portion of the Mariana Archipelago.
[a] signifies estimate pending further evaluation in an initiated and ongoing study.
[b] signifies a preliminary estimate taken from ongoing analyses.
[c] signifies an estimate documented in an unpublished report or draft manuscript.
[d] signifies an estimate documented in a finalized report or published journal article (+ in press).

2.3.4.2 FISH LENGTH DERIVED PARAMETERS

Description: The NMFS Commercial Fishery Biosampling Program started in 2009. This program has two components: first is the Field/Market Sampling Program and the second is the LHP, details of which are described in a separate section of this report. The goals of the Field/Market Sampling Program are:

- Broad scale look at commercial landings (by fisher/trip, gear, and area fished);
- Length and weight frequencies of whole commercial landings per fisher-trip (with an effort to also sample landings not sold commercially);
- Accurate species identification;
- Develop accurate local length-weight curves.

In Guam, the Biosampling Program was focused on the commercial coral reef spear fishery with occasional sampling of the bottomfish fishery occurring locally and less frequently at the northern islands. However, in 2020 the Program switched focus to the MUS. Sampling is conducted in partnership with the fish vendors and fishermen. The Market Sampling information includes (but not limited to): 1) fish length; 2) fish weight; 3) species identification; and 4) basic effort information.

Category: Biological

Timeframe: N/A

Jurisdiction: Guam

Spatial Scale: Island

Data Source: NMFS Biosampling Program

Parameter definition: Identical to Section 2.3.3.2

Rationale: Length derived information is an important component of fisheries monitoring and data poor stock assessment approaches. Maximum length (L_{max}) is used to derive missing species- and location-specific life history information (Nadon et al. 2015; Nadon and Ault 2016; Nadon 2019). The length-weight coefficients (*a* and *b* values) are used to convert length to weight for fishery-dependent and fishery-independent data collection where length is typically recorded but weight is the factor being used for management. This section of the report presents the best available information for the length derived variables for the Guam MUS fisheries.

Table 8. Available length derived information for MUS in Guam

Species	Length derived parameters				Reference
	n	L_{max}	***a***	***b***	
Aphareus rutilans	408	97.6	0.0255	2.84	Mathews and Schemmel (in prep.)
Caranx ignobilis	471	120.4	0.0248	2.96	Mathews and Schemmel (in prep.)
Caranx lugubris	356	80.8	0.0332	2.86	Mathews and Schemmel (in prep.)
Etelis	1095	50.5	0.0162	3.02	Mathews and Schemmel (in

Species	**Length derived parameters**				**Reference**
	n	L_{max}	***a***	***b***	
carbunculus					prep.)
Etelis coruscans	759	95.0	0.0387	2.77	Mathews and Schemmel (in prep.)
Lethrinus rubrioperculatus	2970	57.4	0.0246	2.92	Mathews and Schemmel (in prep.)
Lutjanus kasmira	1067	30.3	0.0175	3.01	Mathews and Schemmel (in prep.)
Pristipomoides auricilla	6440	39.0	0.0099	3.2	Mathews and Schemmel (in prep.)
Pristipomoides filamentosus	337	76.6	0.0252	2.9	Mathews and Schemmel (in prep.)
Pristipomoides flavipinnis	946	67.0	0.0170	3.02	Mathews and Schemmel (in prep.)
Pristipomoides sieboldii	460	63.2	0.0257	2.89	Mathews and Schemmel (in prep.)
Pristipomoides zonatus	1300	44.5	0.0160	3.08	Mathews and Schemmel (in prep.)
Variola louti	1089	49.7	0.0140	3.07	Mathews and Schemmel (in prep.)

[1] *E. carbunculus* is now known to be comprised of two distinct, non-interbreeding lineages (Andrews et al. 2016). Both species occur in the Samoa Archipelago and were likely both captured by fishermen in the 1980s but reported as one species.

2.2

2.2 CORAL REEF ECOSYSTEM PARAMETERS

2.2.1 REGIONAL REEF FISH BIOMASS AND HABITAT CONDITION

Description: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2023. 'Hard Coral Cover' is mean cover derived from benthic imagery (photoquadrats) collected by divers across the survey domain, including most sites where reef fish surveys occurred. In previous reports, this parameter stemmed from diver visual rapid assessments of coral cover. Note that no surveys were conducted in 2020 or 2021 in any region due to COVID-19.

Rationale: Reef fish biomass has been widely used as an indicator of relative ecosystem status and has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime. Hard coral cover is an indicator of relative status of the organisms that build coral reef habitat and has been shown to be sensitive to changes in oceanographic regime, and a range of direct and indirect anthropogenic impacts. Most fundamentally, cover of hard corals has been increasingly impacted by temperature stress as a result of global heating.

Data Category: Fishery-independent

Timeframe: Triennial

Jurisdiction: American Samoa, Guam, the Commonwealth of the Northern Mariana Islands (CNMI), Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), and Pacific Remote Island Areas (PRIA)

Spatial Scale: Regional

Data Source: Data used to generate cover and biomass estimates come from surveys conducted by the National Marine Fisheries Service (NMFS) Pacific Island Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD) and their partners as part of the Coral Reef Conservation Program's (CRCP) National Coral Reef Monitoring Program (NCRMP). Fish survey methods are described in detail in Ayotte et al. (2015). In brief, they involve teams of divers conducting stationary point count cylinder (SPC) surveys within a target domain of < 30 meter hard-bottom habitat at each island, stratified by depth zone and, for larger islands, by section of coastline. For consistency among islands, only data from forereef habitats are used. At each SPC, divers record the number, size, and species of all fishes within or passing through paired 15 meter-diameter cylinders over the course of a standard count procedure. Cover estimates are derived from photoquadrats collected by divers within the same survey domain, including at all the fish survey sites. Post-hoc annotation methods are described in detail in Lamirand et al. (2022).

Fish sizes and abundance are converted to biomass using standard length-to-weight conversion parameters, taken largely from FishBase and converted to biomass per unit area by dividing by the area sampled per survey. Site-level data were pooled into island-scale values by first calculating mean and variance within strata, and then calculating weighted island-scale mean and variance using the formulas given in Smith et al. (2011) with strata weighted by their respective sizes.

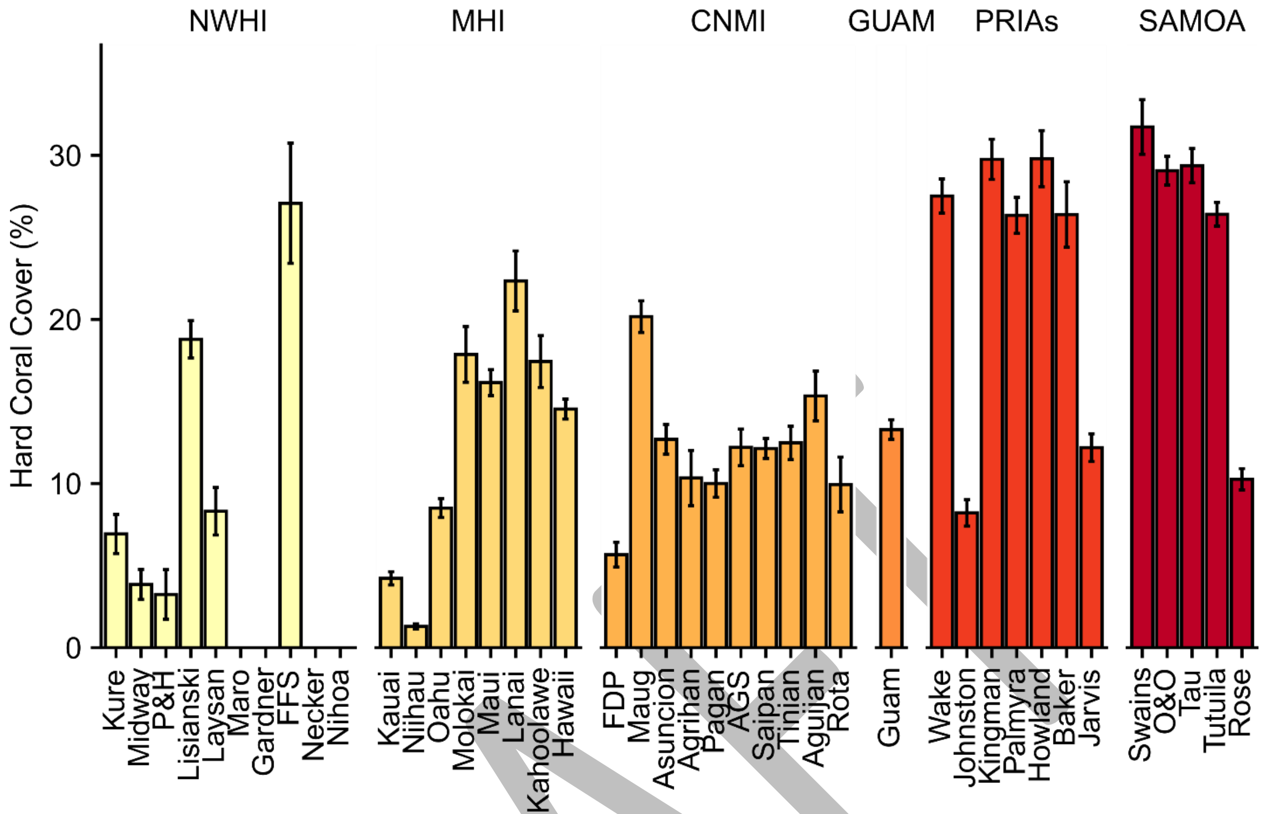

Figure 1. Mean coral cover (%± standard error of the mean, or SEM) per U.S. Pacific Island averaged from 2010-2023 by latitude

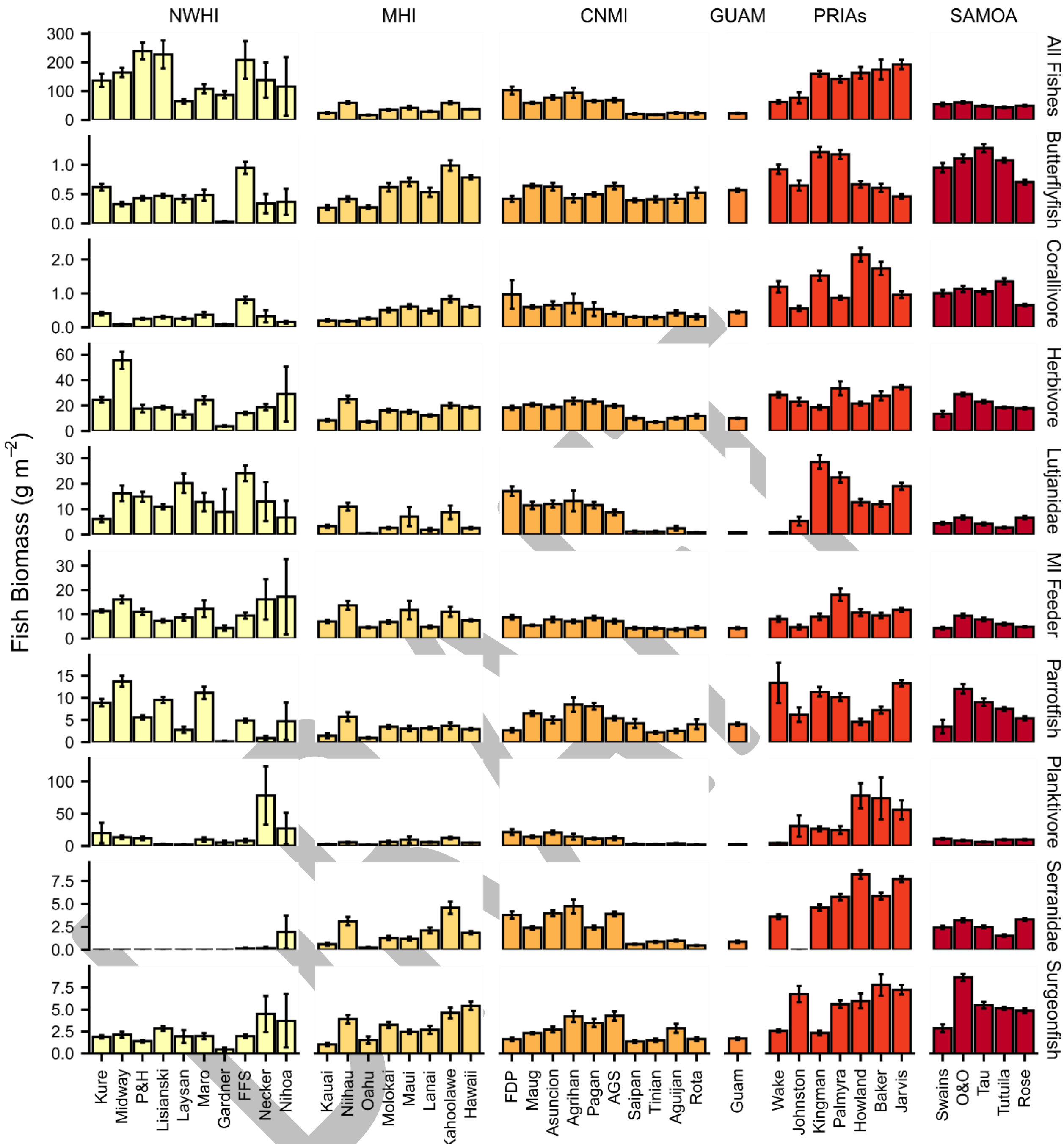

Figure 2. Mean fish biomass (g/m^2 ± SEM) per U.S. Pacific Island of functional, taxonomic, and trophic groups from 2010-2023 by latitude

Note: The group 'Serranidae' excludes planktivorous members of that family (i.e., anthias), which can be hyper-abundant in some regions. Similarly, the bumphead parrotfish, *Bolbometopon muricatum*, has been excluded from the corallivore group. The group 'MI Feeder' consists of fishes that primarily feed on mobile invertebrates; 'Butterflyfish' are non-planktivorous butterflyfish species; and 'Surgeonfish' are mid-large targeted surgeonfish species

2.2.2 CNMI REEF FISH BIOMASS AND HABITAT CONDITION

<u>Description</u>: ‘Reef fish biomass’ is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2023. ‘Hard Coral Cover’ is mean cover derived from benthic imagery (photoquadrats) collected by divers across the survey domain, including most sites where reef fish surveys occurred. In previous reports, this parameter stemmed from diver visual rapid assessments of coral cover. Note that no surveys were conducted in 2020 or 2021 in any region due to COVID-19.

<u>Rationale</u>: Reef fish biomass has been widely used as an indicator of relative ecosystem status and has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime. Hard coral cover is an indicator of relative status of the organisms that build coral reef habitat and has been shown to be sensitive to changes in oceanographic regime, and a range of direct and indirect anthropogenic impacts. Most fundamentally, cover of hard corals has been increasingly impacted by temperature stress as a result of global heating.

<u>Data Category</u>: Fishery-independent

<u>Timeframe</u>: Triennial

<u>Jurisdiction</u>: CNMI

<u>Spatial Scale</u>: Island

<u>Data Source</u>: Data are sourced from surveys conducted by NMFS PIFSC ESD and partners, as part of the Pacific NCRMP. Survey methods and sampling design, and methods to generate biomass and cover parameters are described in Section 2.2.1.

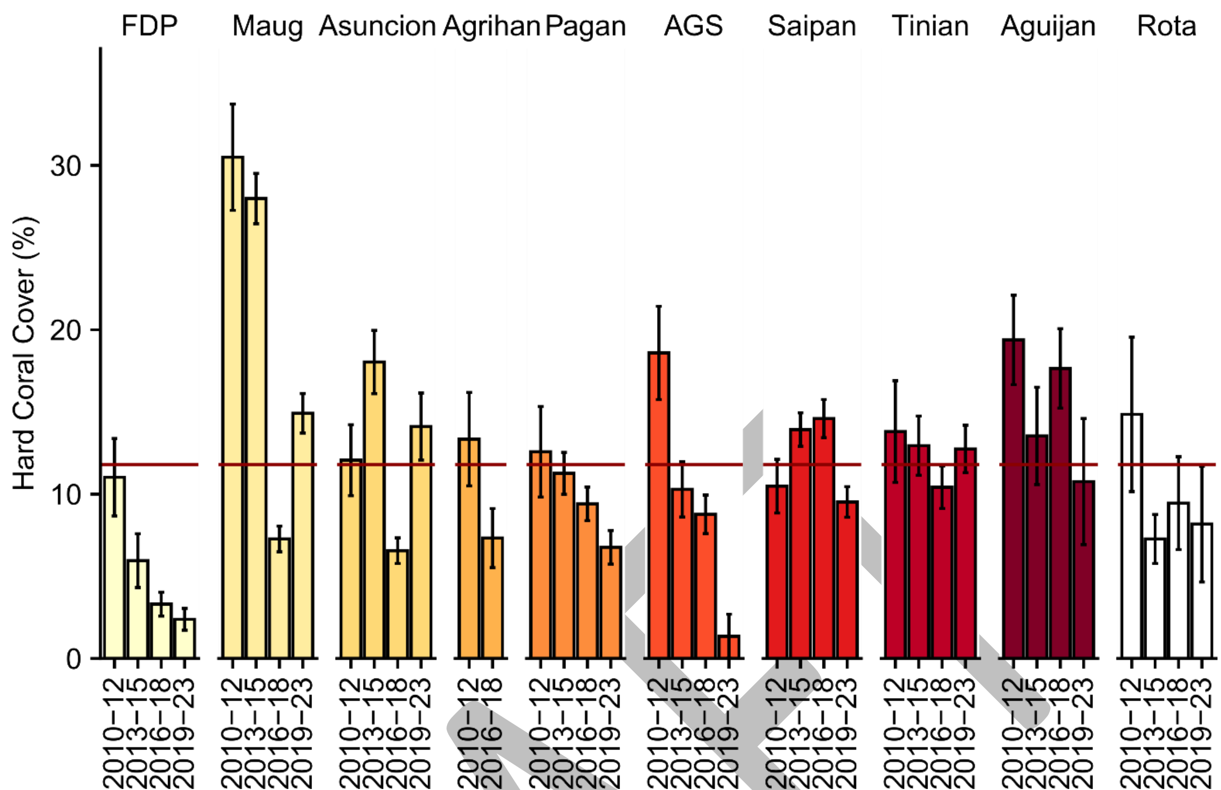

Figure 3. Mean coral cover (% ± SEM) per island of the CNMI from 2010–2023 by latitude

Note: The red horizontal line is the region-wide mean estimate for the entire time period.

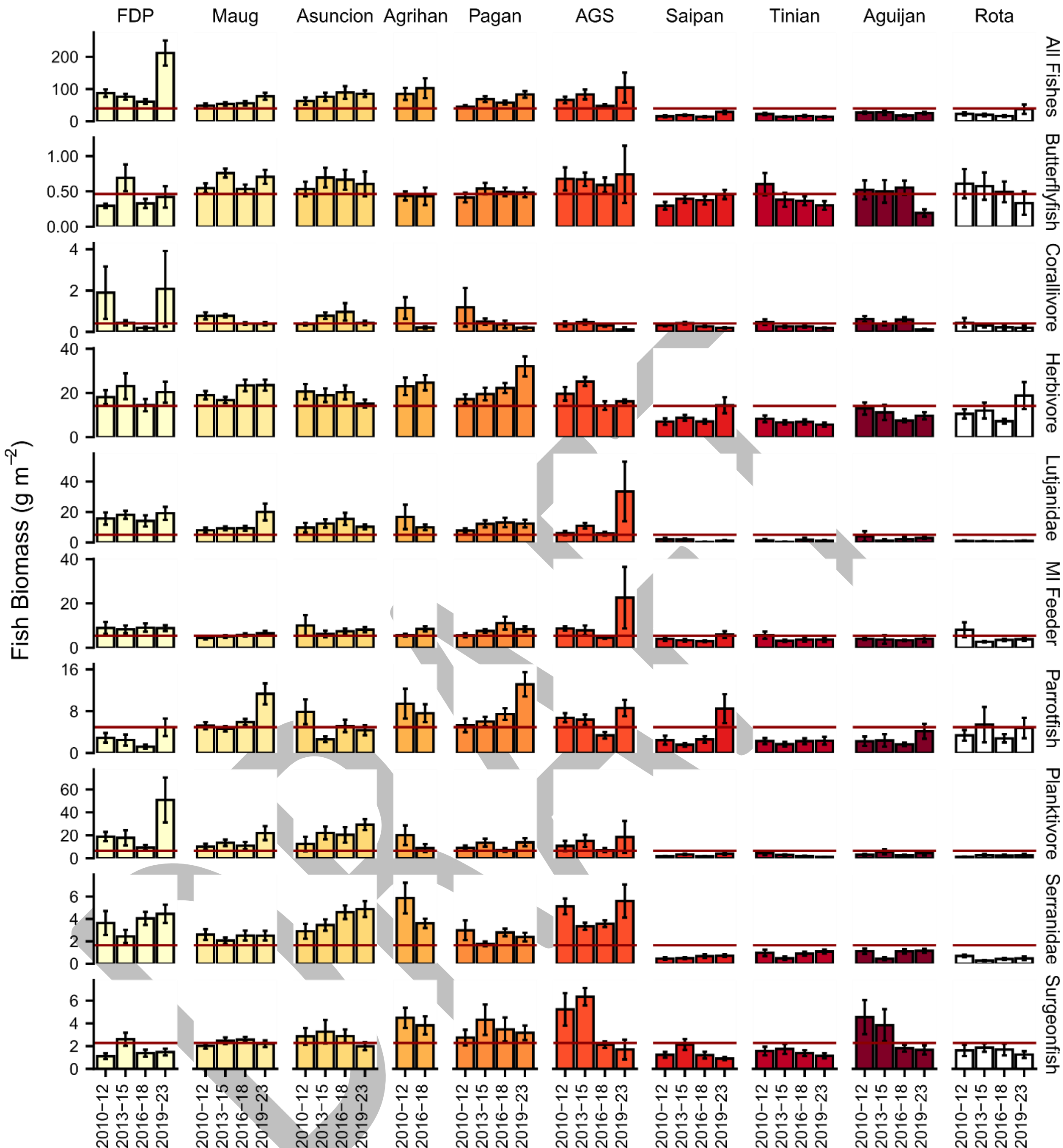

Figure 4. Mean fish biomass (g/m^2 ± SEM) of functional, taxonomic, and trophic groups per island of the CNMI from 2010-2023

Note: The group 'Serranidae' excludes planktivorous members of that family (i.e., anthias), which can be hyper-abundant in some regions. Similarly, the bumphead parrotfish, *Bolbometopon muricatum*, has been excluded from the corallivore group. The group 'MI Feeder' consists of fishes that primarily feed on mobile invertebrates; 'Butterflyfish' are non-planktivorous butterflyfish species; and 'Surgeonfish' are mid-large targeted surgeonfish species. Red horizontal lines are the region-wide mean estimates for the entire time period.

2.2.3 GUAM REEF FISH BIOMASS AND HABITAT CONDITION

<u>Description</u>: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2023. 'Hard Coral Cover' is mean cover derived from benthic imagery (photoquadrats) collected by divers across the survey domain, including most sites where reef fish surveys occurred. In previous reports, this parameter stemmed from diver visual rapid assessments of coral cover. Note that no surveys were conducted in 2020 or 2021 in any region due to COVID-19.

<u>Rationale</u>: Reef fish biomass has been widely used as an indicator of relative ecosystem status and has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime. Hard coral cover is an indicator of relative status of the organisms that build coral reef habitat and has been shown to be sensitive to changes in oceanographic regime, and a range of direct and indirect anthropogenic impacts. Most fundamentally, cover of hard corals has been increasingly impacted by temperature stress as a result of global heating.

<u>Data Category</u>: Fishery-independent

<u>Timeframe</u>: Triennial

<u>Jurisdiction</u>: Guam

<u>Spatial Scale</u>: Island

<u>Data Source</u>: Data are sourced from surveys conducted by NMFS PIFSC ESD and partners, as part of the Pacific NCRMP. Survey methods and sampling design, and methods to generate biomass and cover parameters are described in Section 2.2.1.

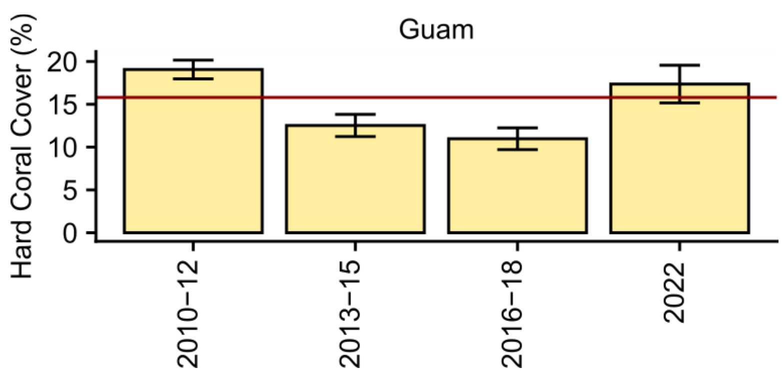

Figure 5. Mean coral cover (% ± SEM) of Guam over the years 2010-2023

Note: The red horizontal line is the region-wide mean estimate for the entire time period.

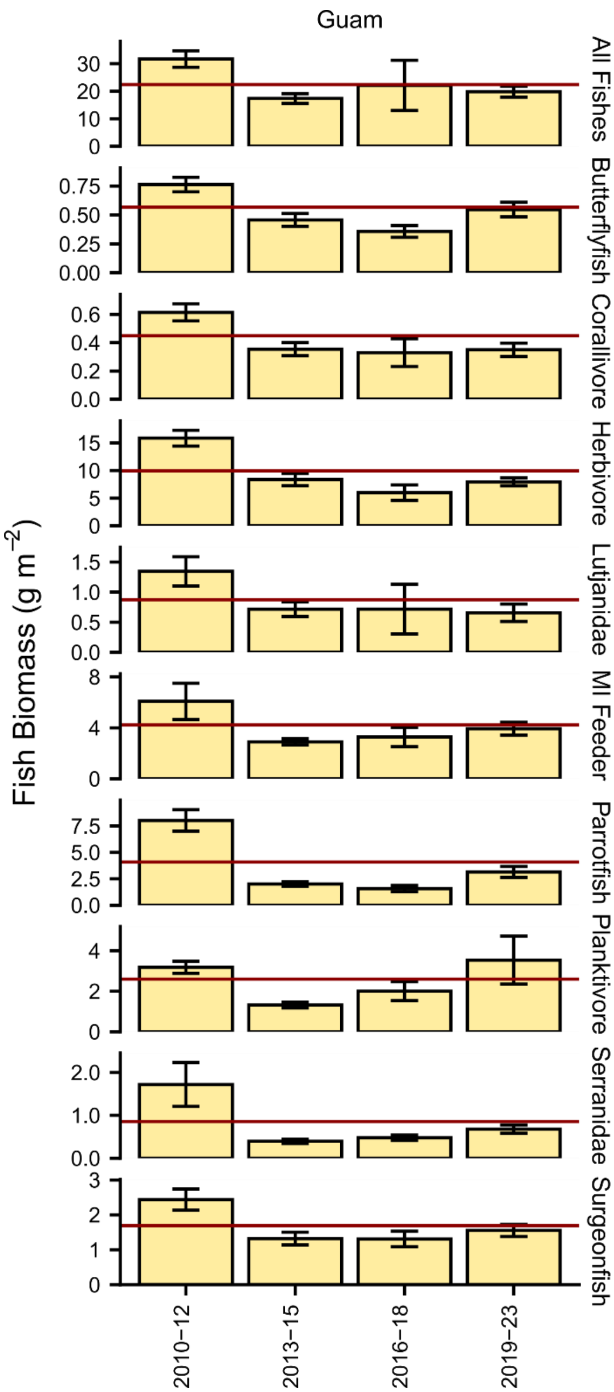

Figure 6. Mean fish biomass (g/m^2 ± SEM) of functional, taxonomic, and trophic groups of Guam from 2010-2023.

Note: The group 'Serranidae' excludes planktivorous members of that family (i.e., anthias), which can be hyper-abundant in some regions. Similarly, the bumphead parrotfish, *Bolbometopon muricatum,* has been excluded from the corallivore group. The group 'MI Feeder' consists of fishes that primarily feed on mobile invertebrates; 'Butterflyfish' are non-planktivorous butterflyfish species; and 'Surgeonfish' are mid-large targeted surgeonfish species. Red horizontal lines are the region-wide mean estimates for the entire time period.

1.1.10 FEDERAL LOGBOOK DATA

1.1.10.1 NUMBER OF FEDERAL PERMIT HOLDERS

In the CNMI, the following federal permits are required for fishing in the exclusive economic zone (EEZ) under the Mariana Archipelago FEP. Regulations governing fisheries under this FEP are in the Code of Federal Regulations (CFR), Title 50, Part 665.

1.1.10.1.1 Northern Mariana Island Bottomfish Permit

Regulations require this permit for any vessel commercially fishing for, landing, or transshipping BMUS or bottomfish ECS in the EEZ around CNMI. Commercial fishing is prohibited within the boundaries of the Islands Unit of the Marianas Trench Marine National Monument.

1.1.10.1.2 Special Coral Reef Ecosystem Permit

Regulations require the coral reef ecosystem special permit for anyone fishing for coral reef ECS in a low-use marine protected area (MPA), fishing for species on the list of Potentially Harvested Coral Reef Taxa or using fishing gear not specifically allowed in the regulations. NMFS will make an exception to this permit requirement for any person issued a permit to fish under any FEP who incidentally catches CNMI coral reef ECS while fishing for BMUS, crustacean ECS, western Pacific pelagic MUS, precious coral, or seamount groundfish. Regulations require a transshipment permit for any receiving vessel used to land or transship potentially harvested coral reef taxa, or any coral reef ECS caught in a low-use MPA.

1.1.10.1.3 Western Pacific Precious Corals Permit

Regulations require this permit for anyone harvesting or landing black, bamboo, pink, red, or gold corals in the EEZ in the Western Pacific Region.

1.1.10.1.4 Western Pacific Crustaceans Permit (Lobster or Deepwater Shrimp)

Regulations require a permit by the owner of a U.S. fishing vessel used to fish for lobster or deepwater shrimp in the EEZ around American Samoa, Guam, Hawaii, and the Pacific Remote Islands Area (PRIA), and in the EEZ seaward of 3 nautical miles of the shoreline of the CNMI.

There is no record of special coral reef or precious coral fishery permits issued for the EEZ around the CNMI since 2007. Table 1 provides the number of permits issued for CNMI fisheries between 2014 and 2023. Data are from the NMFS Pacific Islands Regional Office (PIRO) Sustainable Fisheries Division (SFD) permits program.

Table 1. Number of federal permit holders for the CNMI crustacean and bottomfish fisheries

CNMI Fisheries	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Bottomfish	7	7	18	25	14	9	14	18	9	1
Lobster	0	0	1*	0	1*	0	0	0	0	0
Shrimp	0	1	1	0	0	0	0	0	0	0

Source: PIRO SFD unpublished data.
* Permits apply to multiple areas and may include American Samoa, Guam, the CNMI, and the PRIA.

1.1.10.2 SUMMARY OF CATCH AND EFFORT FOR FEP FISHERIES

The Mariana Archipelago FEP requires fishermen to obtain a federal permit to fish for certain MUS and ECS in federal waters and to report all catch and discards. While NMFS annually issues permits for various FEP fisheries, there is currently limited data available on the level of catch or effort made by federal non-longline permit holders. Determining the level of fishing activity through the required federal logbook reporting for each fishery helps establish the level of non-longline fishing occurring in federal waters to assess whether there is a continued need for active conservation and management measures (e.g., annual catch limits) for these fisheries. For each FEP fishery, the number of federal permits issued since the federal permit and logbook reporting requirements became effective as well as available catch and effort data are presented in Table 2 through Table 4. NMFS has never issued a federal permit for precious coral or coral reef fishing in federal waters around CNMI. Therefore, catch and effort data are not presented for these fisheries.

1.1.10.2.1 Commercial Bottomfish Fishery

Table 2. Summary of available federal logbook data for the commercial bottomfish fishery in the CNMI

Year	No. of Federal Bottomfish Permits Issued[1]	No. of Federal Bottomfish Permits Reporting Catch	No. of Trips in CNMI EEZ	Total Reported Logbook Catch (lb)			Total Reported Logbook MUS Release/Discard (#s)	
				Bottomfish MUS & ECS[2]	*Coral Reef ECS*[2]	*Pelagic MUS*	*Bottomfish MUS & ECS*[2]	*Coral Reef ECS*[2]
2009	3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2010	12	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2011	9	3	16	1,985	1,420	1,115		13
2012	14	5	40	2,309	1,765	159	52	10
2013	5	4	9	3,103	632	300		
2014	7	0						
2015	7	0						
2016	18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2017	25	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2018	14	0						
2019	9	0						
2020	14	0						
2021	18	0						
2022	9	0						
2023	1	0						

[1] Source: PIRO SFD unpublished data.
[2] On February 8, 2019, NMFS published a final rule (84 FR 2767) to reclassify some BMUS and all CREMUS in the Mariana Archipelago as ECS.
Notes: Federal permit and reporting requirements for CNMI bottomfish became effective on May 6, 2009 (74 FR 15373, April 6, 2009); n.d. = Not disclosed due to confidentiality.

1.1.10.2.2 Spiny and Slipper Lobster

Table 3. Summary of available federal logbook data for lobster fisheries in the CNMI

Year	No. of Federal Lobster Permits Issued[1]	No. of Federal Lobster Permits Reporting Catch	No. of Trips in CNMI EEZ	Total Reported Logbook Catch (lb)		Total Reported Logbook Release/Discard (lb)	
				Spiny lobster ECS[2]	*Slipper lobster ECS[2]*	*Spiny lobster ECS[2]*	*Slipper lobster ECS[2]*
2006	2	0					
2007	2	0					
2008	7	0					
2009	0	-					
2010	0	-					
2011	0	-					
2012	0	-					
2013	0	-					
2014	0	-					
2015	0	-					
2016	1*	0					
2017	0	-					
2018	1*	0					
2019	0	-					
2020	0	-					
2021	0	-					
2022	0	-					
2023	0	-					

[1] Source: PIRO Sustainable Fisheries unpublished data.
[2] On February 8, 2019, NMFS published a final rule (84 FR 2767) to reclassify all CMUS in the Mariana Archipelago as ECS.
* Permits apply to multiple areas and may include American Samoa, Guam, CNMI, and PRIA.
Note: Federal permit and reporting requirements for CNMI lobster fisheries became effective on December 4, 2006 (71 FR 69496, December 1, 2006).

1.1.10.2.3 Deepwater Shrimp

Table 4. Summary of available federal logbook data for deepwater shrimp fisheries in the CNMI

Year	No. of Federal Shrimp Permits Issued[1]	No. of Federal Shrimp Permits Reporting Catch	No. of Trips in CNMI EEZ	Total Reported Logbook Shrimp ECS[2] Catch (lb)	Total Reported Logbook Shrimp ECS[2] Release/Discard (lb)
2009	0	-			
2010	2	n.d.	n.d.	n.d.	n.d.

Year	No. of Federal Shrimp Permits Issued[1]	No. of Federal Shrimp Permits Reporting Catch	No. of Trips in CNMI EEZ	Total Reported Logbook Shrimp ECS[2] Catch (lb)	Total Reported Logbook Shrimp ECS[2] Release/Discard (lb)
2011	2	0			
2012	0	-			
2013	0	-			
2014	0	-			
2015	1	0			
2016	1	0			
2017	0	-			
2018	0	-			
2019	0	-			
2020	0	-			
2021	0	-			
2022	0	-			
2023	0	-			

[1] Source: PIRO SFD unpublished data.

[2] On February 8, 2019, NMFS published a final rule (84 FR 2767) to reclassify all CMUS in the Mariana Archipelago as ECS.

Notes: Federal permit and reporting requirements for CNMI bottomfish became effective on June 29, 2009 (74 FR 25650, May 29, 2009); n.d. = Not disclosed due to confidentiality.

1.1.15 ADMINISTRATIVE AND REGULATORY ACTIONS

This summary describes management actions NMFS implemented for insular fisheries in the CNMI during calendar year 2023.

On December 26, 2023, NMFS published the final rule to extend the region-wide moratorium on the harvest of gold corals in the U.S. Pacific Islands through June 30, 2028 (88 FR 88835). NMFS intends this rule to prevent overfishing and to stimulate research on gold corals.

1.10 NON-COMMERCIAL FISHERY CATCH STATISTICS

In the Pacific Islands, small boat fisheries are known to comprise a mix of commercial and non-commercial fishing. While anywhere from 56% to 84% of fish catches in the CNMI are typically intended for sale, non-commercial catch supports fishing communities in many important ways, from contributing to food security to social cohesion and upholding cultural traditions (Chan and Pan 2019; Leong et al. 2020). These benefits, including those from informal and non-market economies, are especially important for community resilience during times of stress, such as during COVID-19 (Smith et al. 2022). While limited data are collected on non-commercial fishing, calculating non-commercial catch estimates is an important first step in demonstrating the potential scope of these additional under-documented benefits from fishing.

1.10.1 Catch Estimates

The general approach agreed upon by the Archipelagic Plan Team for the estimation of non-commercial BMUS catches in the territories is to subtract the dealer-reported (i.e. commercial) catches from the total estimated catches from creel surveys. Three sources of catch data are needed from each territory: the boat-based creel survey data, the shore-based creel survey data, and the dealer-reported catches. This report is preliminary, as continual improvement of the process and integration into the central WPacFIN data warehouse are underway. The estimates of total BMUS catch and effort may differ from those in other sections of this annual SAFE report.

The boat- and shore-based creel surveys consist of fisher interviews and effort surveys conducted by the CNMI DFW. During an interview, species-specific catch and fishing effort information are recorded to obtain catch rate estimates. Effort data are collected through a participation survey and a boating-log survey for shore- and boat-based fishing, respectively, to estimate the total annual fishing effort. The data are uploaded into the WPacFIN data warehouse and quality control and processing scripts (via SQL and R) are used to generate the expanded catch by year. These scripts are stored and maintained in the WPacFIN Github repository (see top box in Figure 1). Further details regarding these data collection programs and the expansion algorithms designed to estimate total catch and effort can be found in Langseth et al. (2019) and Ma et al. (2022).

For each territory, the standard estimates of total annual catch and effort are obtained by first multiplying the catch rate by the total annual effort. The species composition from the creel interviews is then applied to obtain total species-specific catches for each territory. For the dealer-reported catch, the local resource management agencies collect data from first-level purchasers of local fresh fish by species or species groups (e.g. genus, family, and non-taxonomic groups such as “grouper”, “deep snapper”, or “bottomfish”).

The commercial receipt and creel data are checked for errors and inconsistencies before estimating the species-level catches. The PIFSC Stock Assessment and WPacFIN programs continue to work with staff in the jurisdictions to capture and fix the errors in the raw data, when possible. However, some of these errors are identified during the latest stock assessments and are fixed using temporary R scripts that are not yet integrated into the WPacFIN system (Figure 1), resulting in the different estimates of catch presented here. This process will be further reviewed and incorporated into the WPacFIN system in the next improvement phase.

The key difference resulting from this new method is improved estimates of total catch by species from the species groups (e.g. "grouper", "deep snapper", "bottomfish") reported by the dealers using the proportions calculated from the creel surveys.

This methodology for splitting catches by species for the new approach to estimating catch consists of:

1. Calculate the average catch by species in 10-year periods from the creel data, then calculate the proportions of species in each taxonomic group (e.g. deep snapper, grouper). The period averaging controls for temporal changes in species composition (see Section 1.1.2 in Nadon et al. (2023) for further details)
2. Apply the species proportions to the total catch by year in each taxonomic group to split this catch into its individual species.
3. Sum all species-level catches into the BMUS group to obtain a final, corrected catch
4. Subtract the dealer-reported catch from the total catch to obtain the non-commercial catch.

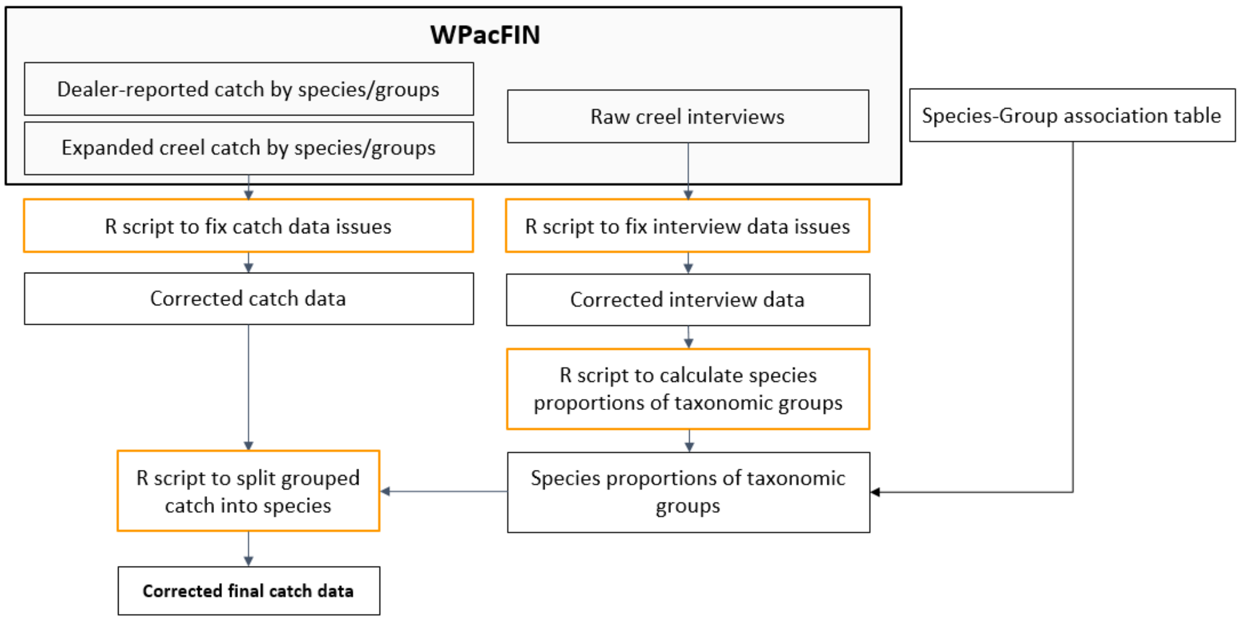

Figure 1. Data sources (gray boxes) and scripts (orange boxes) used to generate commercial and total catch estimates in the territories, from which non-commercial catch can be calculated.

Table 1. Summary of CNMI BMUS non-commercial catch estimates (lb) derived from commercial purchase system data and creel survey program data for all gear types

Year	Total Corrected Creel Survey Catch Estimates	Total Corrected Commercial Landings	Total Estimated Non-Commercial Catch	Proportion of Non-Commercial Catch
2001	122,131	37,664	84,467	0.69
2002	25,858	26,269	-	0
2003	69,396	21,784	47,612	0.69
2004	113,638	19,486	94,152	0.83
2005	63,044	24,916	38,128	0.6
2006	39,158	11,492	27,666	0.71
2007	52,950	16,385	36,565	0.69
2008	20,174	17,263	2,911	0.14
2009	88,176	16,021	72,155	0.82
2010	77,120	7,736	69,384	0.9
2011	27,492	8,200	19,292	0.7
2012	193,946	7,752	186,194	0.96
2013	36,773	11,956	24,817	0.67
2014	3,491	14,225	-	0
2015	6,915	1,864	5,051	0.73
2016	66,704	17,302	49,402	0.74
2017	136,955	13,073	123,882	0.9
2018	1,283	8,997	-	0
2019	30,087	12,869	17,218	0.57
2020	46,751	19,869	26,882	0.58

Year	Total Corrected Creel Survey Catch Estimates	Total Corrected Commercial Landings	Total Estimated Non-Commercial Catch	Proportion of Non-Commercial Catch
2021	75,046	37,032	38,015	0.51
2022	48,578	30,859	17,720	0.36
10-year avg.	**45,258**	**16,805**	**30,299**	**0.51**
10-year SD	**39,012**	**9,798**	**34,680**	**0.29**
20-year avg.	**59,884**	**15,954**	**44,852**	**0.61**
20-year SD	**46,110**	**8,096**	**45,127**	**0.27**

1.10.2 Caveats for Non-Commercial Catch Estimates

There are several important concerns and caveats that must be taken into account when estimating non-commercial catch values and using those data for monitoring and management purposes. With respect to available data, catch estimates are based on the best available existing data collected via creel surveys. As noted by Chan and Pan (2019), the actual populations of fishing participants in the CNMI are difficult to gauge. Without accurate knowledge of the population, the representativeness of the sample cannot be meaningfully calculated. While quantitative evaluations of the survey methods have shown that they are conceptually sound (Pawluk et al. 2023), fishers and members of the fishing community have voiced concerns about the representativeness of expanded data derived from creel interviews. In addition, the estimates of total catch and fish sales come from different reporting systems. The quality of commercial landings data collected through commercial sales receipt books are also variable across years and geographic areas (Chan and Pan 2019). Further, additional commercial activity via channels such as roadside markets or direct-to-consumer sales may not be captured through the commercial purchase system methodology. However, those channels are also more reflective of the broader informal and non-market economies supported by non-commercial fishing.

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