1.2 GUAM FISHERY DESCRIPTIONS

1.2.1 BOTTOMFISH FISHERY

Bottomfish fishing in Guam is a combination of recreational, subsistence, and small-scale commercial fishing. It can be separated into two distinct fisheries separated by depth and species composition. The shallow water complex (< 500 ft.) comprises the largest portion of the total bottomfish harvest and effort, and primarily includes: reef-dwelling snappers of the genera *Lutjanus*, *Aphareus*, and *Aprion*; groupers of the genera *Epinephelus*, *Variola*, and *Cephalopholis*; jacks of the genera *Caranx* and *Carangoides*; Holocentrids (*Myripristis* spp. and *Sargocentron* spp.); emperors of the genera *Lethrinus* and *Gymnocranius*; and Dogtooth Tuna (*Gymnosarda unicolor*). The deep-water complex (>500 ft.) consists primarily of groupers of the genera *Hyporthodus* and *Cephalopholis*, jacks of the genera *Caranx* and *Seriola*, and snappers of the genera *Pristipomoides*, *Etelis*, and *Aphareus*. In recent years, deepwater species have made up a significant portion of the total expanded bottomfish fishing catch.

Most fishers that participate in the bottomfish fishery are either subsistence or part-time commercial fishermen, operate boats less than 25 feet in length, and target primarily the shallow water bottomfish complex. It is not uncommon to intercept fishermen combining bottomfish fishing with other methods such as trolling, spearing, and jigging to maximize their catch. High demand has made it profitable to sell locally caught bottomfish, although overhead costs including fuel and gear may be significant factors for in determining a fisherman's selection of fishing method. The demand for local bottomfish, when combined with environmental pressures, however, may cause stress to local bottomfish stocks.

The majority of bottomfish fishing around Guam takes place on offshore banks, though practically no information exists on the condition of the reefs on offshore banks. On the basis of anecdotal information, most of the offshore banks are in good condition due to their isolation. According to Myers (1997), less than 20 percent of the total coral reef resources harvested in Guam are taken from the exclusive economic zone (EEZ), primarily because the reefs are often associated with less accessible offshore banks. As such, finfish make up most of the catch in the EEZ. Most offshore banks are deep, remote, and subject to strong currents. Generally, these banks are only accessible during calm weather in the summer months (May to August/September). Galvez Bank is the closest and most accessible and, consequently, fished most frequently. In contrast, other banks (White Tuna and Santa Rosa, Rota) are remote and generally are fished only during exceptional weather conditions (Green 1997). Local fishermen report that up to ten commercial boats, with two to three people per boat, and some recreational boats, make use of the banks when the weather is good (Green 1997).

At present, the banks are fished using two methods: bottomfish fishing by hook and line and jigging at night for bigeye scad (*Selar crumenophthalmus*; Myers 1997). In recent years, the estimated annual catch in these fisheries has ranged from 14 to 22 metric tons of shallow bottomfish and 3 to 15 metric tons of bigeye scad (Green 1997). The shallow water component accounted for nearly 68 percent (35,002 to 65,162 lb) of the aggregate bottomfish landings in fiscal years 1992–1994 (Myers 1997). Catch composition of the shallow water bottomfish complex (and coral reef species) is dominated by lethrinids, with a single species (*Lethrinus rubrioperculatus*) alone accounting for 28 percent of the total catch. Other important components of the bottomfish catch include lutjanids, carangids, other lethrinids, and serranids. Holocentrids, mullids, labrids, scombrids, and balistids are minor components of the shallow water bottomfish complex. It should be noted that at least two of these species (*Aprion virescens* and *Caranx lugubris*) are also found in deeper waters, and as a result comprise a portion of the catch of the deep-water fishery.

Species that are commonly taken in the shallow-bottom fishery of Guam are: *Aphareus furca*, *Aprion virescens, Lutjanus kasmira*, *L. fulvus*, *Carangoides orthogrammus*, *Caranx lugubris*, *C. melampygus*, *C. ignobilis*, *Selar crumenophthalmus*, *Cephalopholis argus*, *C. spiloparaea*, *C. urodeta*, *Epinephelus fasciatus*, *Gymnocranius* spp., *Lethrinus atkinsoni*, *L. erythracanthus*, *L. olivaceus*, *L. rubrioperculatus*, *L. xanthochilus*, *Gymnosarda unicolor*, *Sargocentron* spp., *Myripristis* spp., *Variola albimarginata*, and *V. louti*.

Species that are commonly taken in the deep-bottom fishery of Guam are: *Aphareus rutilans*, *Aprion virescens*, *Caranx lugubris*, *Seriola dumerilii*, *Cephalopholis igarashiensis*, *C. sonnerati*, *Hyporthodus octofasciatus*, *Etelis carbunculus*, *E. coruscans*, and *Pristipomoides* spp.

1.2.2 ECOSYSTEM COMPONENT (FORMERLY CORAL REEF) FISHERY

Shore-based fishing accounts for most of the fish and invertebrate harvest from coral reefs around Guam. The coral reef fishery harvests more than 100 species of fish, including members of the families Acanthuridae, Carangidae, Gerreidae, Holocentridae, Kyphosidae, Labridae, Lethrinidae, Lutjanidae, Mugilidae, Mullidae, Scaridae, and Siganidae (Hensley and Sherwood 1993). There are several pulse fisheries for juvenile fish that can be major components of the coral reef fishery, but totals in these can vary year to year. These include juvenile rabbitfish (manahak and lesso'), juvenile jacks (i'e), and juvenile goatfish (ti'ao).

Species that are commonly taken in the coral reef fishery of Guam are: *Naso unicornis, N. lituratus*, *Acanthurus xanthopterus*, *A. lineatus*, *A. triostegus*, *Caranx melampygus*, *C. papuensis*, *Selar crumenophthalmus*, *Gerres acinaces*, *Myripristis* spp., *Sargocentron* spp., *Neoniphon* spp., *Kyphosus cinerascens*, *K. vaigiensis*, *Cheilinus undulatus*, *Cheilinus* spp., *Halichoeres* spp., *Lethrinus harak*, *L. obseletus*, *L. atkinsoni*, *Gnathodentex aurolineatus*, *Lutjanus fulvus*, *L. monostigma*, *L. bohar*, *L. argentimaculatus*, *Mulloidichthys flavolineatus*, *M. vanicolensis* (ti'ao), *Parupeneus multifasciatus*, *P. barberinus*, *P. cyclostomus*, *Ellechelon vaigiensis*, *Moolgarda engeli*, *M. seheli*, *Chlorurus spilurus*, *C. frontalis, Scarus psittacus*, *S. altipinnis*, *S. rubroviolaceus*, *S. ghobban*, *S. schlegeli*, *Siganus spinus (*manahak*)*, and *S. argenteus* (lesso).

Hook and line is the most common method of fishing for coral reef fish in Guam. In 2023, hook and line fishing accounted for around 81% of fishers and 83% of gear in inshore participation surveys. Throw net (talaya) is the second most common method, accounting for about 8% of fishers and 8% of gear. Other methods include gill net, snorkel spearfishing, surround net, drag net, hooks and gaffs, and gleaning.

Guam has continued to experience high levels of commercial activity targeting reef fish. This has primarily been performed by recent migrants from the Federated States of Micronesia. The fishers are generally hired by retail shops to fish six days per week; there have been as many as eight or nine of these stores open at a time. Gathering commercial sales data from these vendors has been difficult due to vendor anxiety surrounding the reason data is being collected and the lack of perceived benefit to the vendor for reporting sales. There have been several instances during data collection where the vendors were not able to comfortably communicate in English.

Data collected from these vendors is of limited value, as fish are not identified to species level, and are frequently labeled simply as “reef fish”. In 2023, there was one vendor reporting sales. In order to improve this situation, the Council, Division of Aquatic and Wildlife Resources (DAWR), and PIFSC partnered to increase vendor participation in the data collection program through the Territory Science Initiative. Extensive training, follow-ups, education, and outreach efforts were conducted to vendors and fishermen to increase participation in data collection.

In 2018, the Council drafted an Amendment 5 to the Mariana Archipelago FEP that reclassified a large number of MUS as ECS (WPRFMC 2018). The final rule was published in the *Federal Register* in early 2019 (84 FR 2767, February 8, 2019), and reduced the number of MUS from 227 species/families to 13 in the Mariana Archipelago FEP. All former CREMUS and CMUS were reclassified as ECS that do not require 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, 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 1.2.6.3 and 2.2.3).

In 2023, there were 47 Broadcast Notice to Mariners (BNM) regarding military exercises on and around Guam. While most of these do not affect inshore fishing, they do affect access to offshore banks for bottomfishing, and some firing ranges being activated restrict access to inshore fishing locations as well. In 2023, there were 144 warning days for area W-517, a large area south and east of Guam, that borders several offshore banks where bottom fishing occurs.

Additionally, in 2023, there were 119 high surf warning dates, which included 108 small craft advisories. Guam also experienced Typhoon Mawar in May 2023, resulting in seven typhoon watch dates.

1.2.3 FISHERY DATA COLLECTION SYSTEM

Guam currently has three fishery-dependent collection programs which can be described as long-term data collection programs with different approaches for gathering important information on fishery harvest methods performed by fishermen. The programs are the shore-based and boat-based data programs and the commercial fishery program. The Sportfish Restoration Grant from the U.S. Fish and Wildlife Service (USFWS) provides the significant portion of the funding for these programs. Training of the fishery staff to collect information is rigorous, and year-end totals are calculated by an expansion process done in collaboration with NMFS PIFSC. Identification of fish to the species level is the goal of Guam’s fishery staff.

The boat- and shore-based creel surveys are part of a long-term program that collects participation, effort, and catch data from fishermen. Collaboration with PIFSC has resulted in a reproducible computer database program that can analyze the data to produce various types of trends that describe status of both charter and non-charter fisheries in federal and local waters. The commercial receipt book program is an important source of information for fish that enter the commercial market; however, obtaining information from dealers has been sporadic, occasionally with less than three dealers providing data. In order to improve this situation, the Council, DAWR, and PIFSC partnered to increase vendor participation in the data collection program through the Territory Science Initiative (TSI).

Oram et al. (2011) and Jasper et al. (2016) describe the fishery data collection process for the offshore program on Guam. In general, DAWR staff collect fishery information through a series of random-stratified surveys for participation (i.e., accounting for fishing effort) and catch interviews (i.e., accounting for catch composition, size frequency, and CPUE). These data are transcribed into the Western Pacific Fisheries Information Network (WPacFIN) database, and the annual catch estimates are expanded from the effort and CPUE information. Monthly commercial vendor reports are tallied at the end of the year and adjusted based on the coverage estimates provided by the vendor and/or the data collection program staff.

1.2.3.1 DAWR CREEL SURVEY DATA COLLECTION

In 2023, DAWR maintained normal survey schedules in the wake of the COVID-19 pandemic. Normally, there are six shore-based creel surveys and two participation surveys completed per month. Boat-based creel surveys were also on a normal schedule with eight boat based creel (Table 22).

Table 1. Number of inshore creel and participation surveys completed by DAWR in 2023

Month	Inshore Creel Surveys Completed	Participation Surveys Completed	Aerial Surveys Completed
January	6	2	0
February	6	2	0
March	6	2	0
April	6	2	0
May	5*	2	0
June	6	2	0
July	6	2	0
August	6	2	0
September	6	2	0
October	6	2	0
November	6	2	0
December	6	2	0
Total	**72**	**24**	**0**

* One survey was cancelled in May due to impacts from Super Typhoon Mawar.

1.2.4 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 random-stratified design applied to pre-scheduled surveys. The number of sampling days, participation runs, and catch interviews would determine if there are enough 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.

1.2.4.1 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 2. Summary of Guam boat-based creel survey meta-data

Year	# Sample Days	# Catch Interviews	
		Regular	Opportunistic
1982	46	469	8
1983	47	431	34
1984	53	531	0
1985	66	812	0
1986	49	522	0
1987	48	612	0
1988	48	949	0
1989	48	931	2
1990	48	1,028	0
1991	48	1,019	1
1992	48	1,110	0
1993	52	1,119	0
1994	55	1,168	0
1995	96	1,613	4
1996	96	1,608	0
1997	96	1,358	0
1998	96	1,581	0
1999	96	1,367	3
2000	96	1,246	1
2001	96	908	6
2002	84	610	1
2003	78	446	0
2004	95	530	1
2005	97	552	0
2006	96	556	0
2007	96	500	0
2008	96	571	2
2009	96	803	0
2010	96	902	0

Year	# Sample Days	# Catch Interviews	
		Regular	Opportunistic
2011	96	645	0
2012	74	371	0
2013	96	561	1
2014	90	635	9
2015	97	651	13
2016	93	900	2
2017	92	820	10
2018	89	795	11
2019	93	786	3
2020	96	349	1
2021	96	884	2
2022	97	803	0
2023	96	571	1
10-year avg.	**94**	**719**	**5**
10-year SD	**3**	**161**	**5**
20-year avg.	**94**	**659**	**3**
20-year SD	**5**	**164**	**4**

1.2.4.2 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 landed 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 landed BMUS species.

Table 3. Summary of Guam commercial receipt book meta-data

Year	# Vendors	# Total Invoices Collected	# BMUS Vendors	# BMUS Invoices Collected
1980	1	1,055	1	14
1981	1	1,292	1	41
1982	1	1,177	n.d.	n.d.
1983	3	2,301	n.d.	n.d.
1984	3	2,583	3	48
1985	n.d.	n.d.	n.d.	n.d.
1986	n.d.	n.d.	n.d.	n.d.
1987	n.d.	n.d.	n.d.	n.d.
1988	n.d.	n.d.	n.d.	n.d.
1989	n.d.	n.d.	n.d.	n.d.

Year	# Vendors	# Total Invoices Collected	# BMUS Vendors	# BMUS Invoices Collected
1990	4	2,667	3	72
1991	3	2,354	n.d.	n.d.
1992	3	2,570	n.d.	n.d.
1993	3	2,506	n.d.	n.d.
1994	n.d.	n.d.	n.d.	n.d.
1995	3	1,563	n.d.	n.d.
1996	6	1,886	3	27
1997	7	2,677	4	41
1998	4	3,400	3	69
1999	5	3,270	3	177
2000	3	3,862	3	174
2001	3	4,154	3	286
2002	3	3,494	n.d.	n.d.
2003	n.d.	n.d.	n.d.	n.d.
2004	3	3,078	n.d.	n.d.
2005	3	2,648	n.d.	n.d.
2006	4	2,586	n.d.	n.d.
2007	n.d.	n.d.	n.d.	n.d.
2008	1	1,746	n.d.	n.d.
2009	1	1,676	n.d.	n.d.
2010	n.d.	n.d.	n.d.	n.d.
2011	n.d.	n.d.	n.d.	n.d.
2012	1	1,238	n.d.	n.d.
2013	1	1,293	n.d.	n.d.
2014	8	1,352	n.d.	n.d.
2015	8	1,332	n.d.	n.d.
2016	8	1,658	n.d.	n.d.
2017	11	1,980	4	104
2018	10	1,732	4	56
2019	6	1,195	n.d.	n.d.
2020	1	855	n.d.	n.d.
2021	1	385	n.d.	n.d.
2022	n.d.	n.d.	n.d.	n.d.
2023	n.d.	n.d.	n.d.	n.d.
10-year avg.	**6**	**1,143**	**2**	**68**
10-year SD	**4**	**544**	**1**	**36**
20-year avg.	**4**	**1,580**	**2**	**98**
20-year SD	**3**	**713**	**1**	**49**

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

1.2.5 FISHERY SUMMARY DASHBOARD STATISTICS

The Fishery Summary Dashboard Statics section consolidates fishery-dependent information comparing the most recent year with short-term (recent 10-year) and long-term (recent 20-year) 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*

↘ - *decreasing trend in the time series*

⇔ - *no trend in the time series*

⊕ - *above 1 standard deviation*

⊖ - *below 1 standard deviation*

⊙ - *within 1 standard deviation*

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

Table 4. Annual indicators for Guam bottomfish 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)
Bottomfish	**Total estimated catch (lb)**		
All gears (BMUS only)	All BMUS from creel survey data	**25,713[▲2%]** ↗ ⊙	**25,713[▼6%]** ⇔ ⊙
	All BMUS from commercial purchase data	**n.d.**	**n.d.**
	Catch-per-unit-effort (from boat-based creel surveys)		
Bottomfish fishing (BMUS only)	Bottomfish fishing lb/trip	**24[▲41%]** ↗ ⊕	**24[▲26%]** ↘ ⊕
	Bottomfish fishing lb/gr-hr	**2.18[▲95%]** ↗ ⊕	**2.18[▲68%]** ↘ ⊕
	Fishing effort (from boat-based creel surveys)		
Bottomfish fishing (BMUS only)	Tallied bottomfish trips	**42[▼31%]** ↗ ⊙	**42[▼31%]** ⇔ ⊖
	Tallied bottomfish gear hours	**453[▼60%]** ↗ ⊙	**453[▼54%]** ↗ ⊙
	Fishing participants (from boat-based creel surveys)		

Fishery	Fishery statistics	Short-term (10 years)	Long-term (20 years)
Bottomfish	**Total estimated catch (lb)**		
Bottomfish fishing (BMUS only)	Tallied number of bottomfish fishing vessels	33[▼25%] ↗ −	33[▼23%] ↔ −
	Estimated average number of fishermen per bottomfish fishing trip	2[▼33%] ↘ −	2[▼33%] ↗ −
	Bycatch		
BMUS	# fish caught	575[▼12%] ↗ •	575[▼11%] ↔ •
	# fish discarded/released	4[▲100%] ↘ +	4[▲33%] ↘ •
	% bycatch	0.70[▲150%] ↘ +	0.70[▲89%] ↘ •

Table 5. Annual indicators for Guam 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	**Total estimated boat-based catch (lb)**		
Prioritized ECS	*Naso unicornis* from creel survey data	4,093[▼17%] ↗ •	4,093[▼28%] ↘ •
	Siganus spinus from creel survey data	28[▼96%] ↗ •	28[▼94%] ↗ •
	Siganus spinus from commercial purchase data	0[▼100%] ↘ •	0[▼100%] ↗ •
	Lethrinus harak from creel survey data	424[▼80%] ↘ •	424[▼87%] ↘ −
	Chlorurus frontalis from creel survey data	705[▼26%] ↗ •	705[▼11%] ↗ •
	Epinephelus fasciatus from creel survey data	1,175[▲3%] ↘ •	1,175[▼29%] ↘ •
	Caranx melampygus from creel survey data	498[▼69%] ↘ •	498[▼82%] ↘ •
	Lethrinus olivaceus from creel survey data	644[▼27%] ↘ •	644[▼33%] ↘ •
	Lutjanus fulvus from creel survey data	5[▼98%] ↘ −	5[▼99%] ↘ −

Fishery	Fishery statistics	Short-term (10 years)	Long-term (20 years)
ECS	**Total estimated boat-based catch (lb)**		
	Scarus rubroviolaceus from creel survey data	**0[▼100%]**	**0[▼100%]**

1.2.6 CATCH STATISTICS

The following section summarizes the catch statistics for bottomfish, the top ten landed species, and nine prioritized species in Guam as decided by DAWR. Estimates of catch are summarized from the creel survey and commercial receipt book data collection programs. Catch statistics provide estimates of annual harvest from the different fisheries. Estimates of fishery removals can provide proxies for the level of fishing mortality and a reference level relative to established quotas. This section also provides detailed levels of catch for fishing methods and the top species complexes harvested in the ECS and bottomfish fisheries.

1.2.6.1 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 fishery data better than the creel surveys.

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

Table 6. Summary of Guam BMUS total catch (lb) from expanded boat- 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
1982	20,677	-	20,677	965
1983	36,150	-	36,150	n.d.
1984	14,655	-	14,655	3,445
1985	38,960	4	38,964	n.d.
1986	16,404	386	16,790	n.d.
1987	24,279	12	24,291	n.d.
1988	33,986	3,092	37,078	n.d.
1989	44,799	76	44,875	n.d.
1990	33,816	1,635	35,451	4,277
1991	31,546	1,641	33,187	n.d.
1992	36,316	2,337	38,653	n.d.
1993	39,073	368	39,441	n.d.
1994	40,719	222	40,941	n.d.
1995	27,194	892	28,086	n.d.

Year	Boat-Based Creel Survey Estimates	Shore-Based Creel Survey Estimates	Total Creel Survey Estimates	Commercial Landings
1996	40,498	1	40,499	1,251
1997	21,255	24	21,279	1,957
1998	22,296	34	22,330	4,576
1999	40,773	46	40,819	20,940
2000	58,640	79	58,719	12,184
2001	43,696	34	43,730	10,554
2002	20,366	30	20,396	n.d.
2003	29,506	-	29,506	n.d.
2004	25,233	20	25,253	n.d.
2005	29,087	2	29,089	n.d.
2006	33,414	3	33,417	n.d.
2007	22,576	3	22,579	n.d.
2008	31,103	4	31,107	6,293
2009	35,029	46	35,075	9,467
2010	23,928	211	24,139	n.d.
2011	52,230	50	52,280	n.d.
2012	17,518	4	17,522	4,745
2013	27,277	218	27,495	2,529
2014	20,687	24	20,711	n.d.
2015	10,782	73	10,855	n.d.
2016	24,479	1	24,480	n.d.
2017	14,653	82	14,735	4,002
2018	28,364	363	28,727	3,029
2019	28,849	143	28,992	n.d.
2020	16,953	-	16,953	8,562
2021	46,388	-	46,388	4,482
2022	33,154	345	33,499	n.d.
2023	25,713	-	25,713	n.d.
10-year avg.	**25,002**	**129**	**25,105**	**3,464**
10-year SD	**9,713**	**137**	**9,741**	**2,299**
20-year avg.	**27,371**	**88**	**27,450**	**5,143**
20-year SD	**9,659**	**116**	**9,665**	**2,859**

'-' indicates no data are available; 'n.d.' indicates that data are non-disclosed due to confidentiality rules.
Note: Boat-based creel survey estimates for 2020 to 2023 were generated using expansion scripts in R, and associated BMUS weights were calculated using new *a* and *b* values provided by the PIFSC Life History Program for Mariana Archipelago BMUS.

1.2.6.2 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 Guam.

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

Table 7. Total catch time series estimates (lb) for all species and BMUS only using Guam expanded boat-based creel survey data for bottomfish fishing gears

Year	Bottomfish		Spearfishing (Snorkel)		Spearfishing (SCUBA)*	
	All	BMUS	All	BMUS	All	BMUS
1982	41,329	20,677	420	-	-	-
1983	50,415	36,150	1,355	-	4,399	-
1984	57,412	14,525	14,108	87	5,460	43
1985	88,047	36,660	18,737	481	12,761	76
1986	34,515	14,904	12,545	10	5,145	92
1987	44,459	23,510	12,448	261	7,474	198
1988	67,038	32,204	24,712	1,717	10,649	50
1989	79,973	43,732	30,931	46	13,985	9
1990	61,401	32,827	28,871	-	22,273	393
1991	60,753	31,113	27,898	49	37,027	339
1992	78,174	33,303	35,162	179	25,226	1,938
1993	107,130	37,092	39,435	-	22,848	293
1994	105,283	40,310	37,554	-	27,244	247
1995	101,075	25,125	40,554	60	74,735	1,246
1996	129,708	38,618	67,446	255	91,810	698
1997	109,345	20,779	37,363	82	41,920	177
1998	99,601	21,618	56,442	272	68,198	314
1999	122,930	39,717	45,200	168	80,859	263
2000	115,837	56,095	42,403	282	116,072	1,052
2001	123,975	43,119	74,369	-	65,105	535
2002	55,447	19,092	21,712	39	34,766	347
2003	82,224	29,057	22,649	-	40,093	77
2004	61,874	23,268	33,601	130	50,442	1,726
2005	62,651	27,838	15,036	256	27,934	896
2006	89,865	32,132	12,796	1,178	4,129	-
2007	57,750	20,363	18,516	357	11,316	1,835
2008	59,639	30,872	29,715	124	24,647	-
2009	89,997	34,369	22,669	305	28,947	-
2010	56,164	22,958	23,635	233	1,775	-

Year	Bottomfish		Spearfishing (Snorkel)		Spearfishing (SCUBA)*	
	All	BMUS	All	BMUS	All	BMUS
2011	88,694	50,576	26,483	-	67,431	26
2012	40,214	17,518	23,986	-	12,204	-
2013	42,602	14,425	20,816	-	2,771	-
2014	69,299	18,011	28,088	274	32,316	-
2015	29,395	10,253	22,371	-	30,654	-
2016	51,475	23,872	28,985	376	21,517	-
2017	46,715	14,096	17,045	88	9,854	-
2018	57,904	27,022	23,051	130	65,998	672
2019	44,208	28,448	13,557	18	15,532	-
2020	33,739	16,561	9,046	29	2,518	-
2021	82,422	45,992	30,534	101	-	-
2022	54,832	31,257	47,959	894	-	-
	39,718	23,421	27,578	734	-	-
10-year avg.	**50,971**	**23,893**	**24,821**	**264**	**17,839**	**67**
10-year SD	**15,301**	**9,715**	**10,242**	**299**	**19,913**	**202**
20-year avg.	**57,958**	**25,663**	**23,773**	**261**	**20,499**	**258**
20-year SD	**17,906**	**9,947**	**8,467**	**315**	**20,451**	**560**

'-' indicates no data are available.
* SCUBA spearfishing was banned by law in March 2020 (5 Guam Code §§ 63116.3).

1.2.6.3 TOP AND PRIORITIZED ECS IN BOAT-BASED FISHERY CATCH

Catch time series can act as indicators of fishery performance. Variations in the catch can be attributed to various 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. Commercial data for ECS harvested in Guam boat-based fisheries are not reported here due to data confidentiality rules pertaining to the disclosure of data from fewer than three dealers and/or vendors. Additionally, Guam DAWR selected nine species that were reclassified as ECS that are still of priority to Guam DAWR 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 8. Top ten landed ECS in Guam from boat-based creel survey data in 2023

Common Name	Scientific Name	Catch (lb)
Assorted reef fish	Multi-genera multi-species	16,925
Bigeye scad	*Selar crumenophthalmus*	14,143
Bluespine unicornfish	*Naso unicornis*	4,093
Deep-water bottomfish	Multi-genera multi-species	3,756
8 barred grouper	*Epinephelus octofasciatus*	1,958
Shallow-water bottomfish	Multi-genera multi-species	1,867
Bluebanded surgeonfish	*Acanthurus lineatus*	1,397

Common Name	Scientific Name	Catch (lb)
Blacktip grouper	*Epinephelus fasciatus*	1,175
Orange-striped emperor	*Lethrinus obsoletus*	1,027
Highfin rudderfish	*Kyphosus cinerascens*	789

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

Table 9a. Catch (lb) from boat-based expansion data for prioritized species in Guam ECS fisheries

Year	*Naso unicornis*	*Siganus spinus*	*Lethrinus harak*	*Chlorurus frontalis*	*Epinephelus fasciatus*	*Caranx melampygus*	*Lethrinus olivaceus*	*Lutjanus fulvus*	*Scarus rubroviolaceus*
1982	-	-	-	-	335	490	43	8	-
1983	10	-	-	16	1,505	670	-	109	-
1984	383	-	-	-	669	96	174	-	-
1985	1,177	-	296	502	3,313	2,961	765	100	175
1986	305	-	33	572	610	512	458	95	288
1987	227	66	21	517	1,482	1,286	77	103	138
1988	1,219	84	127	2,409	3,967	869	214	192	1,906
1989	4,402	422	1,185	105	2,046	1,451	397	1,269	892
1990	4,648	670	2,628	2	1,348	2,861	3,757	202	628
1991	6,683	570	2,022	225	2,827	1,936	744	2,024	2,395
1992	15,510	418	1,544	3,157	2,126	735	1,484	1,018	1,594
1993	5,335	2,103	2,263	181	5,950	2,087	353	617	1,126
1994	6,089	426	3,098	832	2,342	2,606	5,470	3,108	809
1995	23,433	2,133	3,268	1,874	7,747	5,038	1,628	1,514	1,262
1996	40,676	935	6,523	1,221	6,017	8,961	2,700	1,853	983
1997	18,354	1,541	6,151	197	4,581	3,843	2,073	704	457
1998	26,540	1,464	3,293	2,478	8,678	2,913	586	749	708
1999	23,985	2,096	4,185	1,114	6,348	2,985	2,309	477	495
2000	34,700	646	4,188	78	3,607	4,846	4,081	920	1,941
2001	17,222	989	4,705	508	3,590	2,822	3,615	625	940
2002	12,329	1,012	3,675	158	2,030	4,179	11,890	172	49
2003	8,643	740	4,108	1,911	9,998	3,376	629	504	830
2004	18,734	24	5,669	30	3,608	5,622	2,700	238	-
2005	12,089	71	5,451	956	1,446	4,460	1,161	104	814
2006	1,283	192	1,960	268	2,766	6,357	257	297	159

Year	*Naso unicornis*	*Siganus spinus*	*Lethrinus harak*	*Chlorurus frontalis*	*Epinephelus fasciatus*	*Caranx melampygus*	*Lethrinus olivaceus*	*Lutjanus fulvus*	*Scarus rubroviolaceus*
2007	4,848	18	1,354	98	2,616	1,365	799	616	4,175
2008	10,882	1,341	1,023	1,915	1,894	5,349	179	424	375
2009	6,588	101	6,741	1,165	2,003	3,134	1,870	694	-
2010	4,291	-	4,164	847	2,061	1,751	1,454	495	178
2011	2,341	-	6,954	-	2,246	1,218	1,319	1,018	-
2012	93	15	4,781	431	1,073	1,000	414	791	-
2013	3,269	158	7,195	551	1,962	9,524	113	324	785
2014	5,950	344	8,231	115	1,590	5,394	2,729	773	-
2015	2,064	235	2,550	-	1,917	371	741	324	-
2016	2,226	614	2,132	332	1,114	3,669	375	144	453
2017	711	79	2,289	32	1,632	2,162	356	793	-
2018	4,578	-	503	1,752	672	855	756	134	30
2019	5,375	418	1,909	178	756	1,654	905	367	-
2020	1,013	1,625	880	2,101	1,339	277	888	196	15
2021	9,028	3,716	634	350	518	968	1,025	277	145
2022	14,047	415	1,226	3,954	699	446	462	55	1,207
2023	4,093	28	424	705	1,175	498	644	5	-
10-year avg.	**4,909**	**747**	**2,078**	**952**	**1,141**	**1,629**	**888**	**307**	**185**
10-year SD	**4,091**	**1,143**	**2,300**	**1,284**	**476**	**1,691**	**686**	**275**	**386**
20-year avg.	**5,675**	**470**	**3,304**	**789**	**1,654**	**2,804**	**957**	**403**	**417**
20-year SD	**4,953**	**883**	**2,584**	**991**	**789**	**2,550**	**750**	**288**	**949**

'-' indicates no data are available.

Calculations: Catch tallied from commercial purchase data for species identified as priority ECS (Appendix A). From the prioritized ECS list, only *Siganus spinus* is included because there are no specific species codes for the other eight prioritized species in the Guam commercial coding system, which tends to aggregate data into larger groups such as taxonomic family.

Table 30b. Catch (lb) from commercial purchase data for *Siganus spinus* in Guam

Year	*Siganus spinus*
1982	0
1983	26
1984	32
1985	n.d.
1986	n.d.
1987	n.d.
1988	n.d.
1989	n.d.
1990	419
1991	11
1992	18
1993	0
1994	n.d.
1995	0
1996	131
1997	84
1998	1,895
1999	3,450
2000	0
2001	15
2002	891
2003	n.d.
2004	48
2005	0
2006	62
2007	n.d.
2008	0
2009	0
2010	n.d.
2011	n.d.
2012	0
2013	145
2014	1,088
2015	572

Year	***Siganus spinus***
2016	2,377
2017	10,941
2018	6,262
2019	614
2020	0
2021	0
2022	n.d.
2023	0
10-year avg.	**2,732**
10-year SD	**3,653**
20-year avg.	**1,474**
20-year SD	**2,988**

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

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

This section summarizes the estimates for CPUE in the boat-based fisheries both for all species and for BMUS only. The boat-based fisheries include the bottomfish fishing (handline gear), spearfishing (snorkel), and spearfishing (SCUBA). CPUE is reported as both pounds per gear hour and pounds per fishing trip 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 10. Non-expanded CPUE (lb/gear hour and lb/trip) for bottomfish fishing gears in the Guam boat-based fishery for all species and BMUS only

Year	Bottomfish				Spearfish (Snorkel)				Spearfish (SCUBA)*			
	All		BMUS		All		BMUS		All		BMUS	
	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr
1982	27	3.01	17	1.80	7	2.46	-	-	-	-	-	-
1983	23	2.99	20	2.38	7	1.67	-	-	18	5.8928	-	-
1984	28	3.12	17	2.06	39	2.32	10	0.83	24	4.9721	1	0.33
1985	27	2.41	17	1.49	49	4.54	6	0.55	25	6.5899	2	0.67
1986	23	2.33	24	1.80	43	4.15	1	0.20	20	4.3467	3	0.50
1987	24	2.59	18	1.76	28	5.47	4	0.92	30	6.68	3	0.53
1988	21	2.06	13	1.13	35	6.05	34	8.50	20	7.4436	2	0.80
1989	20	2.13	16	1.54	26	3.07	1	0.19	31	5.9778	1	0.29
1990	21	2.00	17	1.48	22	3.66	-	-	46	11.3137	7	1.17
1991	19	2.20	17	1.80	24	4.45	1	0.13	47	14.4483	5	1.05
1992	17	1.91	11	1.11	24	3.52	3	0.50	25	8.1011	12	2.48
1993	19	1.83	17	1.67	21	3.37	-	-	58	19.1414	6	1.47
1994	27	2.43	21	1.75	25	3.62	-	-	55	15.0797	4	0.97
1995	13	1.00	11	0.86	31	3.74	3	0.25	89	17.343	12	1.76
1996	18	1.17	16	1.24	33	4.21	4	1.17	76	11.1943	7	0.50
1997	14	0.96	12	0.73	25	3.11	10	4.00	81	14.5776	4	0.62
1998	14	1.02	10	0.81	21	2.94	6	0.38	98	15.8862	2	0.28
1999	15	1.08	16	1.16	17	2.08	8	4.00	100	14.8241	3	0.35
2000	18	1.34	18	1.26	21	2.72	24	24.00	90	13.9979	5	0.51
2001	20	1.66	16	1.29	56	4.69	21	1.31	69	10.9849	4	0.42
2002	17	1.37	14	1.16	21	3.01	1	0.08	58	6.9783	12	1.28
2003	20	1.55	15	0.94	40	5.05	-	-	108	13.1981	3	0.22
2004	24	1.88	20	1.42	28	3.42	2	0.11	80	9.1049	10	0.97
2005	26	2.11	29	2.11	20	2.57	6	1.20	61	5.5541	13	0.52

Year	Bottomfish				Spearfish (Snorkel)				Spearfish (SCUBA)*			
	All		BMUS		All		BMUS		All		BMUS	
	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr	lb/trip	lb/gr-hr
2006	31	2.12	26	1.39	24	2.34	20	1.24	13	2.6939	-	-
2007	29	2.18	15	1.12	31	3.31	5	0.53	100	8	25	1.56
2008	21	1.76	18	1.26	38	3.05	2	0.21	35	4.4894	-	-
2009	29	2.11	24	1.82	23	2.71	2	0.19	63	7	-	-
2010	17	1.22	13	0.84	19	2.42	1	0.25	2	0.4444	-	-
2011	37	2.72	29	2.16	41	5.17	-	-	140	11.5052	1	0.17
2012	21	2.09	18	1.66	58	7.62	-	-	70	10	-	-
2013	20	1.55	16	1.14	28	2.28	-	-	10	3.5294	-	-
2014	25	1.34	13	0.93	35	2.40	4	0.50	33	8.6087	-	-
2015	16	1.31	15	1.19	33	3.02	-	-	58	2.6977	-	-
2016	21	1.46	16	1.10	27	2.76	4	0.33	68	4.7859	-	-
2017	19	1.37	11	0.71	16	1.92	2	0.22	43	5.3438	-	-
2018	25	0.49	19	0.33	41	3.67	3	0.13	98	7.2778	37	2.27
2019	19	1.62	18	1.38	17	1.46	1	0.13	45	2.9945	-	-
2020	13	1.14	12	0.80	9	1.08	1	0.50	76	4.7789	-	-
2021	24	1.52	25	1.37	23	1.89	3	0.29	-	-	-	-
2022	19	1.41	18	1.18	34	2.36	4	0.32	-	-	-	-
2023	24	2.60	24	2.18	38	3.01	6	1.00	-	-	-	-
10-yr avg.	**21**	**1.43**	**17**	**1.12**	**27**	**2.36**	**3**	**0.38**	**60**	**5**	**37**	**2.27**
10-yr SD	**4**	**0.49**	**4**	**0.47**	**10**	**0.75**	**2**	**0.25**	**21**	**2**	**0**	**0.00**
20-yr avg.	**23**	**1.70**	**19**	**1.30**	**29**	**2.92**	**4**	**0.45**	**59**	**6**	**17**	**1.10**
20-yr SD	**6**	**0.52**	**5**	**0.48**	**11**	**1.37**	**4**	**0.36**	**34**	**3**	**13**	**0.75**

'-' indicates no data are available.
* SCUBA spearfishing was banned by law in March 2020 (5 Guam Code §§ 63116.3).

1.2.8 EFFORT STATISTICS

This section summarizes the effort trends in the Guam 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 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 1982.

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 - Gear-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 11. Non-expanded effort (trips and gear hours) for bottomfish fishing gears in the Guam boat-based fishery for all species and BMUS only

Year	Bottomfish				Spearfish (Snorkel)				Spearfish (SCUBA)*			
	All		BMUS		All		BMUS		All		BMUS	
	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr
1982	97	869	74	715	5	15	0	0	1	1	0	0
1983	89	683	66	566	6	24	0	0	13	40	0	0
1984	124	1,118	39	328	20	336	1	12	12	57	1	3
1985	217	2,391	139	1,635	19	203	4	42	36	139	3	9
1986	103	1,024	41	543	14	145	1	5	8	38	1	6
1987	114	1,041	72	758	20	101	3	13	11	50	3	15
1988	173	1,776	137	1,542	33	190	2	8	25	67	2	5
1989	187	1,790	127	1,307	24	204	3	16	24	123	1	4
1990	157	1,660	108	1,219	18	107	0	0	17	70	1	6
1991	152	1,316	92	852	20	109	2	16	27	89	5	24
1992	152	1,368	98	1,013	30	205	1	6	48	146	3	14
1993	164	1,700	81	842	38	242	0	0	29	87	4	15
1994	185	2,028	105	1,282	37	251	0	0	32	116	5	21
1995	302	3,860	127	1,613	56	464	1	12	56	287	8	56
1996	277	4,173	97	1,284	62	482	2	6	48	327	5	75
1997	238	3,554	75	1,183	41	328	1	3	27	150	2	13
1998	315	4,311	125	1,551	96	700	4	66	40	246	6	50
1999	285	4,039	112	1,549	51	428	1	2	43	290	9	65
2000	200	2,676	92	1,345	47	366	1	1	41	265	8	72
2001	197	2,337	95	1,161	22	261	1	16	29	182	4	38
2002	150	1,861	73	878	29	202	1	12	11	92	2	18
2003	107	1,411	55	905	22	175	0	0	13	106	2	23
2004	112	1,432	60	837	17	138	2	27	11	97	3	31
2005	121	1,510	69	946	24	186	2	10	7	76	1	25

Year	Bottomfish				Spearfish (Snorkel)				Spearfish (SCUBA)*			
	All		BMUS		All		BMUS		All		BMUS	
	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr	Trips	Gr-hr
2006	104	1,519	61	1,123	19	198	2	32	5	25	0	0
2007	84	1,126	55	745	13	121	2	19	2	25	1	16
2008	104	1,226	57	792	26	322	3	34	6	47	0	0
2009	146	1,979	76	1,019	28	233	4	43	3	27	0	0
2010	165	2,287	96	1,460	27	207	4	20	1	5	0	0
2011	101	1,373	62	840	15	118	0	0	4	49	1	6
2012	53	530	32	353	8	61	0	0	3	21	0	0
2013	60	763	31	437	12	148	0	0	3	9	0	0
2014	92	1,625	46	604	17	205	1	8	3	12	0	0
2015	73	887	34	432	17	184	0	0	4	86	0	0
2016	106	1,506	62	927	25	241	2	24	22	313	0	0
2017	115	1,573	69	1,073	31	256	2	19	4	32	0	0
2018	99	5,010	54	3,053	19	215	2	45	16	216	3	49
2019	127	1,525	76	1,016	20	217	1	8	6	91	0	0
2020	74	858	42	626	17	149	1	2	3	48	0	0
2021	151	2,390	90	1,628	44	532	4	35	0	0	0	0
2022	145	1,957	96	1,435	41	596	7	92	0	0	0	0
2023	72	654	42	453	20	252	2	11	0	0	0	0
10-year avg.	**105**	**1,798**	**61**	**1,125**	**25**	**285**	**2**	**24**	**6**	**80**	**0**	**5**
10-year SD	**28**	**1,181**	**20**	**746**	**10**	**144**	**2**	**26**	**7**	**100**	**1**	**15**
20-year avg.	**105**	**1,586**	**61**	**990**	**22**	**229**	**2**	**21**	**5**	**59**	**0**	**6**
20-year SD	**30**	**929**	**19**	**585**	**9**	**126**	**2**	**21**	**5**	**76**	**1**	**13**

* SCUBA spearfishing was banned by law in March 2020 (5 Guam Code §§ 63116.3).

1.2.9 PARTICIPANTS

This section summarizes the estimated participation in each 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 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 12a. Non-expanded number of unique vessels for bottomfish fishing gears in the Guam boat-based fishery for all species and BMUS only

Year	Bottomfish		Spearfish (Snorkel)		Spearfish (SCUBA)*	
	All	BMUS	All	BMUS	All	BMUS
1982	58	47	4	0	1	0
1983	51	41	5	0	4	0
1984	75	33	13	1	6	1
1985	97	66	9	3	21	3
1986	62	27	12	1	7	1
1987	71	42	14	3	8	2
1988	92	76	22	2	14	1
1989	100	70	20	3	18	1
1990	87	58	17	0	9	1
1991	96	65	19	2	19	4
1992	88	62	23	1	29	3
1993	116	53	25	0	20	4
1994	122	71	32	0	22	4
1995	170	82	39	1	30	5
1996	148	68	44	2	28	3
1997	126	51	31	1	18	2
1998	153	72	54	4	20	4
1999	152	69	44	1	16	6
2000	107	61	35	1	21	5
2001	131	73	18	1	16	3
2002	104	58	24	1	9	2
2003	80	48	21	0	9	2
2004	83	47	16	2	5	2
2005	78	42	16	2	6	1
2006	72	45	18	2	4	0
2007	58	41	11	2	2	1

Year	Bottomfish		Spearfish (Snorkel)		Spearfish (SCUBA)*	
	All	BMUS	All	BMUS	All	BMUS
2008	78	44	19	3	3	0
2009	98	49	25	4	3	0
2010	103	61	22	4	1	0
2011	72	44	14	0	3	1
2012	46	29	8	0	2	0
2013	48	28	12	0	3	0
2014	69	39	12	1	3	0
2015	60	26	15	0	2	0
2016	75	41	18	2	10	0
2017	85	54	26	2	2	0
2018	67	37	16	2	7	3
2019	84	52	13	1	3	0
2020	63	35	14	1	3	0
2021	93	55	28	3	0	0
2022	93	63	29	7	0	0
2023	55	33	16	2	0	0
10-year avg.	**74**	**44**	**19**	**2**	**3**	**0**
10-year SD	**13**	**11**	**6**	**2**	**3**	**1**
20-year avg.	**74**	**43**	**17**	**2**	**3**	**0**
20-year SD	**16**	**10**	**6**	**2**	**2**	**1**

* SCUBA spearfishing was banned by law in March 2020 (5 Guam Code §§ 63116.3).

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. A blank cell indicates insufficient data to generate an estimate of average fishers.

All: Average fishers from all trips by gear type.

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

Table 33b. Non-expanded average number of fishers per trip for bottomfish fishing gears in the Guam boat-based fishery for all species and BMUS only

Year	Bottomfish		Spearfish (Snorkel)		Spearfish (SCUBA)*	
	All	BMUS	All	BMUS	All	BMUS
1982	2	2	3	0	1	0
1983	2	2	2	0	1	0
1984	3	3	4	3	2	1
1985	3	3	4	3	2	1
1986	3	2	3	1	3	2
1987	2	2	2	1	2	2
1988	3	3	3	2	2	1

Year	Bottomfish		Spearfish (Snorkel)		Spearfish (SCUBA)*	
	All	BMUS	All	BMUS	All	BMUS
1989	3	3	3	2	3	3
1990	3	3	4	0	3	4
1991	3	3	3	3	3	4
1992	3	3	4	1	3	3
1993	3	3	3	0	4	4
1994	3	3	3	0	4	4
1995	4	3	3	2	4	5
1996	5	3	3	1	4	6
1997	6	4	3	5	4	4
1998	4	3	3	4	4	5
1999	4	3	3	2	4	4
2000	4	3	3	2	4	4
2001	3	2	3	2	4	5
2002	3	2	3	2	4	4
2003	3	3	4	0	4	4
2004	4	3	3	6	4	4
2005	3	2	3	3	3	5
2006	3	2	3	3	3	0
2007	4	3	3	2	4	4
2008	3	2	3	3	3	0
2009	3	2	3	3	4	0
2010	3	3	3	3	3	0
2011	3	3	4	0	4	3
2012	3	3	3	0	5	0
2013	3	3	4	0	3	0
2014	3	3	4	4	3	0
2015	4	4	4	0	7	0
2016	3	3	3	2	5	0
2017	2	2	3	3	5	0
2018	4	3	4	4	5	3
2019	3	3	4	5	7	0
2020	3	3	4	6	6	0
2021	3	3	4	4	0	0
2022	3	2	4	4	0	0
2023	2	2	5	5	0	0
10-year avg.	**3**	**3**	**4**	**4**	**4**	**0**
10-year SD	**1**	**1**	**1**	**2**	**3**	**1**
20-year avg.	**3**	**3**	**4**	**3**	**4**	**1**

Year	Bottomfish		Spearfish (Snorkel)		Spearfish (SCUBA)*	
	All	BMUS	All	BMUS	All	BMUS
20-year SD	**1**	**1**	**1**	**2**	**2**	**2**

* SCUBA spearfishing was banned by law in March 2020 (5 Guam Code §§ 63116.3).

1.2.10 BYCATCH ESTIMATES

This section focuses on 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 establish SBRMs.

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 13. Non-expanded catch and bycatch in Guam boat-based fisheries

Year	BMUS			Non-BMUS			BMUS + Non-BMUS		
	# Caught	# Discard or Release	% Bycatch	# Caught	# Discard or Release	% Bycatch	# Caught	# Discard or Release	% Bycatch
1982	1,062	0	0.00	535	0	0.00	1,597	0	0.00
1983	940	0	0.00	567	0	0.00	1,507	0	0.00
1984	590	0	0.00	2,757	0	0.00	3,347	0	0.00
1985	1,830	0	0.00	3,010	0	0.00	4,840	0	0.00
1986	546	0	0.00	1,078	0	0.00	1,624	0	0.00
1987	1,313	0	0.00	1,206	0	0.00	2,519	0	0.00
1988	1,399	0	0.00	1,603	0	0.00	3,002	0	0.00
1989	2,028	0	0.00	1,534	0	0.00	3,562	0	0.00
1990	1,542	0	0.00	1,328	0	0.00	2,870	0	0.00
1991	1,366	0	0.00	1,417	0	0.00	2,783	0	0.00
1992	1,046	0	0.00	1,481	0	0.00	2,527	0	0.00
1993	946	0	0.00	1,947	0	0.00	2,893	0	0.00
1994	1,663	0	0.00	2,067	0	0.00	3,730	0	0.00
1995	1,449	0	0.00	3,536	0	0.00	4,985	0	0.00
1996	1,281	0	0.00	3,963	0	0.00	5,244	0	0.00
1997	983	0	0.00	3,359	0	0.00	4,342	0	0.00

Year	BMUS			Non-BMUS			BMUS + Non-BMUS		
	# Caught	# Discard or Release	% Bycatch	# Caught	# Discard or Release	% Bycatch	# Caught	# Discard or Release	% Bycatch
1998	993	0	0.00	4,145	0	0.00	5,138	0	0.00
1999	1,081	0	0.00	3,857	0	0.00	4,938	0	0.00
2000	1,090	6	0.55	2,815	526	18.69	3,905	532	13.62
2001	1,023	16	1.56	2,873	607	21.13	3,896	623	15.99
2002	629	2	0.32	1,875	351	18.72	2,504	353	14.10
2003	497	20	4.02	1,391	171	12.29	1,888	191	10.12
2004	586	0	0.00	1,218	122	10.02	1,804	122	6.76
2005	616	0	0.00	1,090	66	6.06	1,706	66	3.87
2006	1,140	27	2.37	1,048	118	11.26	2,188	145	6.63
2007	417	7	1.68	955	132	13.82	1,372	139	10.13
2008	572	3	0.52	1,085	118	10.88	1,657	121	7.30
2009	860	0	0.00	1,991	77	3.87	2,851	77	2.70
2010	890	0	0.00	1,698	29	1.71	2,588	29	1.12
2011	707	0	0.00	1,421	45	3.17	2,128	45	2.11
2012	309	0	0.00	615	37	6.02	924	37	4.00
2013	293	0	0.00	929	44	4.74	1,222	44	3.60
2014	658	6	0.91	1,794	163	9.09	2,452	169	6.89
2015	366	0	0.00	1,054	70	6.64	1,420	70	4.93
2016	641	2	0.31	1,033	45	4.36	1,674	47	2.81
2017	766	0	0.00	1,547	26	1.68	2,313	26	1.12
2018	406	2	0.49	1,115	27	2.42	1,521	29	1.91
2019	865	3	0.35	982	44	4.48	1,847	47	2.54
2020	302	0	0.00	525	16	3.05	827	16	1.93
2021	693	0	0.00	1,253	5	0.40	1,946	5	0.26
2022	1,273	1	0.08	744	15	2.02	2,017	16	0.79
2023	575	4	0.70	514	0	0.00	1,089	4	0.37
10-yr avg.	**655**	**2**	**0.28**	**1,056**	**41**	**3.41**	**1,711**	**43**	**2.36**
10-yr SD	**268**	**2**	**0.31**	**388**	**45**	**2.67**	**487**	**46**	**2.00**
20-yr avg.	**647**	**3**	**0.37**	**1,131**	**60**	**5.28**	**1,777**	**63**	**3.59**
20-yr SD	**262**	**6**	**0.62**	**391**	**46**	**3.80**	**536**	**49**	**2.65**

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

<u>Data Source</u>: 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

<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 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*Δ$_{50}$ (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 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

<u>Description</u>: 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

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 **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 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

<u>Description</u>: 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

<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 Table 7 for specific details on data sources by species.

<u>Parameter Definitions: Identical to Section 2.3.3.1</u>

<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. 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.

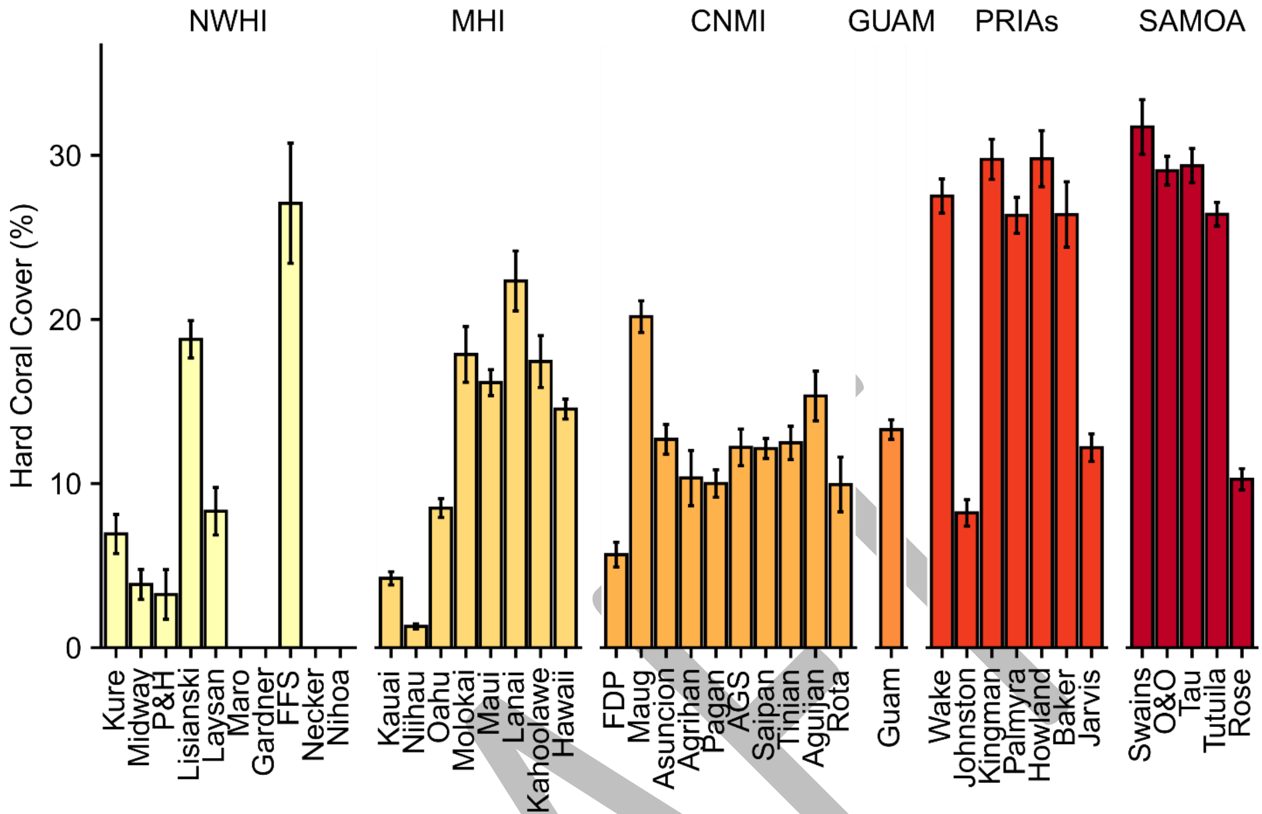

Figure 1. Mean coral cover (%± standard error of the mean, or SEM) per U.S. Pacific Island averaged from 2010-2023 by latitude

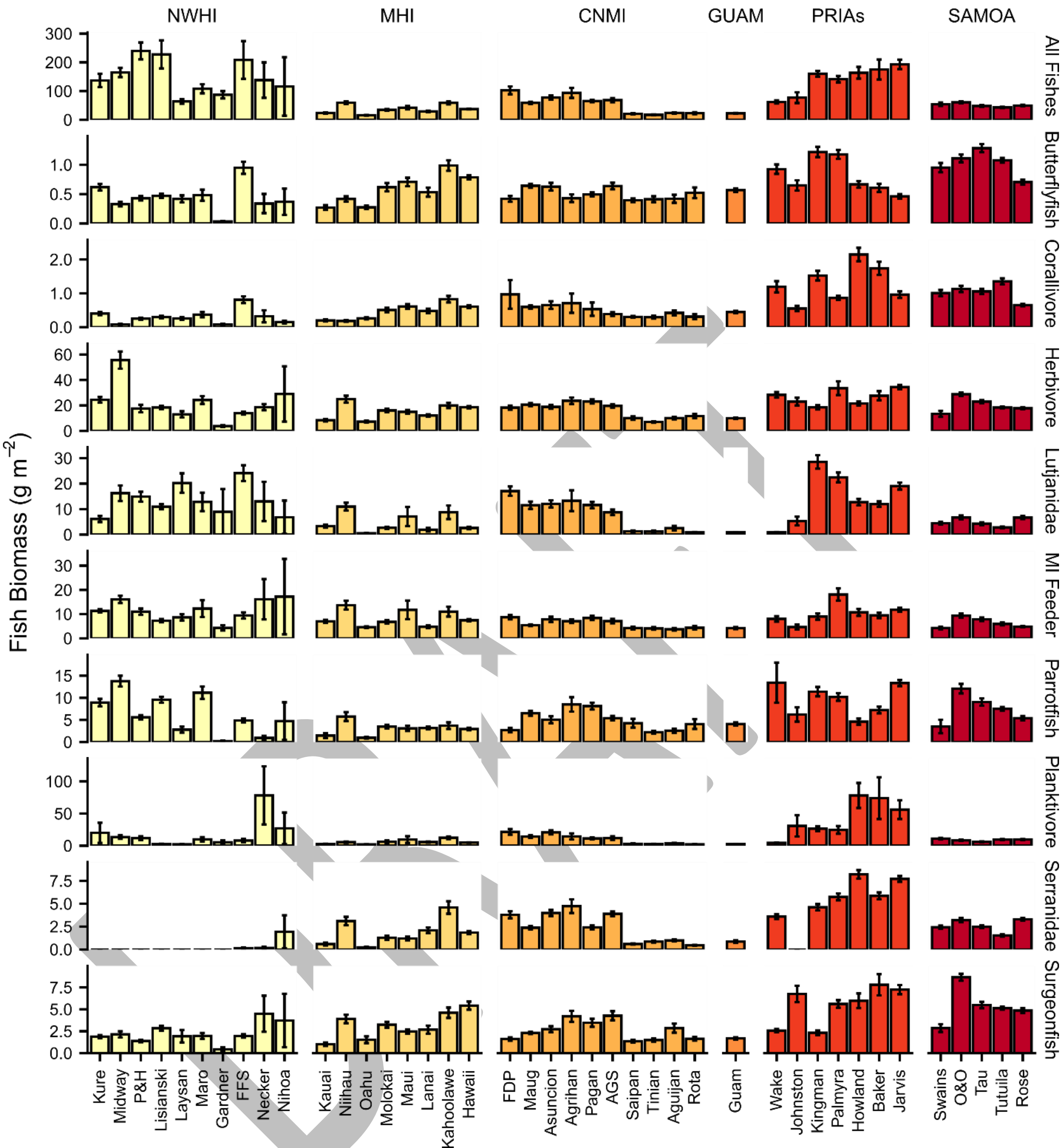

Figure 2. Mean fish biomass (g/m^2 ± SEM) per U.S. Pacific Island of functional, taxonomic, and trophic groups from 2010-2023 by latitude

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

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: CNMI

Spatial Scale: Island

Data Source: 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.

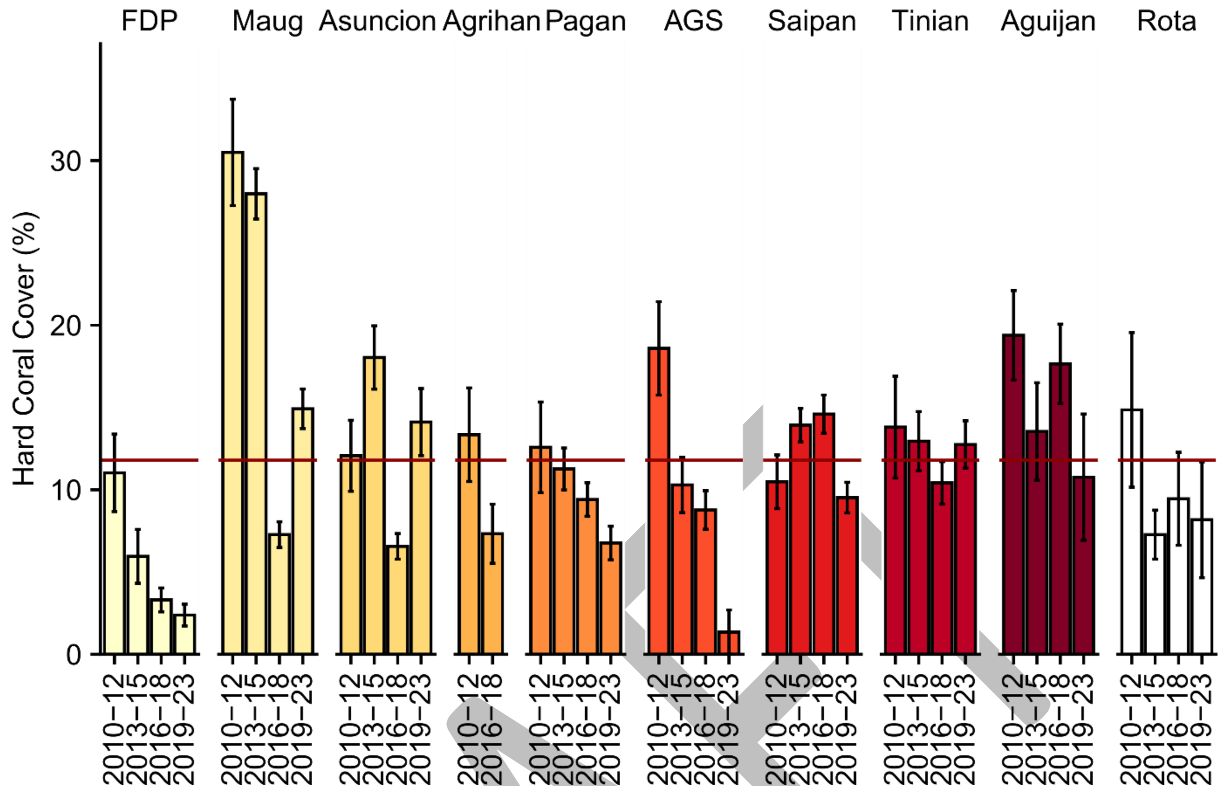

Figure 3. Mean coral cover (% ± SEM) per island of the CNMI from 2010–2023 by latitude

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

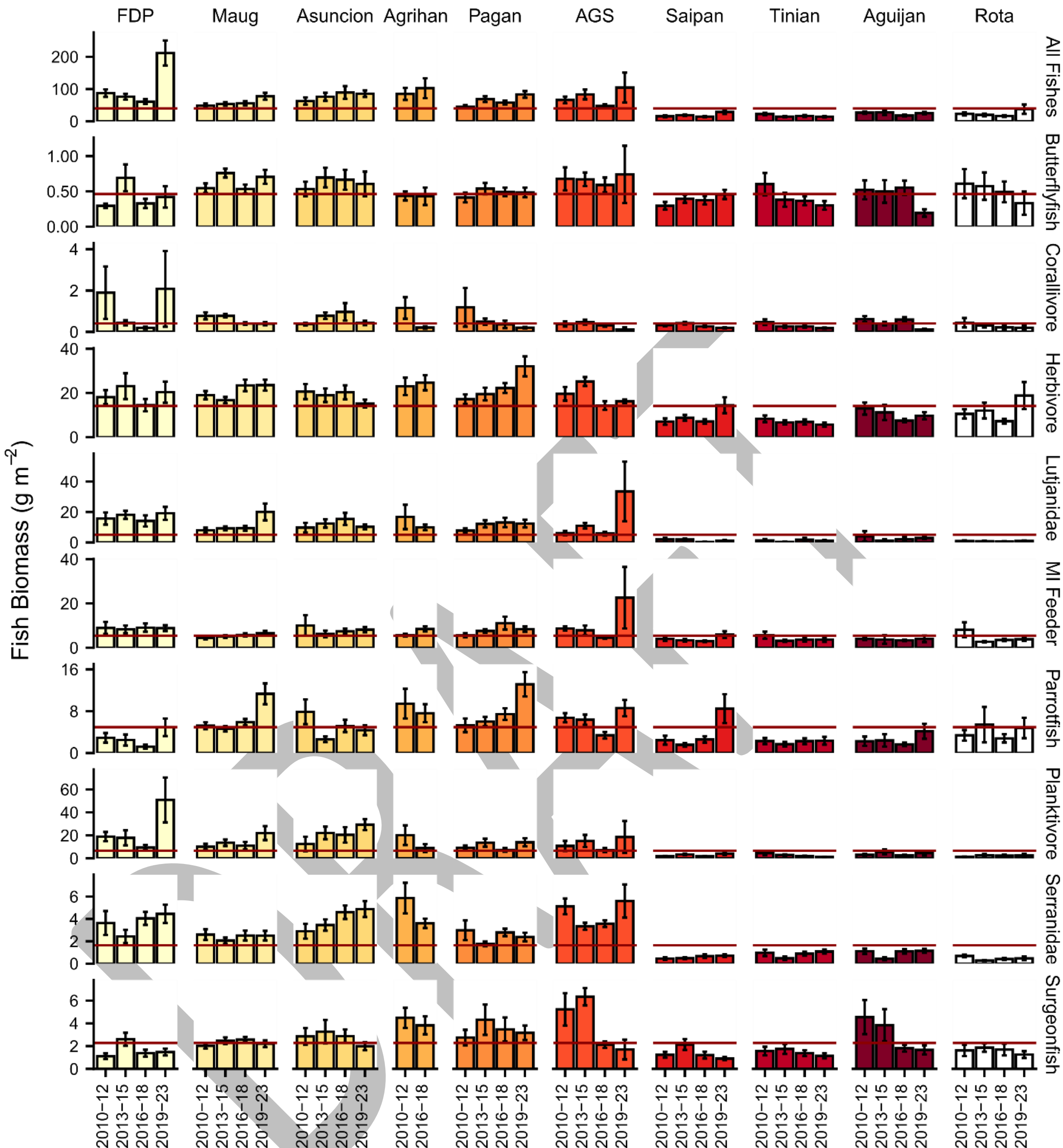

Figure 4. Mean fish biomass (g/m^2 ± SEM) of functional, taxonomic, and trophic groups per island of the CNMI from 2010-2023

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.

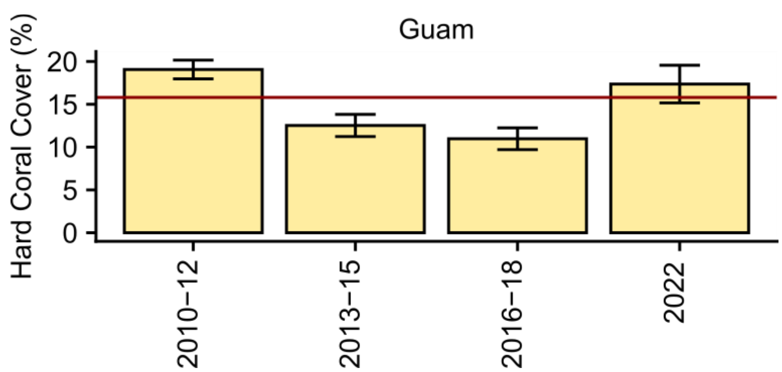

Figure 5. Mean coral cover (% ± SEM) of Guam over the years 2010-2023

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

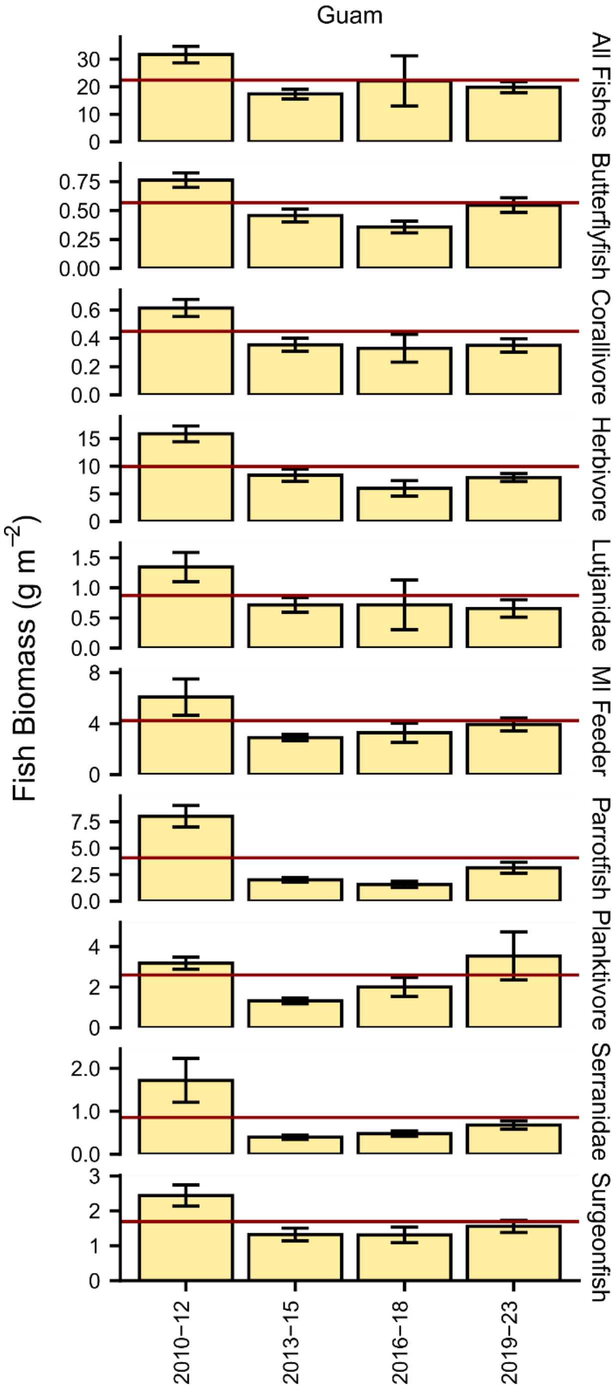

Figure 6. Mean fish biomass (g/m^2 ± SEM) of functional, taxonomic, and trophic groups of Guam from 2010-2023.

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.

1.2.11 FEDERAL LOGBOOK DATA

1.2.11.1 NUMBER OF FEDERAL PERMIT HOLDERS

The CFR, Title 50, Part 665 requires the following federal permits for Guam fisheries in the EEZ under the Mariana Archipelago FEP. Regulations governing fisheries under this FEP are in the CFR, Title 50, Part 665

1.2.11.1.1 Guam Large Vessel Bottomfish Permit

Regulations require this permit for any large vessel (50 feet or longer in overall length) fishing for, landing, or transshipping BMUS or bottomfish ECS in the EEZ seaward of Guam.

1.2.11.1.2 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 Guam coral reef ECS while fishing for bottomfish MUS, 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 ecosystem ECS caught in a low-use MPA.

1.2.11.1.3 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.

1.2.11.1.4 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 deep-water shrimp in the EEZ around American Samoa, Guam, CNMI, Hawaii, and the PRIA.

There is no record of special coral reef or precious coral fishery permits issued for the EEZ around Guam since 2007. Table 1 provides the number of permits issued for Guam fisheries between 2014 and 2023. Data are from the NMFS PIRO SFD permits program.

Table 1. Number of federal permits holders in Guam crustacean and bottomfish fisheries

Guam Fisheries	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Bottomfish	2	1	1	1	1	0	0	0	0	0
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, CNMI, and the PRIA.

1.2.11.2 SUMMARY OF CATCH AND EFFORT FOR FEP FISHERIES

The Mariana Archipelago FEP requires fishermen to obtain a federal permit to fish for certain MUS or 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 Guam. Therefore, catch and effort data are not presented for these fisheries.

1.2.11.2.1 Large Vessel Bottomfish Fishery

Table 2. Summary of federal logbook data for the Guam large vessel bottomfish fishery

Year	No. of Federal Bottomfish Permits Issued[1]	No. of Federal Bottomfish Permits Reporting Catch	No. of Trips in Guam EEZ	Total Reported Logbook Catch (lb)		Total Reported Logbook MUS Release/Discard (lb)	
				Bottomfish MUS & ECS[2]	*Coral Reef ECS*[2]	*Bottomfish MUS & ECS*[2]	*Coral Reef ECS*[2]
2006	0	-					
2007	1	0					
2008	2	0					
2009	1	0					
2010	6	0					
2011	6	0					
2012	2	0					
2013	2	0					
2014	2	0					
2015	1	0					
2016	1	0					
2017	1	0					
2018	1	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 some BMUS and all CREMUS in the Mariana Archipelago as ECS.
Note: Federal permit and reporting requirements for large vessels in Guam's bottomfish fishery became effective on December 4, 2006 (71 FR 69496, December 1, 2006).

1.2.11.2.2 Spiny and Slipper Lobster Fishery

Table 3. Summary of federal logbook data for Guam lobster fisheries

Year	No. of Federal Lobster Permits Issued[1]	No. of Federal Lobster Permits Reporting Catch	No. of Trips in Guam 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]
2004	0	-					
2005	0	-					
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 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.
* 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 6, 2006 (71 FR 69496, December 1, 2006).

1.2.11.2.3 Deepwater Shrimp Fishery

Table 4. Summary of federal logbook data for Guam deepwater shrimp fisheries

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

Year	No. of Federal Shrimp Permits Issued[1]	No. of Federal Shrimp Permits Reporting Catch	No. of Trips in Guam EEZ	Total Reported Logbook Shrimp ECS[2] Catch (lb)	Total Reported Logbook Shrimp ECS[2] Release/Discard (lb)
2010	2	0			
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.
Note: Federal permit and reporting requirements for deepwater shrimp fisheries became effective on June 29, 2009 (74 FR 25650, May 29, 2009).

1.2.17 ADMINISTRATIVE AND REGULATORY ACTIONS

This summary describes management actions NMFS implemented for insular fisheries in Guam 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. Anywhere from 38% to 58% of fish catches in Guam are typically intended for sale, and the non-commercial proportion of the 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 Guam DAWR. 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.

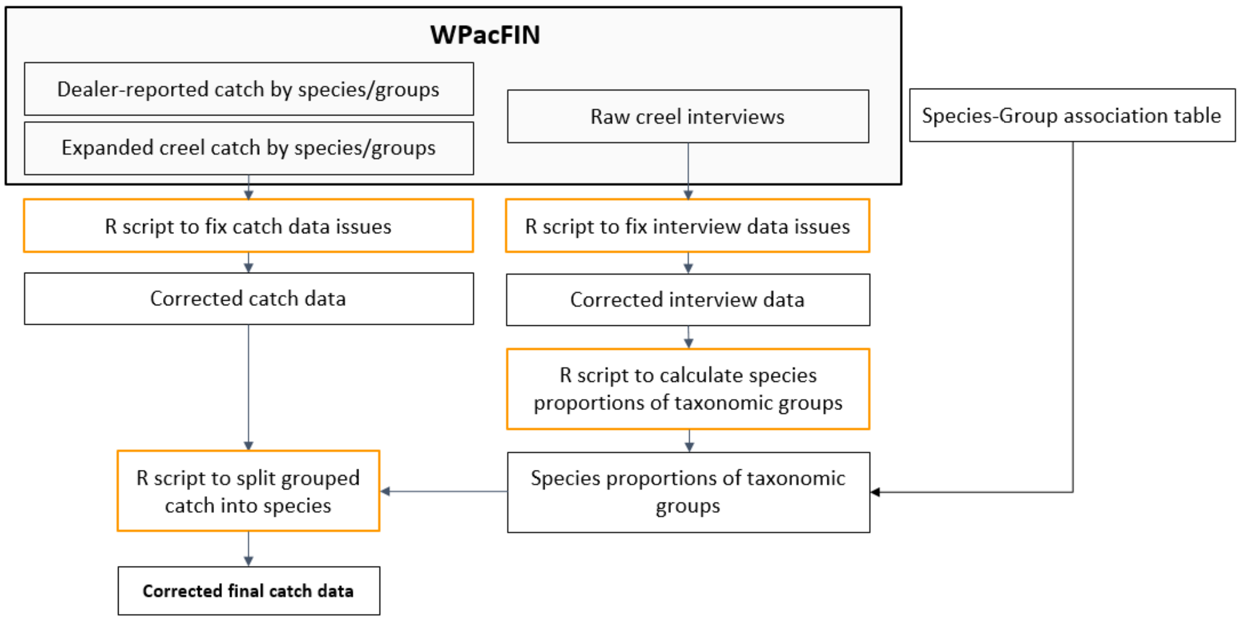

Figure 1. Data sources (gray boxes) and scripts (orange boxes) used to generate commercial and total catch estimates in the territories, from which non-commercial catch can be calculated.

Table 1. Summary of Guam 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
1982	26,701	3,101	23,600	0.88
1983	43,012	18,359	24,653	0.57
1984	47,887	14,199	33,688	0.70
1985	71,074	17,437	53,637	0.75
1986	27,966	8,076	19,890	0.71
1987	38,730	7,194	31,536	0.81
1988	49,770	5,857	43,913	0.88
1989	48,685	7,017	41,668	0.86
1990	36,073	10,075	25,998	0.72
1991	44,323	6,186	38,137	0.86
1992	45,218	5,933	39,285	0.87
1993	54,987	5,398	49,589	0.90
1994	56,647	11,143	45,503	0.80
1995	37,236	5,934	31,302	0.84
1996	51,580	3,598	47,982	0.93
1997	31,697	5,973	25,724	0.81
1998	33,837	8,076	25,760	0.76
1999	46,975	19,833	27,143	0.58
2000	64,278	14,131	50,147	0.78
2001	48,395	15,685	32,710	0.68
2002	22,117	11,238	10,879	0.49
2003	31,036	6,976	24,060	0.78
2004	26,241	15,047	11,193	0.43
2005	30,717	13,811	16,906	0.55
2006	35,068	10,667	24,401	0.70
2007	24,178	8,239	15,939	0.66
2008	35,551	5,884	29,667	0.83
2009	42,612	7,062	35,550	0.83
2010	28,314	5,667	22,647	0.80
2011	57,120	7,532	49,588	0.87
2012	24,363	4,283	20,080	0.82
2013	36,359	2,077	34,281	0.94
2014	25,067	3,132	21,935	0.88
2015	13,351	2,699	10,652	0.80
2016	25,654	3,400	22,253	0.87
2017	17,542	13,539	4,003	0.23
2018	26,632	3,729	22,903	0.86
2019	30,895	2,229	28,667	0.93

Year	Total Corrected Creel Survey Catch Estimates	Total Corrected Commercial Landings	Total Estimated Non-Commercial Catch	Proportion of Non-Commercial Catch
2020	17,661	5,649	12,012	0.68
2021	51,209	1,785	49,424	0.97
2022	36,662	3,314	33,348	0.91
10-year avg.	**28,103**	**4,155**	**23,948**	**0.81**
10-year SD	**10,671**	**3,295**	**12,615**	**0.21**
20-year avg.	**30,811**	**6,336**	**24,475**	**0.77**
20-year SD	**10,480**	**3,984**	**11,627**	**0.18**

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 Guam 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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