Evaluation of the data available for bottomfish stock assessments in American Samoa

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Table of Contents

List of Figures

List of Tables

Executive Summary

The deep-slope fishes of American Samoa support a small yet valuable boat-based fishery in depths ranging around 100 m to 400 m. This fishery is comprised primarily of double-hulled aluminum “alia” catamarans less than 30 ft in length that generally fish within 20 nm around Tutuila and the Manuʻa island group, with a few larger vessels fishing various offshore banks. Collectively referred to as bottomfishing, this fishery targets species mainly from the snappers (Lutjanidae), emperors (Lethrinidae), jacks (Carangidae), and groupers (Serranidae) families. Bottomfishing is an important subsistence fishing activity in American Samoa and carries a high non-monetary value.

The Western Pacific Regional Fishery Management Council’s fishery ecosystem plan for American Samoa includes 11 bottomfish management unit species (BMUS) that have traditionally been assessed and managed as a group (i.e., a species complex). A 2019 assessment concluded this complex was both undergoing overfishing and was in an overfished state, with the next benchmark assessment due in 2023. In preparation for this assessment, the Pacific Islands Fisheries Science Center (PIFSC) Stock Assessment Program began reviewing the data available in American Samoa to identify the next steps in improving stock assessments. The goal of this report is to explore the different data sources in American Samoa for catch, catch per unit effort (CPUE), and size data, to determine the types of assessment models that could be implemented in the next benchmark assessments, including single-species assessments. More specifically, this report explored the data generated by the boat- and shore-based creel surveys, the biosampling program, the NOAA diver surveys, and the commercial purchase program. Figure S1 presents the types of data available with the types of assessment models that can incorporate them.

All data sets available in American Samoa are heavily centered on Tutuila. While the shore- and boat-based creel surveys had a significant presence in the Manuʻa Islands starting in 1986, there have been no consistent boat-based creel surveys in these islands since 2009. Furthermore, only 6% of boat-based interviews were conducted from fishing trips on offshore banks located about 40 miles south and east of Tutuila. The current and historical data generated by the biosampling program and commercial purchases are almost solely from Tutuila. The NOAA diver surveys visit all islands in American Samoa, including the Manuʻa Islands, however, this survey is primarily aimed at reef fishes and is limited to a depth of 30 m, which is outside the depth range of most bottomfish.

One potential improvement to the bottomfish assessment would be to split the complex into its component BMUS (i.e. single-species assessments). This would allow the implementation of age-structured models and the incorporation of size and life history information. Moving assessment models from a complex-level to a finer taxonomic resolution means that special consideration needs to be given to species identification in the various data sets. For the creel surveys, there was originally no standard training protocol for species identification, and many fish were identified at a coarser taxonomic resolution. This changed in 2016 when a standardized training protocol was implemented, with most fish observations now identified at the species level. For the pre-2016 creel data, the disappearance and reappearance of species in certain periods suggest some inconsistencies in identifying fish to the species level, and the pre-2016 data may be less reliable for certain species-level analyses. It is important to note that these patterns could also be related to changes in species targeting or abundances. Species-level

identification in the biosampling and diver survey data sets appeared generally reliable, with almost all fish identified at the species level. However, the reliability of species-level identification for commercial purchases is highly vendor-dependent.

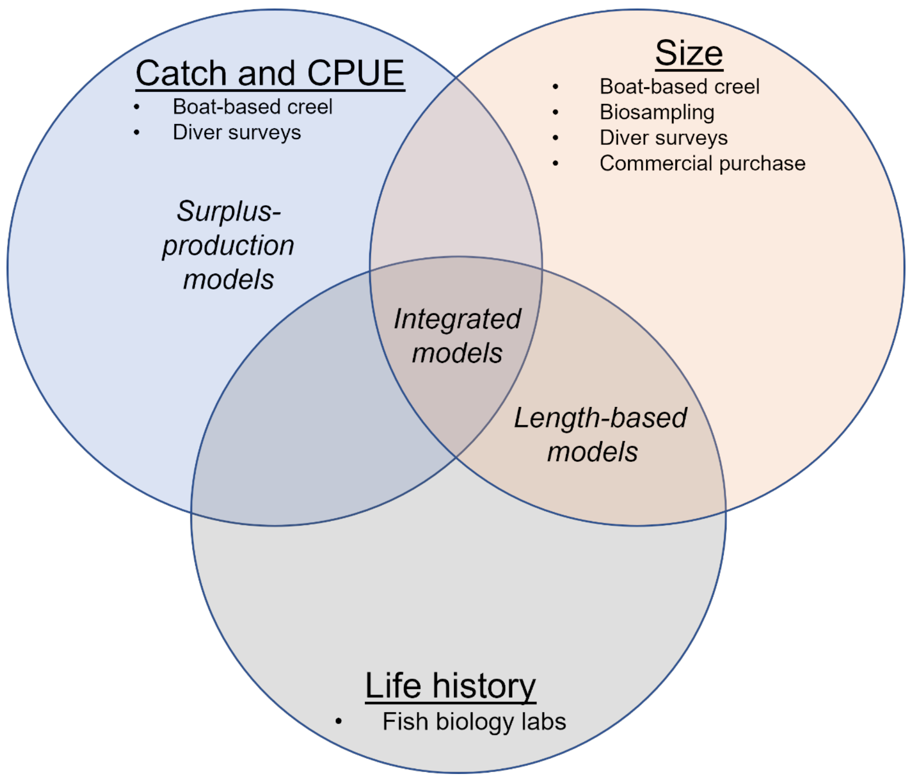

Figure S1. The three main categories of data used in stock assessments (catch and CPUE timeseries, size, and life history data) with their main sources in American Samoa. In *italics* are the different types of stock assessment models that operate on these different data types. Only surplus-production models can be used on complex-level assessments, the others require species-specific life history information.

For all BMUS, the main data source that can generate a CPUE index is the boat-based creel survey. The ongoing diver surveys (2007–2019) could also potentially generate an abundance index for a few shallow species (*Variola louti* and *Aprion virescens*), although with high variability. While the biosampling data set did collect the necessary information to generate a CPUE index (hours fished, catch by weight), this program was only active from 2010 to 2015, which is too short to form an informative abundance trend. The commercial purchase data also could not be used to generate a CPUE index, given that fishing effort is not recorded in this data set.

Total annual catches are estimated by combining the CPUE obtained from the boat- and shore-based creel surveys with the total annual effort estimates also generated by these programs. The annual catch estimates, therefore, have similar strengths and weaknesses as the CPUE estimates (i.e., Tutuila-focused, species misidentification issues in early years, high variability for some BMUS). While the commercial purchase catches represent only a fraction of the annual catch, the high variability associated with the creel catch estimates sometimes leads to receipt catch being higher than creel catch estimates. In previous assessments, the higher of the two values was taken for any given year, with the commercial purchase catches acting as a hard floor for the annual catch estimates.

In order of importance, size data for BMUS were available from biosampling, boat-based creel surveys, diver surveys, commercial purchases, and shore-based creel surveys. Diver surveys generated enough length observations for a few nearshore species (*A. virescens*, *Lutjanus kasmira*, and *V. louti*), while the commercial purchases may have enough observations for *L. kasmira*, *Etelis carbunculus*, and *A. virescens*. For the recent period, shore-based creels surveys generated very low numbers of size observations for BMUS and is likely not useful for this purpose. It is important to note that the size data obtained from these various data sets suffered from the same general strengths and limitations described in previous paragraphs (i.e., Tutuila-centered, species identification concerns, depth limits, etc.).

Table S1. Summary of the data available for all 11 BMUS in American Samoa. Six main criteria are presented. A more detailed version of this table is presented in Section 8. Data quality and quantity are classified as green (satisfactory), yellow (some concerns), and red (problematic).

Group	Species	Samoan name	Species ID issues	Historical catch	Spatial coverage	Abundance index		Recent catch data	Size data	Life history
						Pre-2016	Post-2016			
Deep snapper	*Etelis carbunculus*	Palu-malau								
Deep snapper	*Etelis coruscans*	Palu-loa								
Deep snapper	*Pristipomoides filamentosus*	Palu-‘ena-‘ena								
Deep snapper	*Pristipomoides flavipinnis*	Palu-sina								
Deep snapper	*Pristipomoides zonatus*	Palu-ula, palu-sega								
Snapper	*Aphareus rutilans*	Palu-gutusiliva								
Snapper	*Aprion virescens*	Asoama								
Snapper	*Lutjanus kasmira*	Savane								
Emperor	*Lethrinus rubrioperculatus*	Filoa-paomumu								
Grouper	*Variola louti*	Papa, velo								
Jack	*Caranx lugubris*	Tafauli								

The table above presents a summary of the data available for BMUS assessments in American Samoa. Seven main criteria are presented pertaining to (1) issues with species-level identification, (2) the presence of historical catch information, (3) spatial segregation of the data, (4) creel interview sample size, which relates to the ability to generate an abundance index, (5) average annual catch in recent years (in pounds), which relates to the ability to use catch data to scale the analyses to generate catch limits, (6) the maximum number of length observations in recent years from either the boat-based creel surveys (2016–2019) or biosampling program (2011–2015), and (7) the nearest location of life history parameters. This table suggests that we should be able to implement data-limited or data-moderate age-structured, single-species assessment models on most species. *Pristipomoides filamentosus* likely does not have enough data to assess, and pre-2020 *Etelis carbunculus* data are confounded with a new species (*Etelis boweni*), which will introduce a significant challenge to its assessment.

1 Introduction

American Samoa consists of seven small islands in the central South Pacific Ocean (Figure 1-1). The largest island is Tutuila followed by Ofu, Olosega, and Ta‘u Islands in the Manu‘a group. The two smallest islands, Swains and Rose, lie 220 miles north and 160 miles east of Tutuila, respectively. The total land area is 77 square miles, consisting mostly of steep volcanic slopes covered by jungle. The American Samoa population was 55,312 in 2019 and located primarily on Tutuila Island.

The deep-slope fishes of American Samoa include snappers (Lutjanidae), emperors (Lethrinidae), jacks (Carangidae), and groupers (Serranidae). They support a valuable boat-based hook-and-line fishery in waters ranging from 100 m to 400 m depths. Collectively referred to as "bottomfishing," this fishery is made up primarily of double-hulled aluminum alia catamarans less than 30 ft in length that generally fish within 20 nmi around Tutuila (Levine & Allen 2009a). There are also alia boats in the Manu‘a Islands and several large vessels that fish the offshore banks east and south of Tutuila.

Bottomfishing is a culturally significant activity in American Samoa and carries a high non-monetary value (Severance et al. 2013; Kleiber & Leong 2018). The documented commercial market revenues are small compared to those of the pelagic tuna fishery. In 2019, documented commercial value of snappers, emperors, jacks, and groupers combined was $69,000, while the estimated value of all tuna species landings was $4,100,000 (Liddel & Yencho 2019). The American Samoa bottomfish fishery has undergone several cycles of development and attrition over the past several decades, mainly owing to government-sponsored boat-building programs, marketing initiatives, and natural disasters. For example, the Dory Project provided boats to fishers at low cost or on credit and led to a spike in bottomfishing in 1973–1975, primarily in the relatively shallow waters around Tutuila. This was followed by a drop in catches and participation as the fleet became dilapidated by the late 1970s (Itano 1996a, 1996b). The fishery grew again following the widespread adoption of aluminum alia boats, the arrival of several larger-powered diesel vessels entering the fishery, government-sponsored training, and efforts to develop the export market for bottomfish. The American Samoa bottomfish fishery peaked during the early to mid-1980s with 45–50 vessels and more than 120,000 lb of reported bottomfish landings annually (Hamm & Quach 1988; Itano 1996a, 1996b). However, it is important to note this estimate likely includes landings of many non-bottomfish management unit species (see below). Several factors may have contributed to the reduction of bottomfish landings over the past several decades, including fleet damage due to hurricanes, market influences such as increased importing of bottomfish, higher operating costs for American Samoa fishers, fishers moving to the pelagic fisheries, and declining catch rates (Levine & Allen 2009a; Langseth et al. 2019). The average annual estimated landings of bottomfish management unit species in recent years is approximately 21,000 lb/year (Langseth et al. 2019; Liddel & Yencho 2019).

The bottomfishes occurring in federal waters (3 to 200 miles from shore) are currently managed by the Western Pacific Regional Fishery Management Council (WPRFMC) under the Fishery Ecosystem Plan for the American Samoa Archipelago (FEP; WPRFMC 2009). The FEP was preceded by the 1986 Fishery Management Plan for the Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region, which named 19 bottomfish management unit species

(BMUS) across Hawai‘i, American Samoa, and Guam (the bottomfishes of the Commonwealth of the Northern Mariana Islands were added to the fishery management plan in 2006; WPRFMC 1986). The 2009 FEP specified 205 species or families of fish and invertebrates, including 17 species of bottomfish that had to be managed with catch limits or other regulations. However, most species within the FEP were reclassified as "ecosystem component species" in 2019, leaving only 11 BMUS that required management by the WPRFMC in American Samoa (84 FR 2767). These 11 species (Table 1-1) were retained as BMUS since they were considered by local fishers and fisheries scientists to be most in need of conservation and management.

The American Samoa BMUS were initially assessed as a complex (i.e., all species combined) using an informal index-based assessment method. For this approach, annual nominal catch rates (i.e., the total estimated lb of BMUS caught each year divided by the total estimated number of hours fished each year) were compared to an established indicator level equal to 50% of average nominal catch rates over 1982–1984. Following this method, the American Samoa BMUS catch rates were deemed "not a cause for concern" from 2000 to 2005 (WPRFMC 2006). The first formal stock assessment of American Samoa bottomfishes was completed in 2007 (Moffitt et al. 2007). This assessment improved upon the index-based assessment method and relied on a Bayesian surplus production model which accounted for both process and observation errors and therefore captured parameter uncertainty for status determinations. The base case model for the 2007 stock assessment concluded that the BMUS complex was not overfished and not experiencing overfishing (Moffitt et al. 2007). The 2012 and 2016 assessment updates used a similar approach as the 2007 assessment, with additional data. These assessments reached similar conclusions regarding the stock status of the BMUS in American Samoa (Brodziak et al. 2012; Yau et al. 2016). The most recent assessment was completed in 2019 and used a similar Bayesian surplus production model as the previous assessments. However, it incorporated improvements in data and modeling methodology as recommended by the Western Pacific Stock Assessment and Review process (WPSAR; Langseth et al. 2019). The 2019 assessment concluded the BMUS complex was both undergoing overfishing and in an overfished state.

The next benchmark stock assessment for the American Samoa BMUS is expected to be completed and undergo an independent review process in February 2023, following the WPSAR timeline .[1] One key improvement for this new benchmark will be to consider single-species assessment models following the WPSAR panel recommendations associated with the 2016 assessment (Chaloupka et al. 2015). Specifically, the WPSAR panel recommended the exploration of length- and life history-based single-species modeling approaches, as well as splitting the BMUS into shallow- and deep-species complexes. Complex-level assessments are limited to surplus-production models, which mainly rely on catch and catch-per-unit-effort data. In contrast, single-species assessments are more flexible, ranging in complexity from simple length-based per-recruit analyses to more advanced age-structured integrated models, such as Stock Synthesis (Methot & Wetzel 2013).

The purpose of this report is to explore and analyze the fisheries data pertaining to the 11 BMUS in American Samoa to evaluate the feasibility of single-species models for the 2023 stock

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[1] https://fisheries.noaa.gov/pacific-islands/population-assessments/western-pacific-stock-assessment-review-schedule

assessment. We present general trends in research activities and information on the following data sources:

- The boat-based and shore-based creel surveys
- Commercial purchase data set
- Biosampling program
- PIFSC diver surveys
- Historical catches

We evaluated the types and amounts of species-specific data available for each of the 11 BMUS to indicate which single-species assessment models can be explored in the next phases of this assessment.

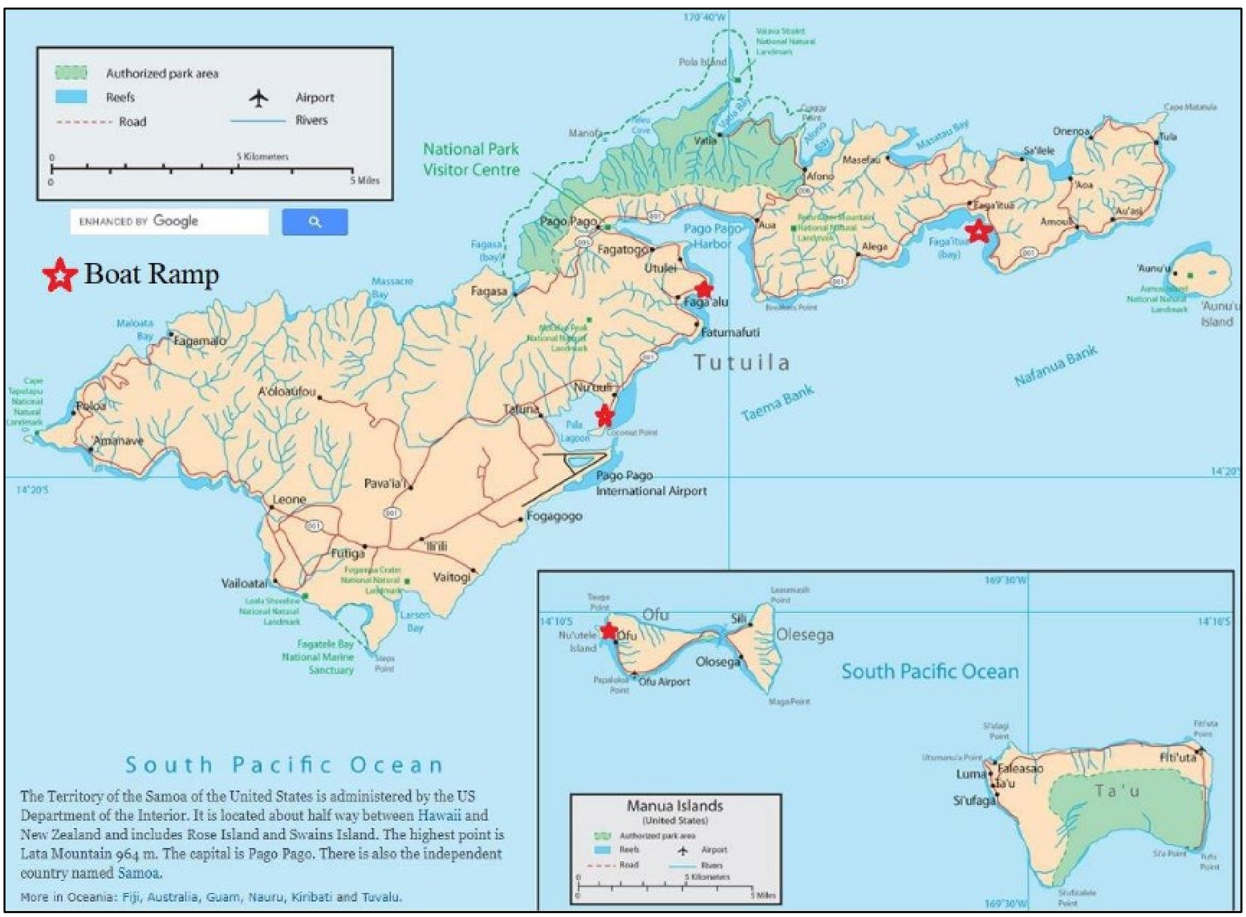

Figure 1-1. Map of American Samoa.

Table 1-1. American Samoa bottomfish management unit species (BMUS).

Species	Samoan name	Hawaiian and English common names	Code
Aphareus rutilans	Palu-gutusiliva	Lehi, rusty jobfish	APRU
Aprion virescens	Asoama	Uku, green jobfish	APVI
Caranx lugubris	Tafauli	Ulua la‘uli, black jack	CALU
Etelis carbunculus	Palu-malau	Ehu, deep-water red snapper	ETCA
Etelis coruscans	Palu-loa	Onaga, deepwater longtail red snapper	ETCO
Lethrinus rubrioperculatus	Filoa-paomumu	Spotcheek emperor	LERU
Lutjanus kasmira	Savane	Ta'ape, bluestripe snapper	LUKA
Pristipomoides filamentosus	Palu-‘ena-‘ena	Opakapaka, crimson jobfish	PRFI
Pristipomoides flavipinnis	Palu-sina	Yelloweye opakapaka, golden eye jobfish	PRFL
Pristipomoides zonatus	Palu-ula, palu-sega	Gindai, oblique-banded snapper	PRZO
Variola louti	Papa, velo	Yellow-edged lyretail	VALO

2 Boat-based Creel Survey

The American Samoa Department of Marine and Wildlife Resources (DMWR) Boat-based Creel Survey Program (BBS) is designed to monitor fisheries catch and participation. The BBS targets fishing vessels that are berthed at marinas as well as smaller trailered boats that may be launched from boat ramps. Small shore-launched boats, typically used by fishers to capture reef fish species close to shore or within the lagoon, are not included in the BBS. The BBS began in the early 1980s with data management and sampling methodology mostly standardized by 1986. The BBS includes two data streams: (1) interviews of fishermen returning to port with observation of their catch, and (2) estimates of the number of boats leaving port and the number of trips taken. Together, these two data streams are used by NOAA Fisheries to estimate annual landings for management purposes. BBS creel interviews may also provide catch per unit effort (CPUE) timeseries and fish length or weight composition observations for stock assessments. Details on the history and methodology of the BBS are documented in Oram et al. (2011).

2.1 Creel interviews

On Tutuila, DMWR staff visit or monitor the four main ports of Pago Pago, Fagatogo, Utulei, and Faga‘alu to conduct interviews a minimum of 12 weekdays and 2 Saturday/holiday (weekend) days per month (Ma et al., in prep.). Additional locations throughout Tutuila and Aunu’u may be added on an opportunistic basis, mostly influenced by the availability of staff residing in other villages. In the Manu‘a Islands, the limited number of fishing boats and fishers enabled a census of fishing trips until 2009, when staff on Ofu-Olosega and Ta'u were no longer available. Since 2009, DMWR has not conducted regular BBS interviews in the Manu‘a Islands.

Participation in BBS interviews is voluntary, although many fishers choose to cooperate (Oram et al. 2011). Interviewers collect information on trip effort (hours fished, number and types of fishing gear, and number of fishers), areas fished, economic information (trip cost, fish price per pound), and catch. Catch information includes total catch per species in numbers and weight, and may also include individual fish size observations, in length or weight. Over the course of the survey, there have been some inconsistencies in species identification, selection of fish for size observations, and whether the number and weight of fish caught was directly measured or estimated based on a subset of the catch.

Standardized staff training in fish species identification was implemented in 2016. Following this change, the surveyed catch have been identified to the species level with the great majority of fish measured. However, in many years prior to 2016, only a subset of fish were identified to species or measured, and there was no standard protocol for unbiased selection of individuals for subsampling.

2.1.1 Spatial-temporal and fishing gear effort trends

Between 150 and 1130 BBS interviews were recorded each year from 1986 to 2019, averaging 410 interviews/year (Figure 2-1). Troll and longline fishing gears accounted for 43% and 27% of all interviews, respectively. Approximately 73 interviews/year (range 9 – 130) included bottomfish management unit species (BMUS)-identified species, with bottomfishing and mixed bottomfishing/troll being the predominant gear types capturing these species (accounting for 76% and 21% of interviews for bottomfishing and bottomfishing/troll mix, respectively; Figure

2-1). Given that identified BMUS are seldom recorded in interviews of fishing gears other than bottomfishing and bottomfishing/troll mix, only bottomfishing and bottomfishing/troll mix fishing gears are considered further in this analysis of BBS interviews. However, estimated annual landings of BMUS from all BBS gear types are included in the catch section of this report (Section 2.3).

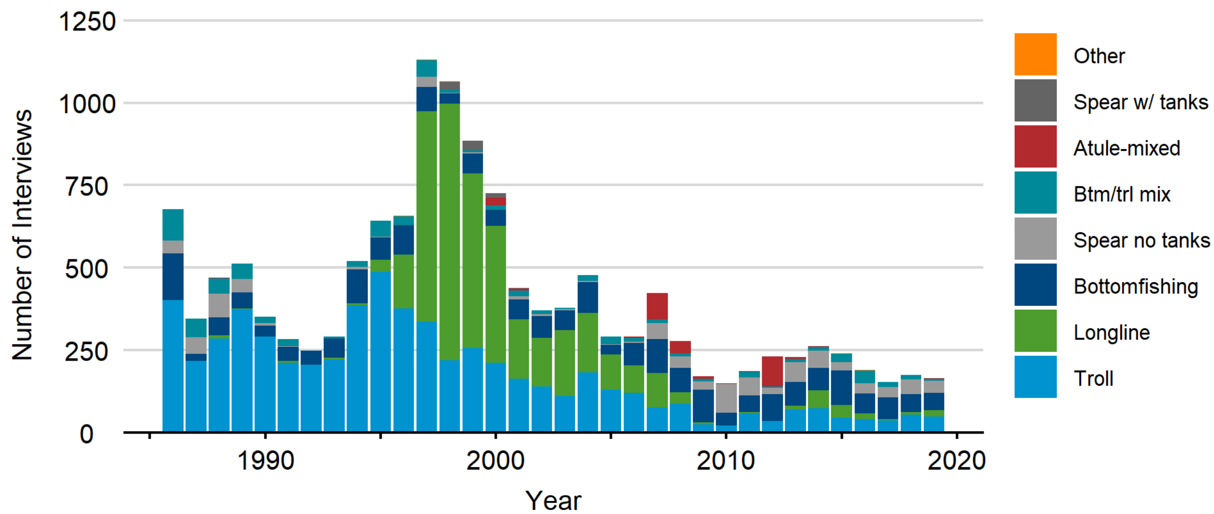

Figure 2-1. Total number of BBS interviews/year by fishing gear. Btm/trl mix are trips that reported both bottomfishing and trolling.

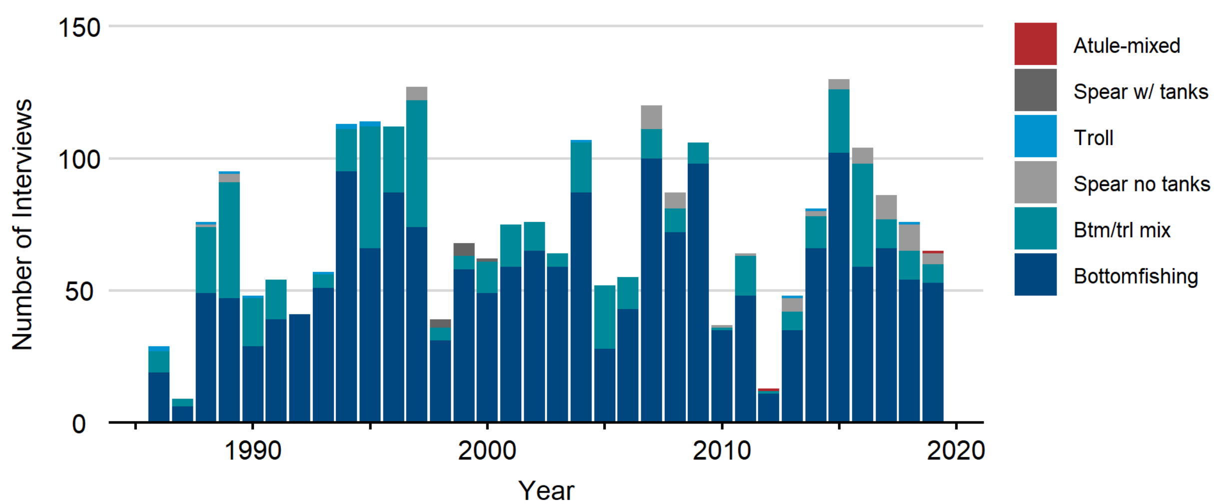

Figure 2-2. Number of BBS interviews per year by fishing gear that recorded identified BMUS. Btm/trl mix are trips that reported both bottomfishing and trolling.

From 1986 to 2008, Tutuila and the Manu'a Islands were represented somewhat evenly in the bottomfishing and btm/trl mix interview data (52% and 41% of all interviews were from Tutuila and the Manu‘a Islands, respectively, Figure 2-3). Since 2009, the Manu‘a Islands have not been consistently sampled by the BBS. Interviews for fishing trips to the banks averaged 5 per year or 6.4% of total interviews from 1986 to 2019. There are no interviews attributed to the areas around Rose Atoll or Swains Island. Most interviews of Tutuila ports have occurred at the Fagatogo Marina Dock (Figure 2-4). A DMWR technician lived on Aunu’u for several years and opportunistically interviewed fishers returning to Aunu’u, providing 106 interviews of Aunu’u fishers between 2002 and 2010.

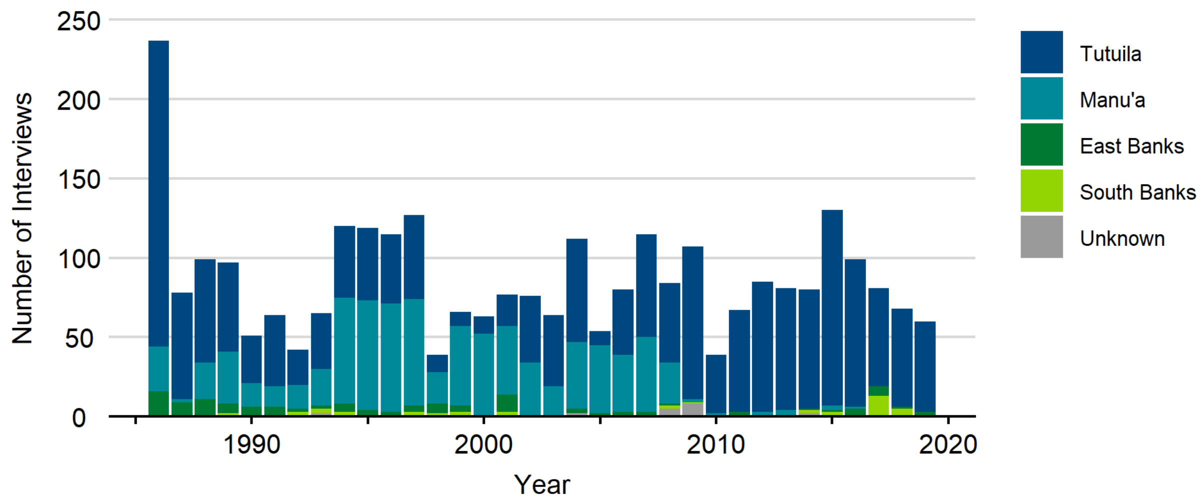

Figure 2-3. Number of BBS interviews per year by area for bottomfishing and bottomfishing/troll mix fishing gears.

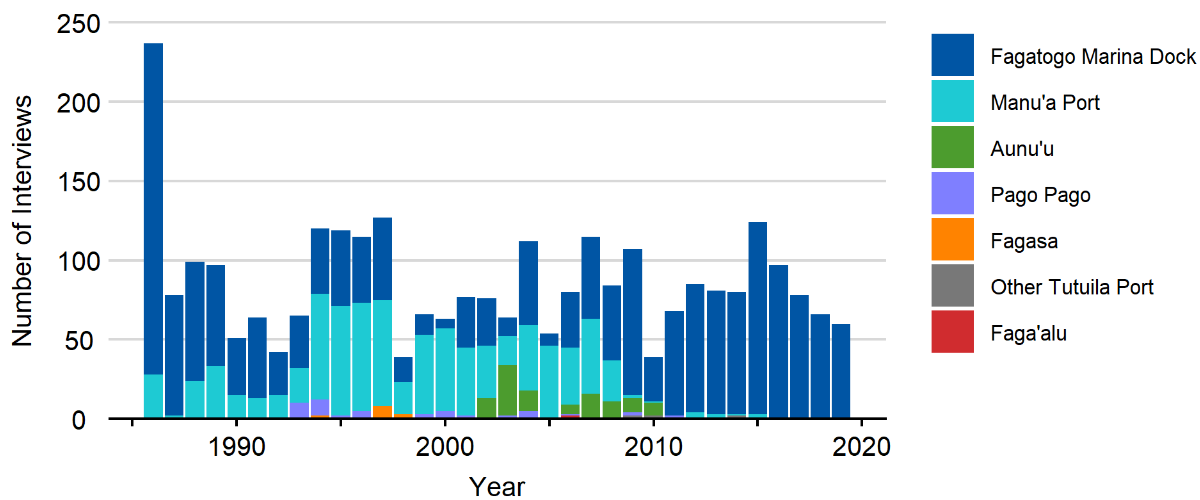

Figure 2-4. Number of BBS interviews per year and interview port for bottomfishing and bottomfishing/troll mix fishing gears.

2.1.2 Species observed

There were 116 species and 6 genus spp. groups identified from bottomfishing (excluding bottomfishing/troll mix) from 2016 to 2019 (Table 2-1).

Table 2-1. Surveyed catch by species (as percent total weight) from bottomfishing 2016–2019. Asterisks (*) denote BMUS.

Species	Percent Surveyed Catch by Weight
**Aprion virescens*	11.2
**Etelis coruscans*	9.9
**Aphareus rutilans*	8.9
Lutjanus gibbus	7.8
Lethrinus xanthochilus	7.8
Lutjanus bohar	6.0
**Lethrinus rubrioperculatus*	4.3
**Etelis carbunculus*	4.0
Gymnosarda unicolor	3.2
**Caranx lugubris*	3.2
Lutjanus timorensis	2.9
**Lutjanus kasmira*	2.5
**Pristipomoides zonatus*	1.0
**Pristipomoides flavipinnis*	0.7
**Variola louti*	0.2
**Pristipomoides filamentosus*	<0.1
All Other Species (N = 106)	26.3

2.1.3 BMUS species identification and occurrence

Prior to 2016, catches were often recorded in the database under several group categories including bottomfishes, deepwater snappers, emperors, groupers, inshore groupers, inshore snappers, jacks, *Pristipomoides* / *Etelis* spp., or trevallies. It is possible that catch of the 11 managed BMUS have been included in these groups (hereafter 'BMUS groups'). During the beginning years of the BBS, fish were seldom identified to the species level in interviews and BMUS groups were often used, such that species-identified BMUS accounted for less than 10% of total surveyed catch (by weight) in 1986 and 1987 (Figure 2-5). From 1988 to 2015, species-identified BMUS generally accounted for approximately 49% (range 14–70%) of annual surveyed catch from the bottomfishing gear type. The proportion of surveyed catch identified to species-level BMUS was less for the bottomfishing / troll mix gear type, owing to the greater amount of identified tuna species, but was still approximately 33% (range 12–61%) per year. BBS interview protocols and training were modified in 2016 and the use of unidentified species groups was largely discontinued, such that >99.94% of all catch by weight was identified to species between 2016 and 2019.

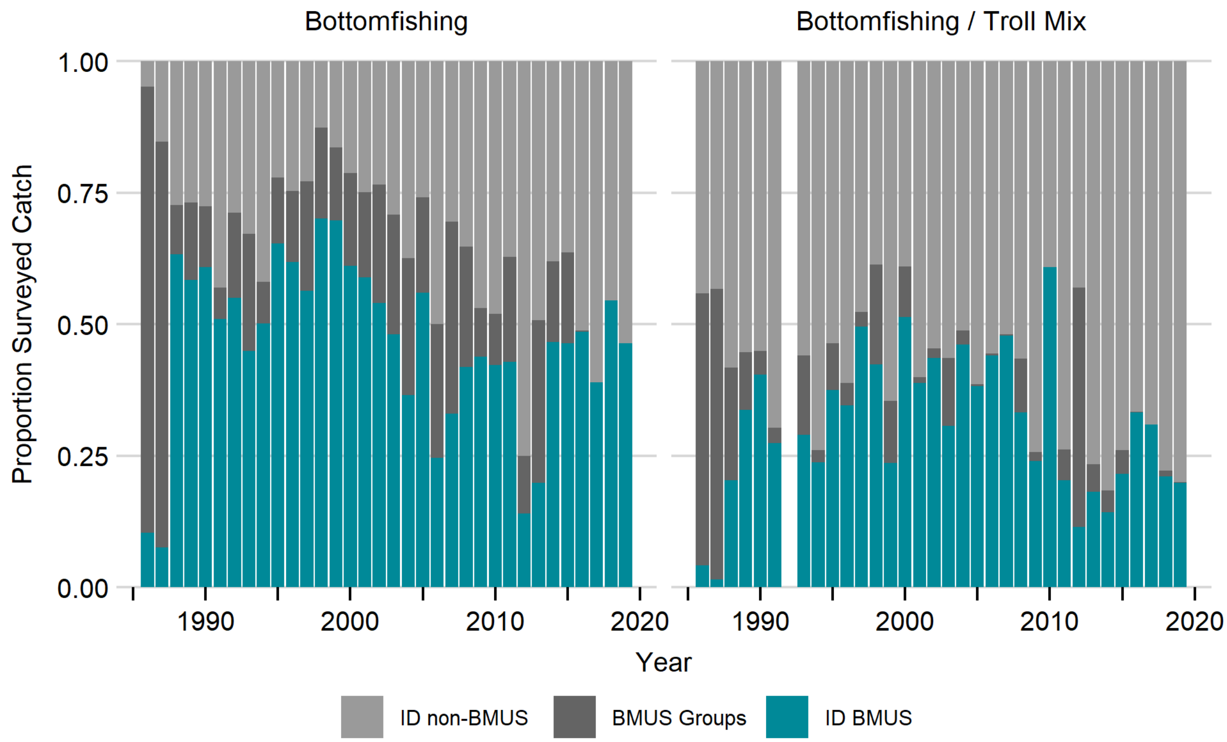

Figure 2-5. Proportion of surveyed catch (weight) by level of identification and year for bottomfishing (left) and bottom/troll mix (right) fishing gears.

There are several trends in BMUS occurrence in the BBS interview data. Some species were prevalent in Manu‘a catches, but were comparatively rare in Tutuila catches: *C. lugubris*, *E. carbunculus*, *E. coruscans*, and *P. zonatus* (Figure 2-6). One species, *L. rubrioperculatus*, was seldom observed in the Manu‘a Islands, but was in greater than 75% of Tutuila interviews during several years. Two species, *P. filamentosus* and *P. flavipinnis* were not consistently observed over the timeseries in either area. Both species were essentially absent from interviews until the late 1990s, when occurrence surged, especially in the Manu‘a Islands. *P. filamentosus* occurrence exhibited a second surge between 2008 and 2015. *A. rutilans*, *A. virescens*, and *L. kasmira* were most consistently present throughout the timeseries. *V. louti* was fairly common up until 2009 in both areas but has been very rarely observed since. For 2 years, 2012–2013, all BMUS species show a dip in occurrence, which is most apparent from the percent occurrence in BBS interviews pooled over all areas (Figure 2-7).

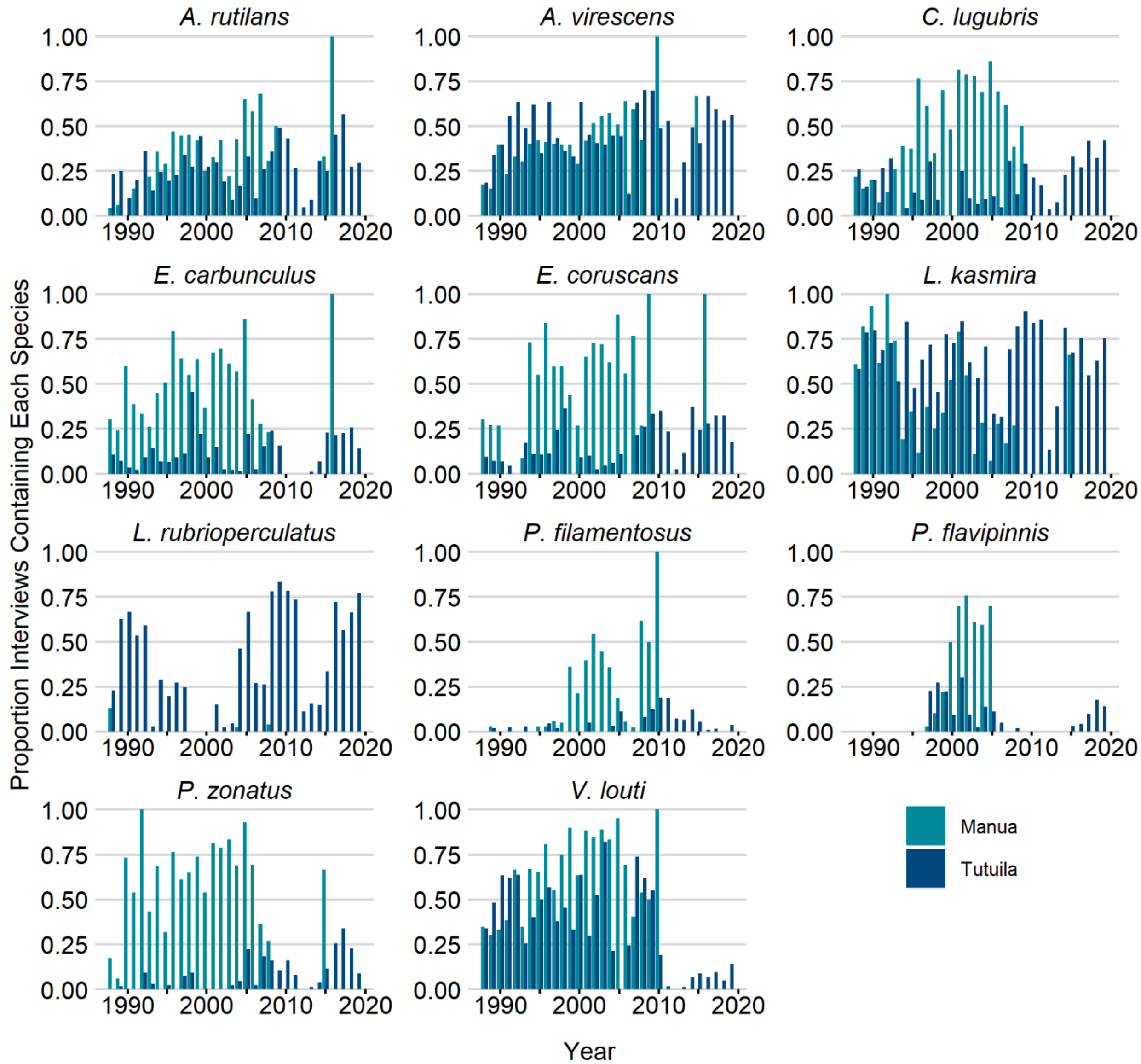

Figure 2-6. Proportion of total interviews positive for each species by area.

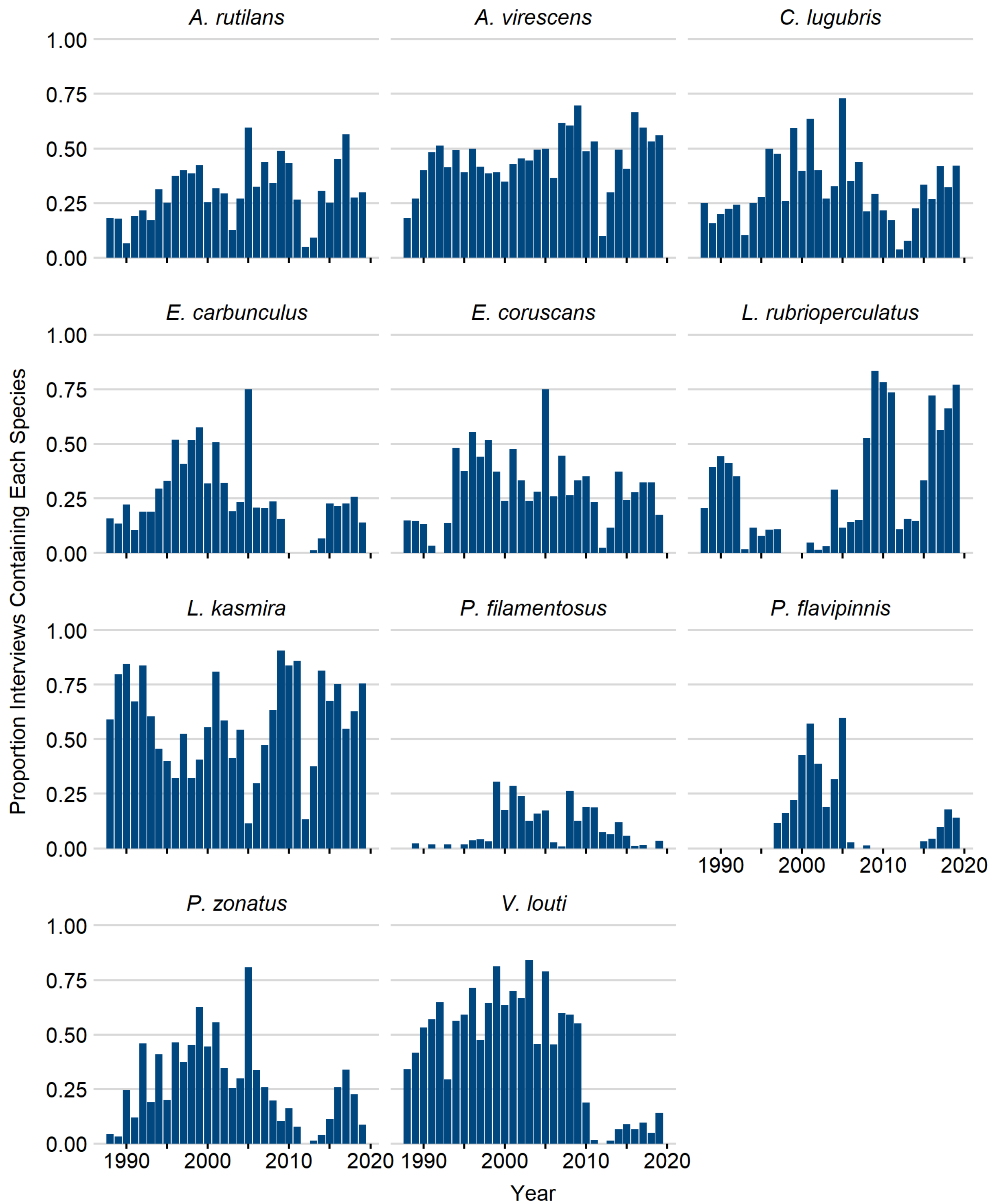

Figure 2-7. Proportion of total interviews positive for each species, all areas combined.

2.1.4 Size data

Individual fish size data were collected in terms of weight during the early years of the BBS, then switched to predominantly length in 2005–2006 (Figure 2-8). The number of individual size observations collected per year for each species was general small before 2005–2006 and highly variable for all species thereafter, with typically greater than 150 measurements/year for the most consistently encountered BMUS (*L. rubrioperculatus* and *L. kasmira*) and less than 15 measurements/year for the rarely encountered BMUS (*P. filamentosus*, *P. flavipinnis*, and *V. louti*).

The total number of individual size observations can overestimate the sample size given that multiple individuals measured within the same interview are likely caught together. Hence these individuals are not truly independent samples from the others they were caught with. The number of interviews containing species size observations could be a more accurate representation of sample size in the case where individual fish are caught during a specific fishing activity (Pennington & Volstad 1994). There is also unquantifiable bias in the size observations in the early part of the timeseries because, in addition to bias introduced by the common use of unidentified species groups (Section 2.1.3), only a subset of individuals of a species within an interview were measured (Figure 2-9). For example, although there were 212 interviews totaling 236 individual size observations of *E. coruscans* between 1994 and 1997, 92% of those interviews did not measure every *E. coruscans* identified in the catch. There were no established protocols for the selection of individuals to be measured, hence it is possible that fish selected for individual size observations were not representative of the total catch (e.g., large individuals were more often measured than smaller individuals).

Starting in 2016, BBS interviewers placed a high priority on measuring the length of every fish and, when rarely used, subsampling was applied randomly in instances when interviewers had limited access to the catch, usually due to time constraints (personal communication, T. Lavata'i, DMWR). For 2016–2019, greater than 90% of interviews containing the more numerous species (*A. virescens*, *L. rubrioperculatus*, and *L. kasmira*) included measurements for every fish; greater than 98% of interviews containing *A. rutilans*, *C. lugubris*, and *E. coruscans* included measurements for every fish; and 100% of all *E. carbunculus*, *P. filamentosus*, *P. flavipinnis*, *P. zonatus*, and *V. louti* have been measured.

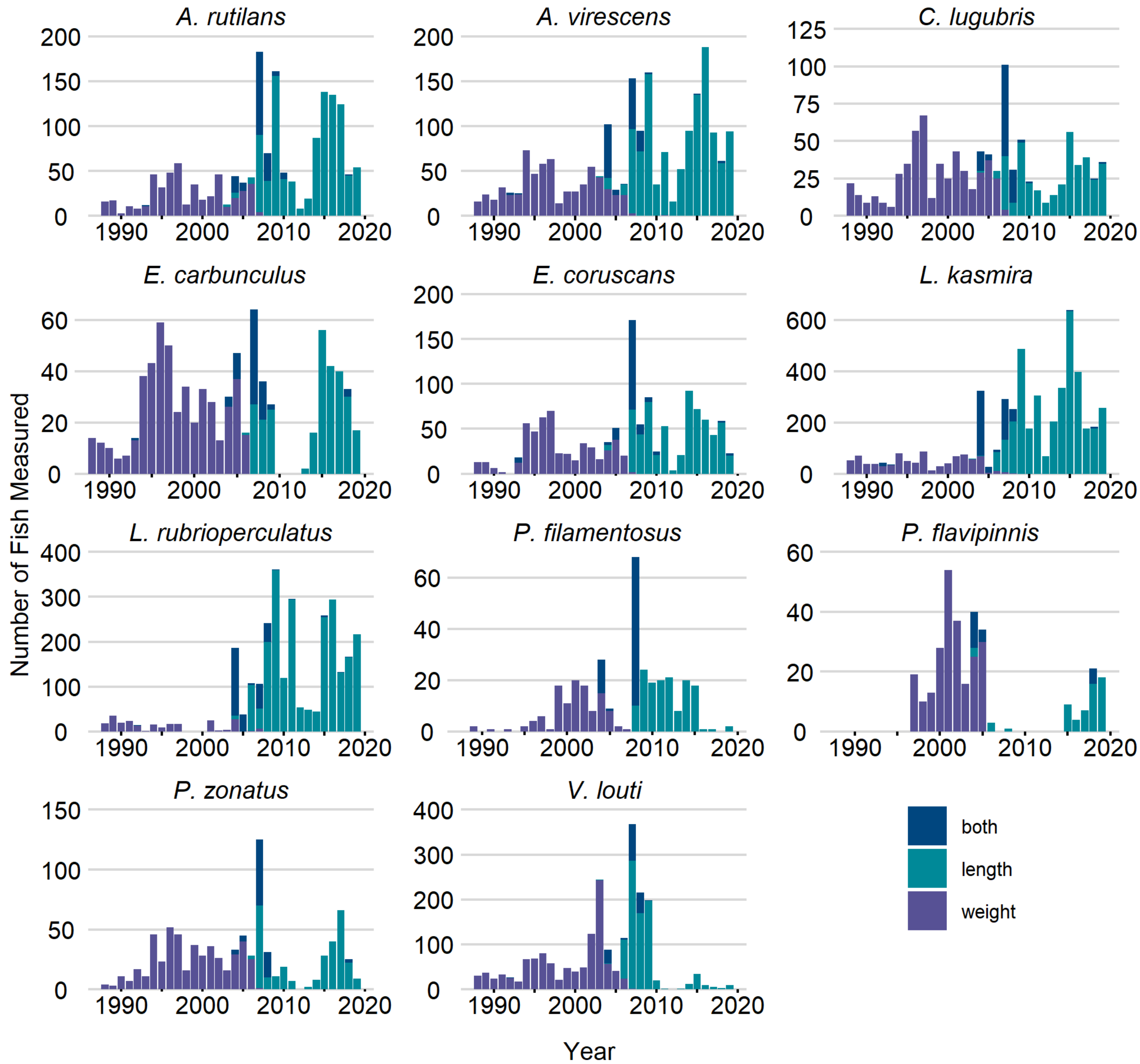

Figure 2-8. Number of BMUS individuals with size observations (length, weight, or both length and weight) in the BBS by year.

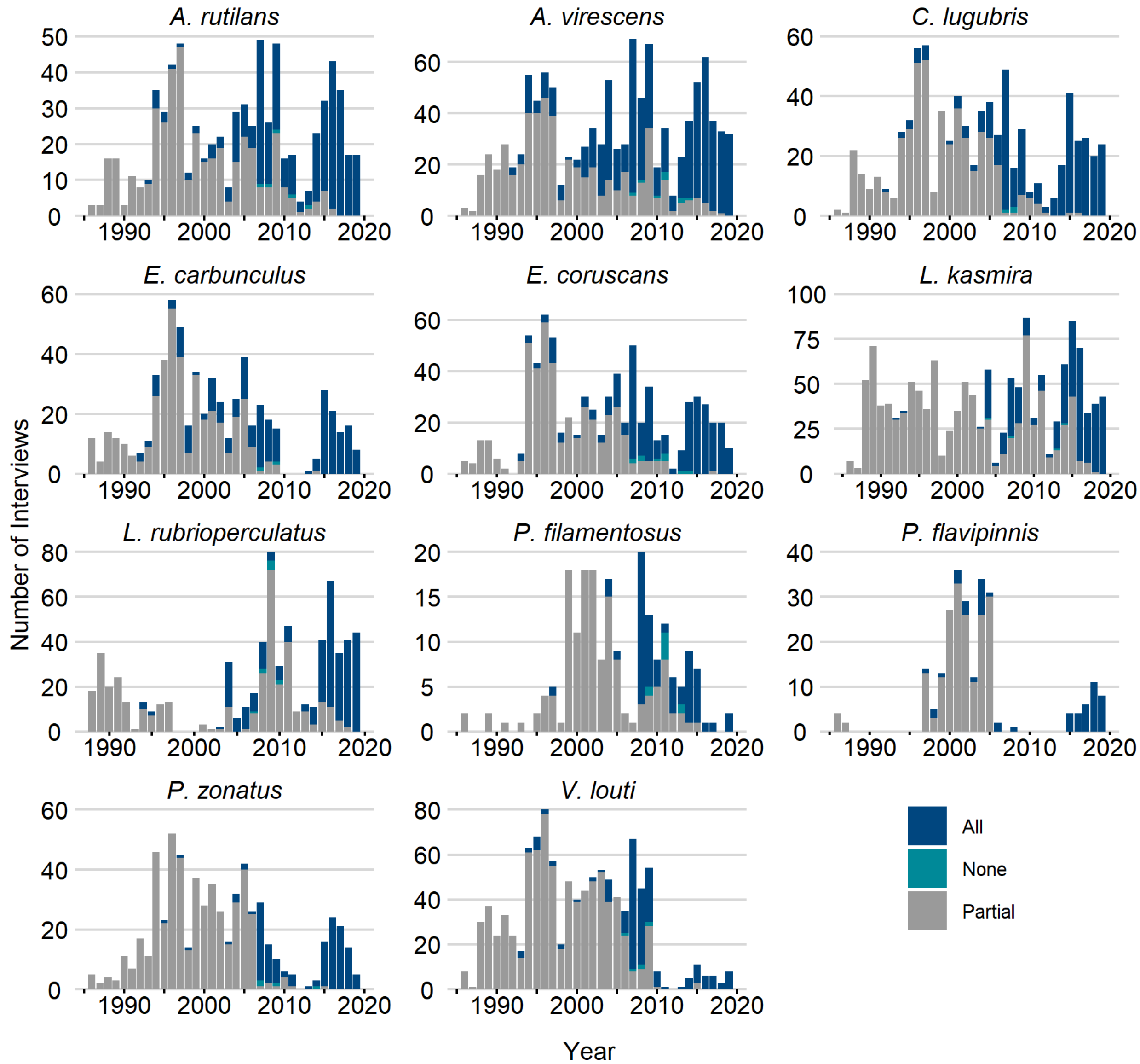

Figure 2-9. Number of BBS interviews containing individual size data (weight or length) in the BBS by BMUS and year. Interviews during which every individual of the species was measured are noted as "All," interviews during which only a subset of individuals were measured are noted as "Partial," and interviews that recorded catch of each BMUS but did not include any individual size observations are noted as "None."

Frequency plots of length observations (fork length, FL, in cm) pooled from BBS interviews over 2016–2019, all taken from Tutuila ports, indicate that BMUS are rarely harvested below 20 cm (Figure 2-10). Sample sizes of *P. filamentosus* and *V. louti* length observations from 2016–2019 are small, hence the length frequencies are likely uninformative. The length distribution for *E. carbunculus* is bimodal, likely because individuals within the second peak between 70 and 90 cm FL may have been a separate species, *Etelis boweni*, which was only recently described in Andrews et al. (2021).

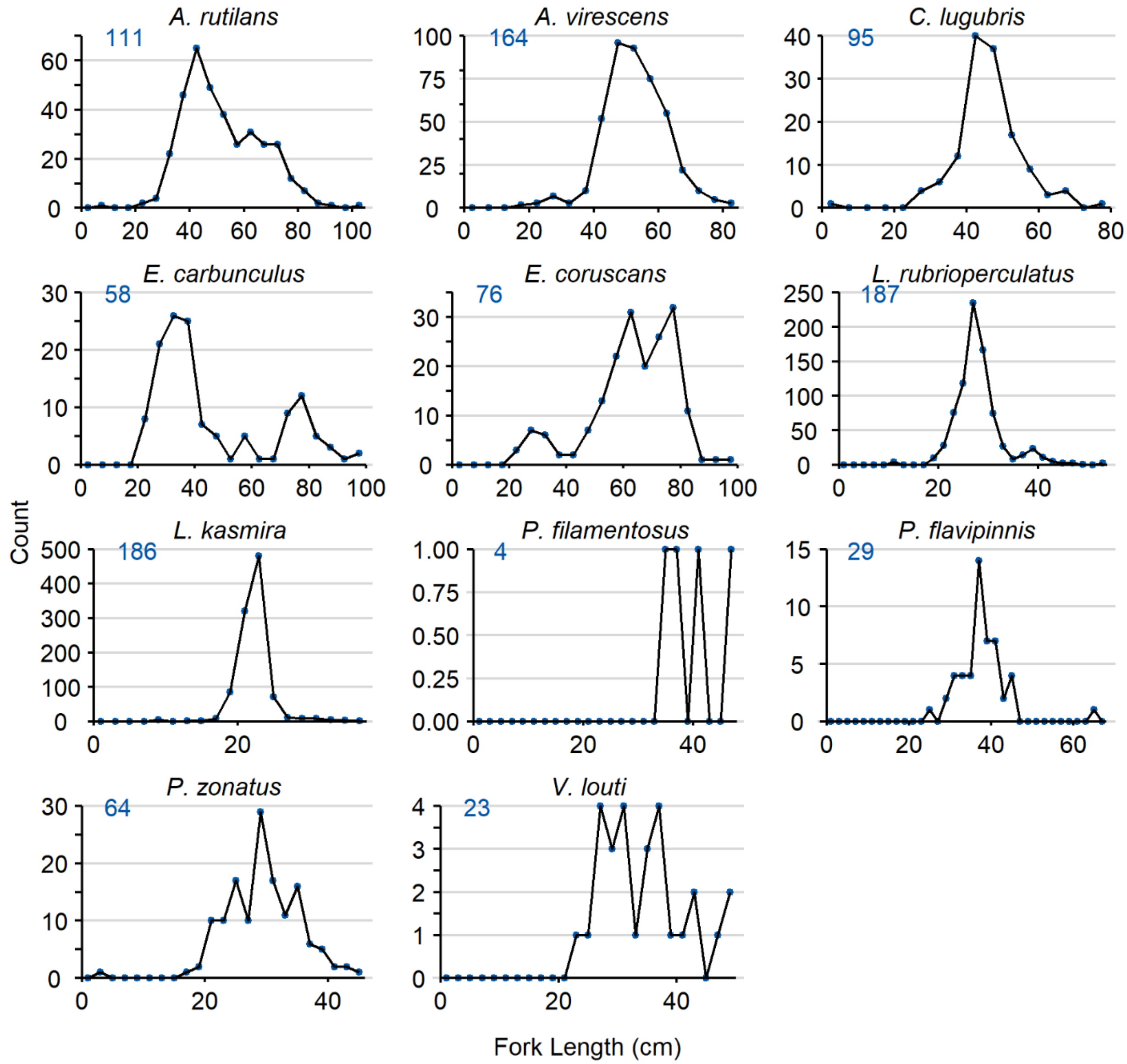

Figure 2-10. BMUS length frequencies recorded in BBS interviews over 2016–2019. The number of interviews included in each length frequency plot are shown in blue.

2.1.5 *BMUS disposition*

There were 3,293 BMUS individuals with length data recorded from BBS interviews from 2016 to 2019. The dispositions of the majority (82.5%) were listed as 'local sale to unknown buyers,' 15.9% had listed specific buyers or markets, and less than 1% each were recorded as unknown or not sold (Table 2-2). The amount of BMUS not sold increased to 1.3% when all fish, not just individuals with length data, were considered. However, inconsistencies in the interview 'number kept' data field suggest it may be unreliable to estimate total catch by number in recent years. For many interviews, 'number kept' likely underestimates the number of fish caught because reported catch weight was greater than 0 for the interview and individual lengths were recorded, yet 'number kept' = 0. Conversely, 'number kept' is most often the number of fish per species, but is summed over all species for some interviews within the data, hence 'number kept' would likely be an overestimate in those instances.

Table 2-2. Recorded disposition for all BMUS with length data from BBS interviews 2016–2019.

Disposition	Number of fish	Percent of total
Local sale (unknown buyer(s))	2,716	82.5
Specified buyers total	522	15.9
U.S. MART	221	
TSM	182	
FJP KRUSE-FAGATOGO	41	
DDW (DONT DRINK THE WATER)	30	
FJP KRUSE STORE (LEONE)	28	
FJP KRUSE-PAGOPAGO (SUPER K)	14	
7-H HALECKS (FAGAALU)	6	
Null	29	0.9
Not sold	26	0.8

2.1.6 *Vessels participating*

Included in the BBS interview data were 126 unique vessel registration numbers (Figure 2-11). However, the total number of fishers that participated in interviews over the timeseries may be larger because years prior to 2008, >30% of all interviews did not include vessel registration numbers. Just more than half (58%) of Tutuila fishers also fished other areas such as the banks.

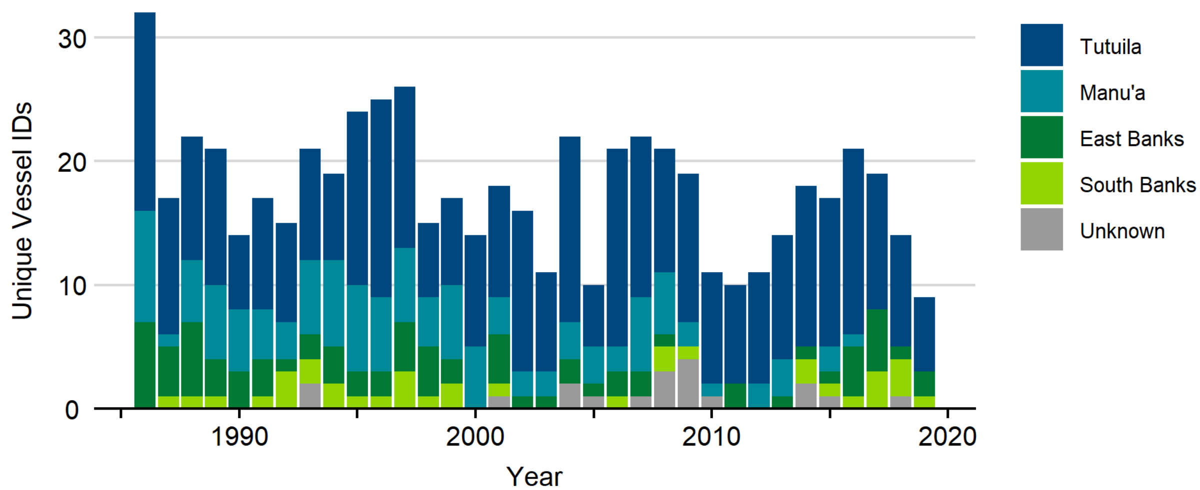

Figure 2-11. Number of vessel registration numbers (denoting unique vessels) that provided BBS interview data each year by area for bottomfishing and btm/trl mix fishing gears. Vessels that fished in more than one area appear in each.

2.2 Participation counts

On Tutuila, DMWR staff visit or monitor the 4 main ports of Pago Pago, Fagatogo, Utulei, and Faga'alu to estimate the number of fishing boats going out to sea a minimum of 12 weekdays and 2 Saturday/holiday (weekend) days per month, as staff and resources allow. In addition to conducting BBS interviews (section 2.1), staff perform participation counts by identifying boats that are away on fishing trips, either by noting empty berths at marinas or by observing boats departing or returning to port. Total fishing effort each year, in number of trips, is estimated by multiplying the average trips per day from the participation counts by the number of days per year within each expansion domain (gear, day type, and charter status). Additional adjustment factors are used to correct for trips where fishing gear was unknown, as well as to account for temporal undercoverage and unsampled ports (Ma 2021, in review). DMWR does not conduct participation counts in the Manu'a Islands.

The average number of weekdays per month surveyed for participation counts in Tutuila was 11.8 from 1986 to 2019, with a minimum of 4.1 weekdays per month (on average) in 1992–1993 and a maximum of 19.6 weekdays per month (on average) in 2012 (Figure 2-12). The average number of weekend days per month surveyed for participation counts in Tutuila was 2.1 from 1986–2019, with minimum of 0.7 weekend days per month (on average) in 2011 and maximum of 3.3 weekend days per month (on average) in 2015. BBS creel interviews documented five gear types with BMUS catch from 1986 to 2019: bottomfishing, bottomfishing / troll mix, spearfishing (including with and without scuba), and atule-mixed fishing. The number of trips observed during the participation count surveys for those five gears combined (including both Tutuila and Manu'a) ranged from 42 trips in 1992 to 588 trips in 2008 (Figure 2-13). Fagatogo Marina Dock accounted for the majority of trips observed every year since 2004. The least commonly sampled ports (*N* = total number of observed trips 1986–2020) include Leone (*N* =

149), Aunu’u ($N = 147$), Vatia ($N = 102$), Fagaitua ($N = 52$), Utulei ($N = 44$), Asili ($N = 29$), Amaluia ($N = 17$), and Masefau ($N = 1$).

The total annual estimated number of fishing trips (for bottomfishing, bottomfishing/troll mix, spearfishing, and atule-mixed fishing), expanded from participation count surveys, is highly variable between years, ranging from 111 trips in 1992 to 867 trips in 2008 (Figure 2-14). Of those gear types, bottomfishing accounted for the majority of fishing trips most years since 2000. Fishing activity was notably reduced following damage to fishing fleets from natural disasters such as tropical cyclones and the 2009 tsunami (WPRFMC 2020).

From 1986 to 2019, the majority of the estimated total number of fishing trips (84%) occurred on weekdays (Figure 2-15). Charter fishing trips were rare, occurring only in 2016, 2017, and 2019 (Figure 2-16). From 1986 to 2008, the Manu‘a Islands accounted for approximately 10.0% of the total number of estimated fishing trips (Figure 2-17). As noted previously, the limited number of fishing boats and fishers in the Manu‘a Islands enabled a census of fishing trips until 2009 when staff on Ofu-Olosega and Ta’u were no longer available. Since 2009, DMWR has not conducted regular BBS interviews in the Manu‘a Islands, instead, 20 creel survey interviews (hence 20 trips) have been sporadically recorded throughout the years from 2009–2019. Variance estimates on the number of annual trips in Tutuila (Ma 2021, in review) are generally higher in the early part of the timeseries. Still, relative percent error (standard deviation/expected) was less than 10% from 1997 to 2019 (average 6.3%).

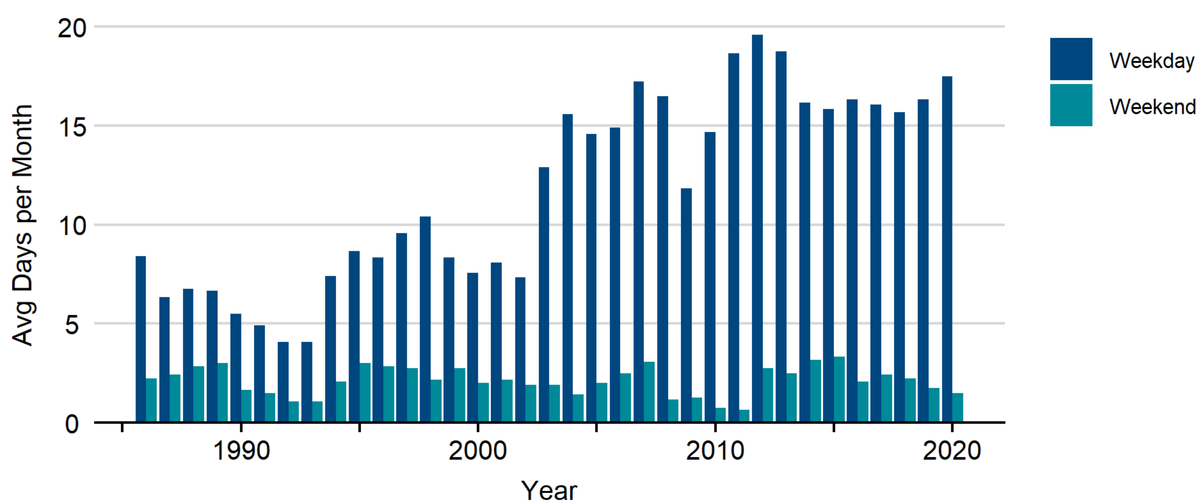

Figure 2-12. Tutuila participation count average days surveyed per month by type of day and year.

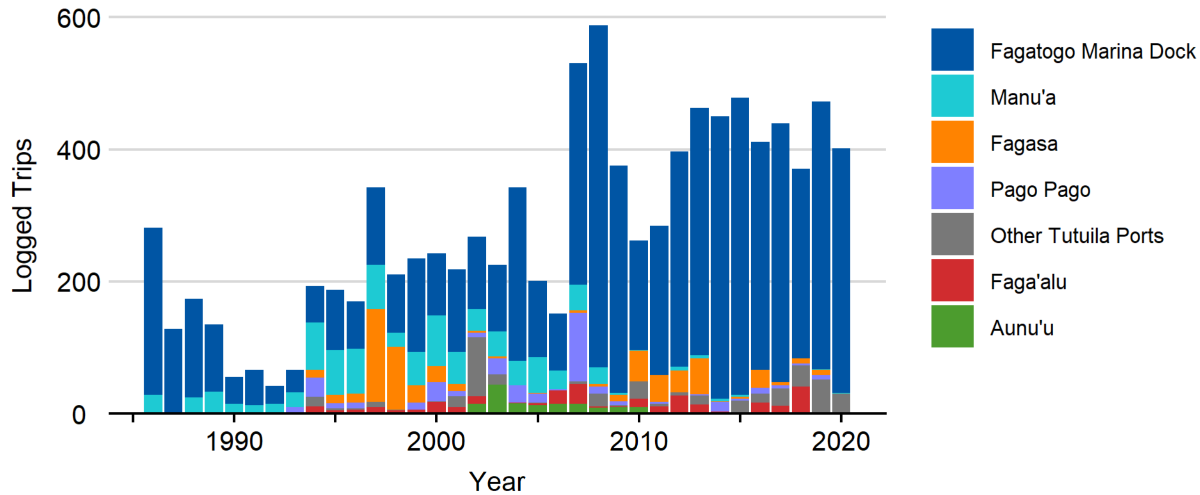

Figure 2-13. Tutuila participation count observed trips per year by port. Includes trips with gear types bottomfishing, bottomfishing / troll mix, spearfishing (including with and without SCUBA), and atule-mixed fishing. 'Other Tutuila Ports', in descending order of logged trips from 1986–2020, include Leone ($N = 149$), Vatia ($N = 102$), Fagaitua ($N = 52$), Utulei ($N = 44$), Asili ($N = 29$), Amaluia ($N = 17$), and Masefau ($N = 1$).

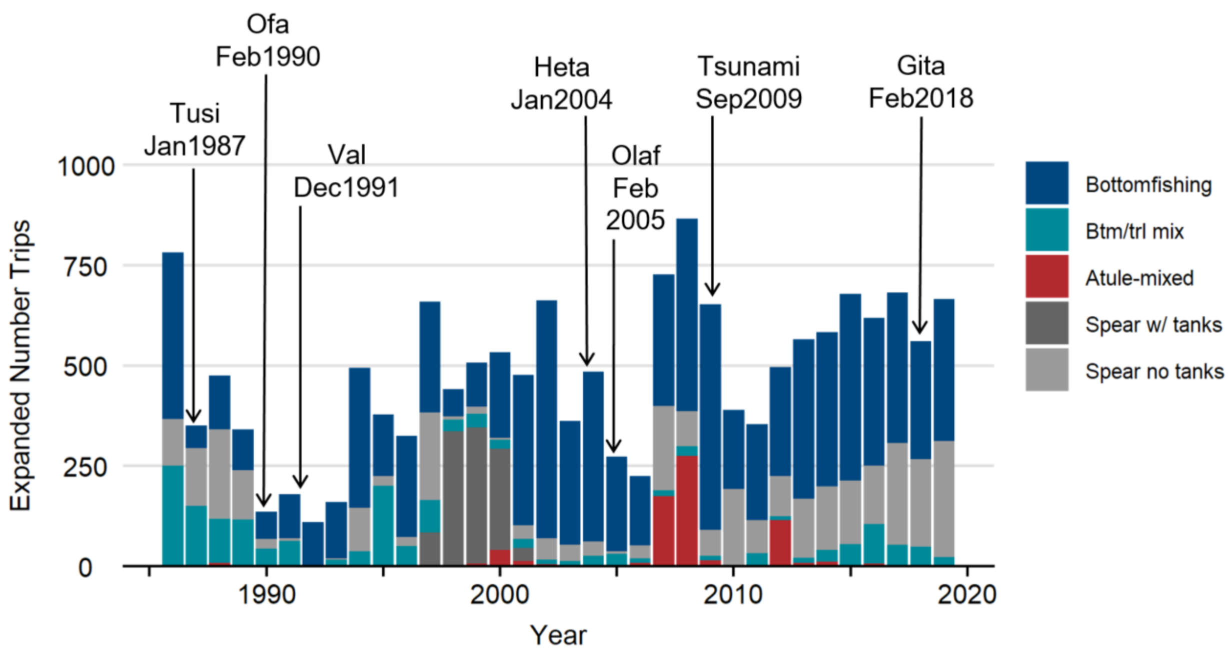

Figure 2-14. Annual number of trips by gear expanded from the BBS. The approximate dates of named tropical cyclones, as well as the 2009 tsunami, are noted.

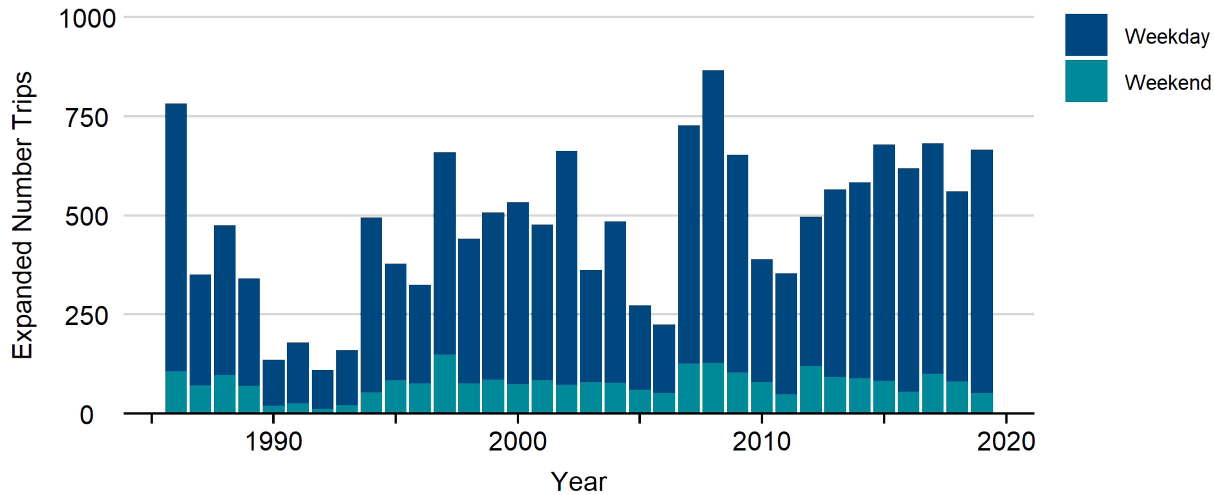

Figure 2-15. Annual number of trips by type of day expanded from the BBS.

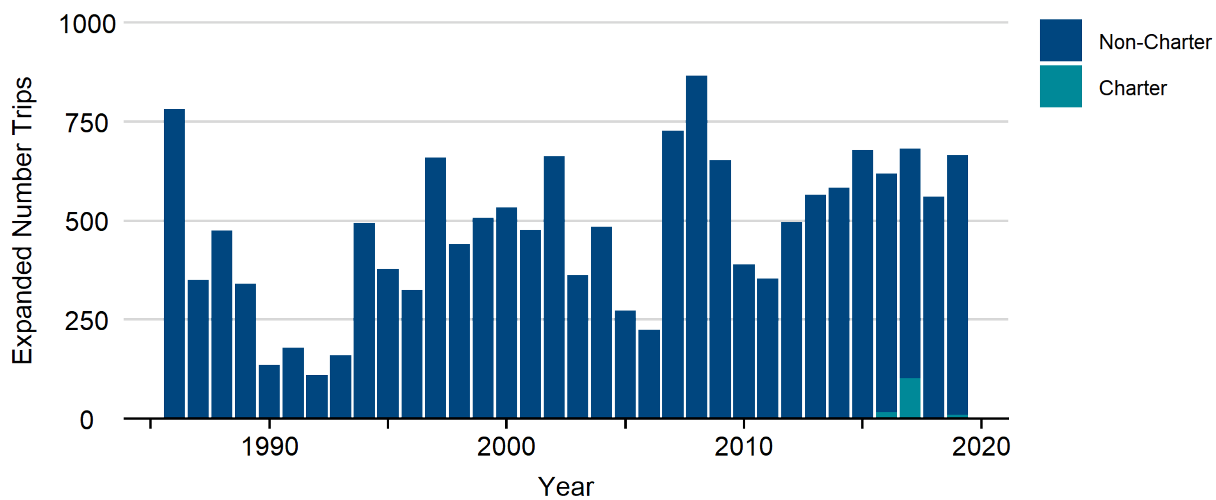

Figure 2-16. Annual number of trips by charter status expanded from the BBS.

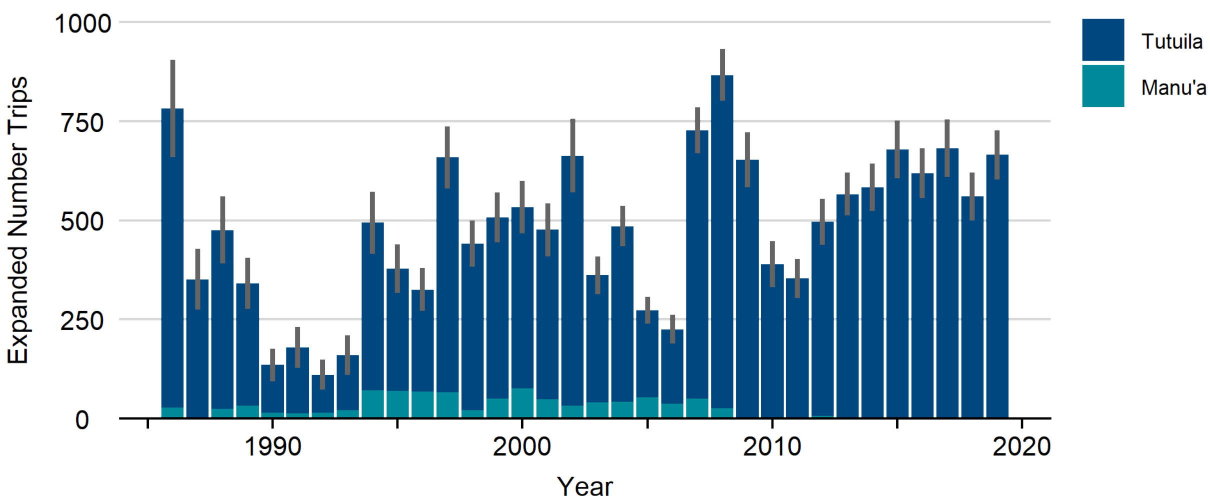

Figure 2-17. Annual number of trips by area expanded from the BBS. Error bars are 95% confidence intervals (± 1.96 standard deviations) and apply to Tutuila trips only.

2.3 Annual catch estimation

Annual catch (equal to landings, in pounds) from Tutuila for each BMUS was estimated together with a measure of relative error following the expansion methodology described in Ma (2021, in review). Briefly, catch rates (catch per unit effort, as lb landed per trip) are estimated for each of the expansion domains (gear type, day type, and charter status). The total number of fishing trips for each expansion domain is estimated from participation counts (Section 2.2), then multiplied by catch rates within each expansion domain and summed across domains to give the annual estimate of total catch from Tutuila. All catch observed in BBS interviews from the Manuʻa Islands are included in estimated annual total catch.

Estimated annual catch is highly variable over the timeseries and among the 11 BMUS (Figure 2-19, Figure 2-20, and Figure 2-21). Over the past 10 years (2010–2019), *A. virescens* had the highest average annual catch (approximately 2795 lb). Four other BMUS had average annual catches greater than 1000 lb from 2010 to 2019: *E. coruscans* (2325 lb/year), *A. rutilans* (2140 lb/year), *L. rubrioperculatus* (1600 lb/year), and *L. kasmira* (1585 lb/year). *E. carbunculus* catch was zero from 2010 to 2012 but has averaged 980 lb/year from 2013 to 2019. *P. flavipinnis* and *V. louti* had high landings during the earlier years of the timeseries (peaking at 2560 lb for *P. flavipinnis* in 2001 and 6170 lb for *V. louti* in 2003). However, both species have been comparatively rare in the landings over the past ten years, averaging 85 and 113 lb/year for *P. flavipinnis* and *V. louti*, respectively.

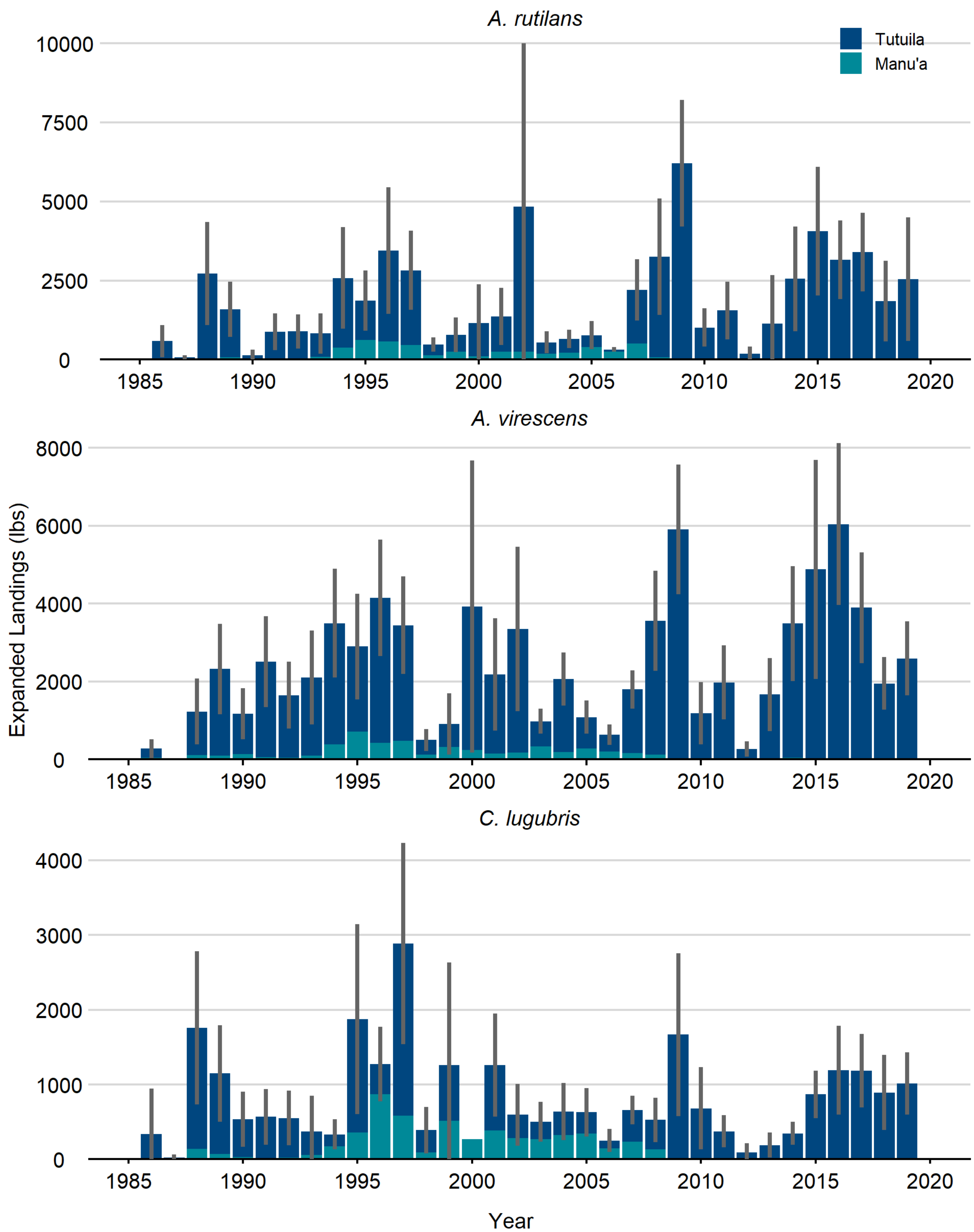

Figure 2-18. Estimated annual catch (landings, lb) of *A. rutilans*, *A. virescens*, and *C. lugubris*. Error bars are 95% confidence intervals (± 1.96 standard deviations) and apply to Tutuila catch only.

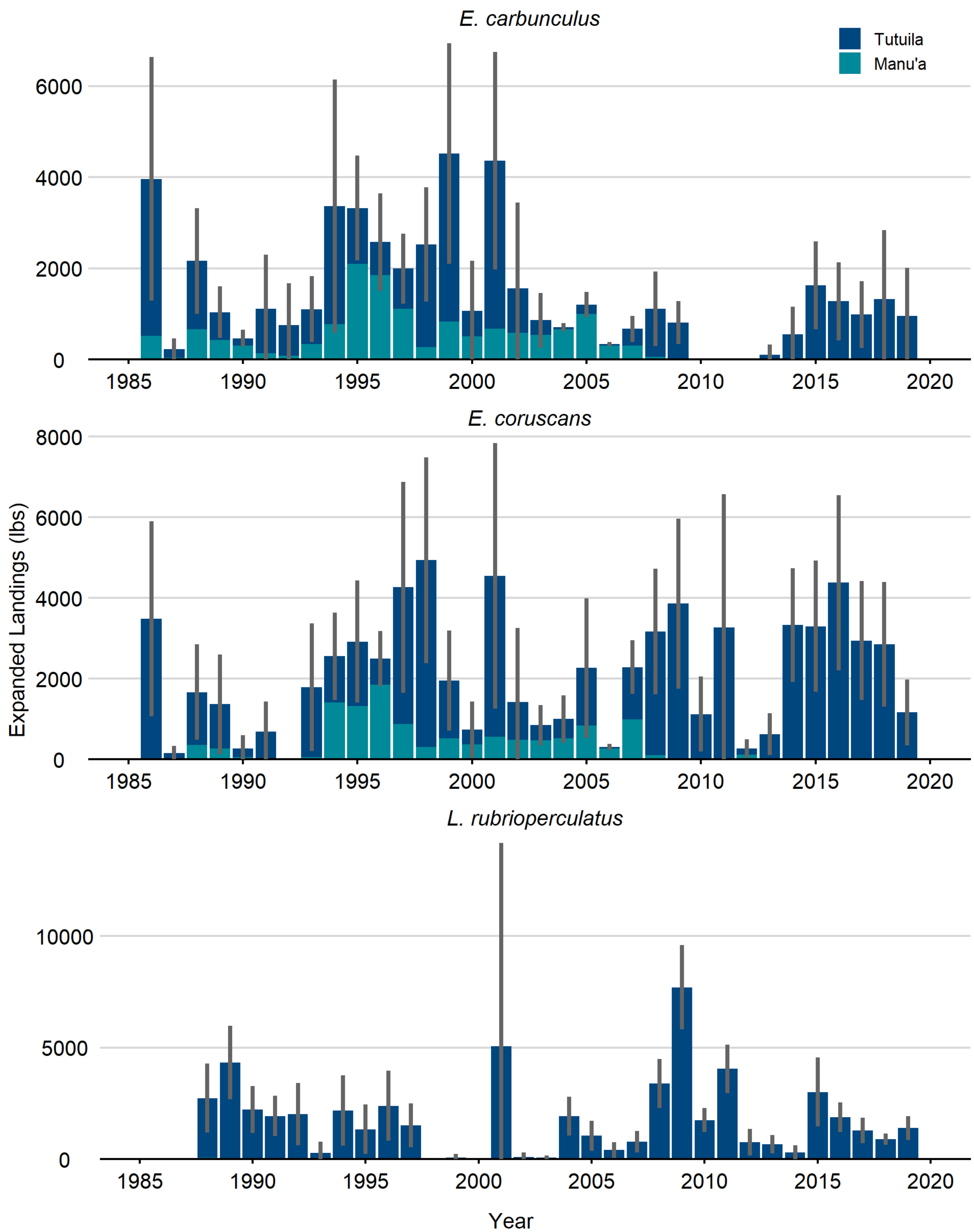

Figure 2-19. Estimated annual catch (landings, lb) of *E. carbunculus*, *E. coruscans*, and *L. rubrioperculatus*. Error bars are 95% confidence intervals (± 1.96 standard deviations) and apply to Tutuila catch only.

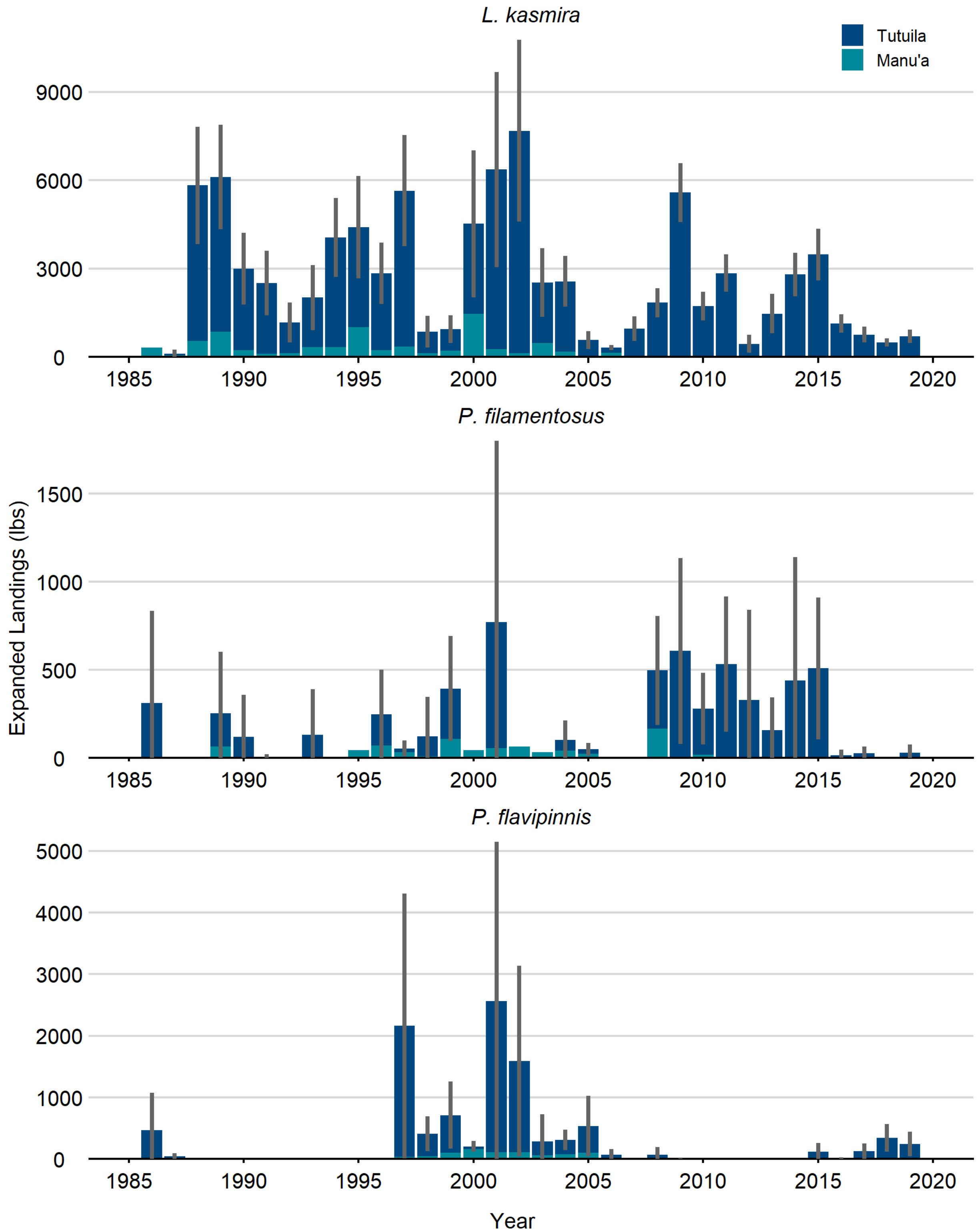

Figure 2-20. Estimated annual catch (landings, lb) of *L. kasmira*, *P. filamentosus*, and *P. flavipinnis*. Error bars are 95% confidence intervals (± 1.96 standard deviations) and apply to Tutuila catch only.

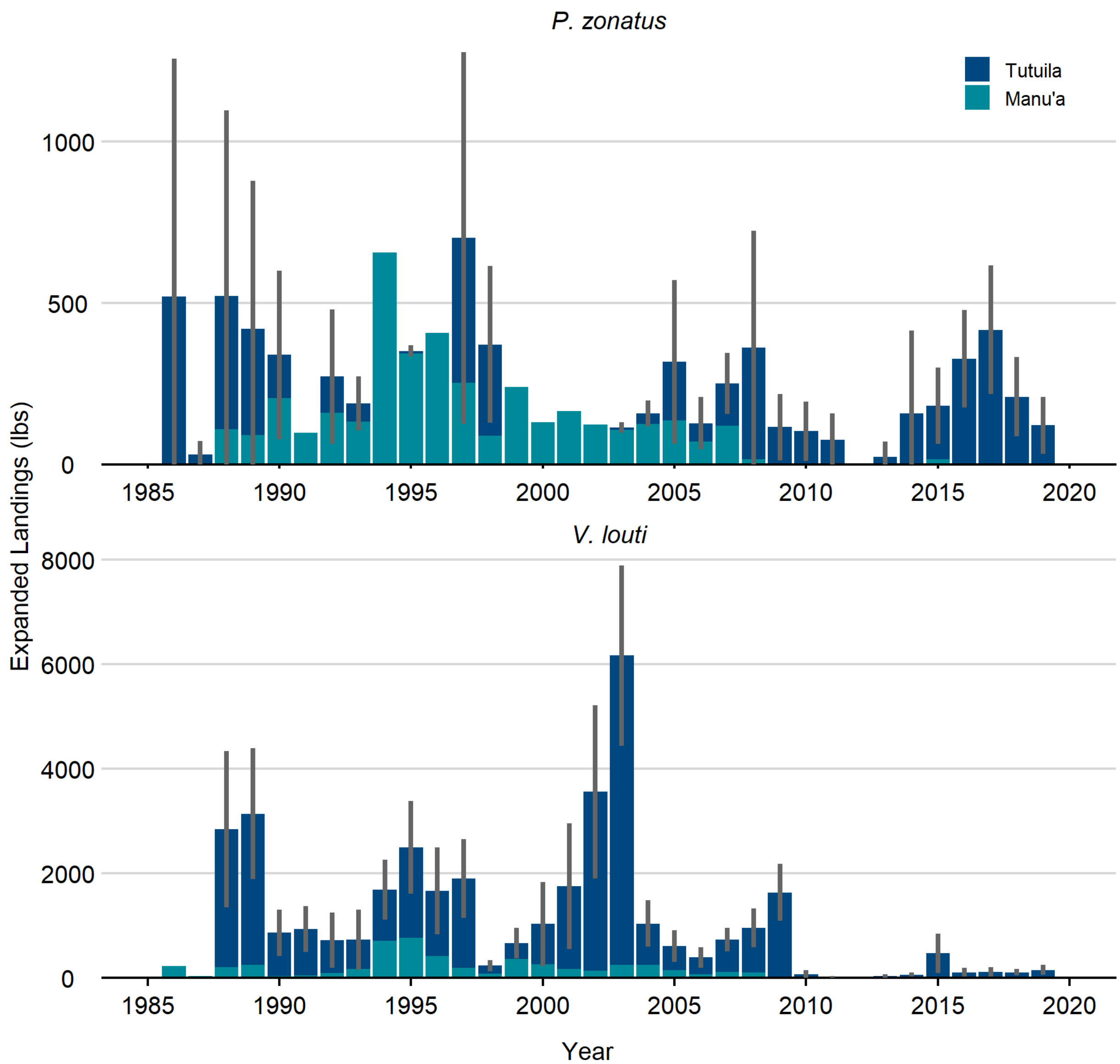

Figure 2-21. Estimated annual catch (landings, lb) of *P. zonatus* and *V. louti*. Error bars are 95% confidence intervals (± 1.96 standard deviations) and apply to Tutuila catch only.

Prior to 2016, BBS interviews commonly recorded catch as unknown group categories containing fish that were not identified to species but could have been BMUS (Section 2.1.3). Three of these group categories (bottomfishes, deepwater/inshore snappers, and *Pristipomoides*/*Etelis* spp.) are used sporadically throughout the timeseries and can account for a large amount of catch in some years (Figure 2-22). For example, estimated landings of unidentified bottomfishes was almost 75,000 lb in 1986 and surpassed 19,500 lb in each year 1987, 1988, and 2013. Unidentified groupers, emperors, and jacks/trevallies were landed in most years of the timeseries, averaging 1000 lb groupers, 3200 lb emperors, and 650 lb jack/trevallies per year from 1986 to 2015 (Figure 2-23).

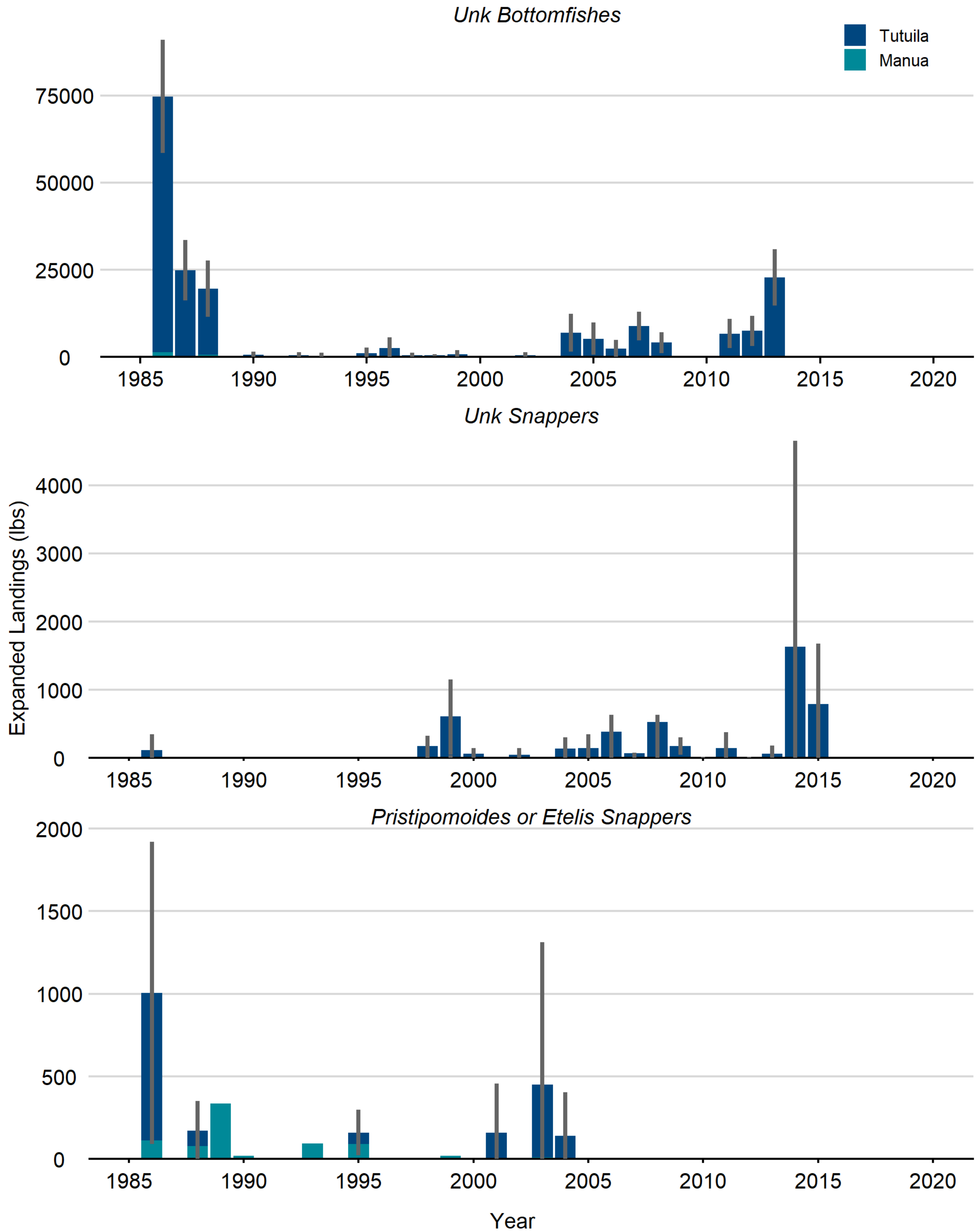

Figure 2-22. Estimated annual catch (landings, lb) of unidentified species groups bottomfishes, snappers, and *Pristipomoides*/*Etelis* spp. Error bars are 95% confidence intervals (± 1.96 standard deviations) and apply to Tutuila catch only.

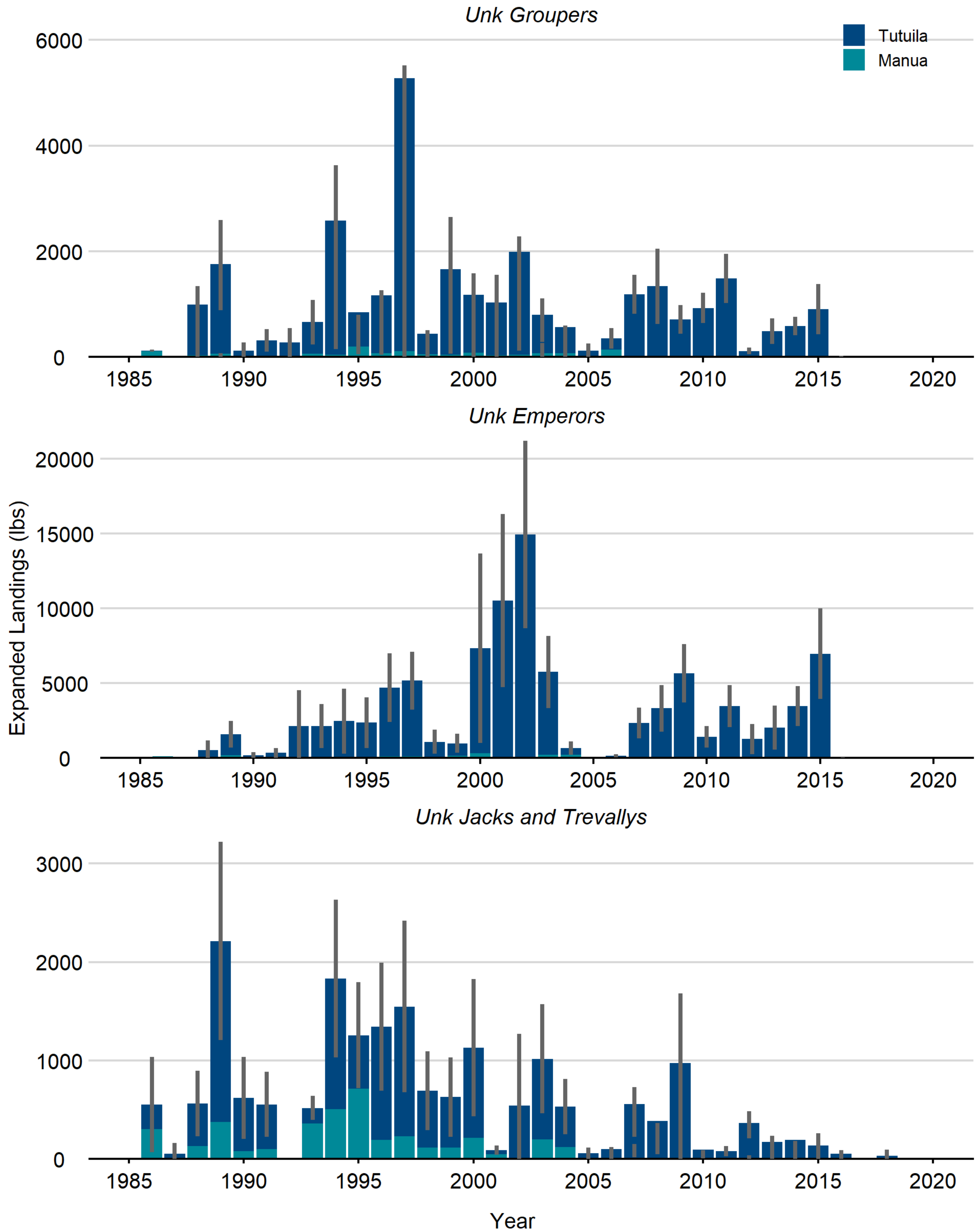

Figure 2-23. Estimated annual catch (landings, lb) of unidentified (unk) species groups groupers, emperors, and jacks / trevallies. Error bars are 95% confidence intervals (± 1.96 standard deviations) and apply to Tutuila catch only.

3 Shore-based Creel Survey

The American Samoa Department of Marine and Wildlife Resources (DMWR) Shore-based Creel Survey Program (SBS) is designed to monitor fisheries catch and participation by fishers in the inshore lagoon and nearshore areas beyond the reef using a wide variety of fishing gears, including throw nets, gillnets, seines, hook-and-line, spearfishing, gleaning, harpoon, traps, weirs, and various other methods. Small boats, typically without motors that may be launched by hand and used to transport catch and gear in support of shore-based fishing activities, are also included in the SBS. Similar to the boat-based creel survey program (BBS), the SBS includes two datastreams: 1) interviews of fishermen intercepted by survey technicians on the shore together with the observation of their catch, and 2) participation estimates (number of fishers and types of fishing) made by observers from the shore. The SBS is conducted by technicians traveling along survey routes (Figure 3-1) several times per month, stratified by time and type of day (weekend/holiday vs. weekday).

Sampling of shore-based fishers has occurred in some form since 1978. However, the SBS as a survey has undergone periods of inactivity and numerous changes in field methodology (sampling routes traveled by technicians and selection of fishers for interviews) and data management throughout the timeseries (Oram et al. 2013) (Michael Quach pers. comm.; Figure 3-2). The Western Pacific Fisheries Information Network (WPacFIN) at the Pacific Islands Fisheries Science Center began data management in the 1980s, discontinued oversight in late 1996, and re-established in 2002. Following the 1996–2002 WPacFIN data management hiatus, SBS interview data were largely unavailable until 2005 in Tutuila and 2007 in Ofu-Olosega and Ta'u. General characteristics and observations specific to bottomfish management unit species (BMUS) in the SBS are included in this report for completeness, even though the inconsistencies in survey methodology and implementation would greatly complicate efforts to use these data to develop a reliable catch per unit effort (CPUE) timeseries for use in a stock assessment. For clarity, the remainder of this section will refer to the SBS data for two periods: early (1988–1996) and late (2005–2019). Additional details on the history and methodology of the SBS are documented in Oram et al. (2013). Although the SBS primarily includes reef-associated fish and invertebrates, it is included in this summary of available data for the American Samoa bottomfish assessment because some BMUS, particularly juveniles, may be captured by these shore-based fishers.

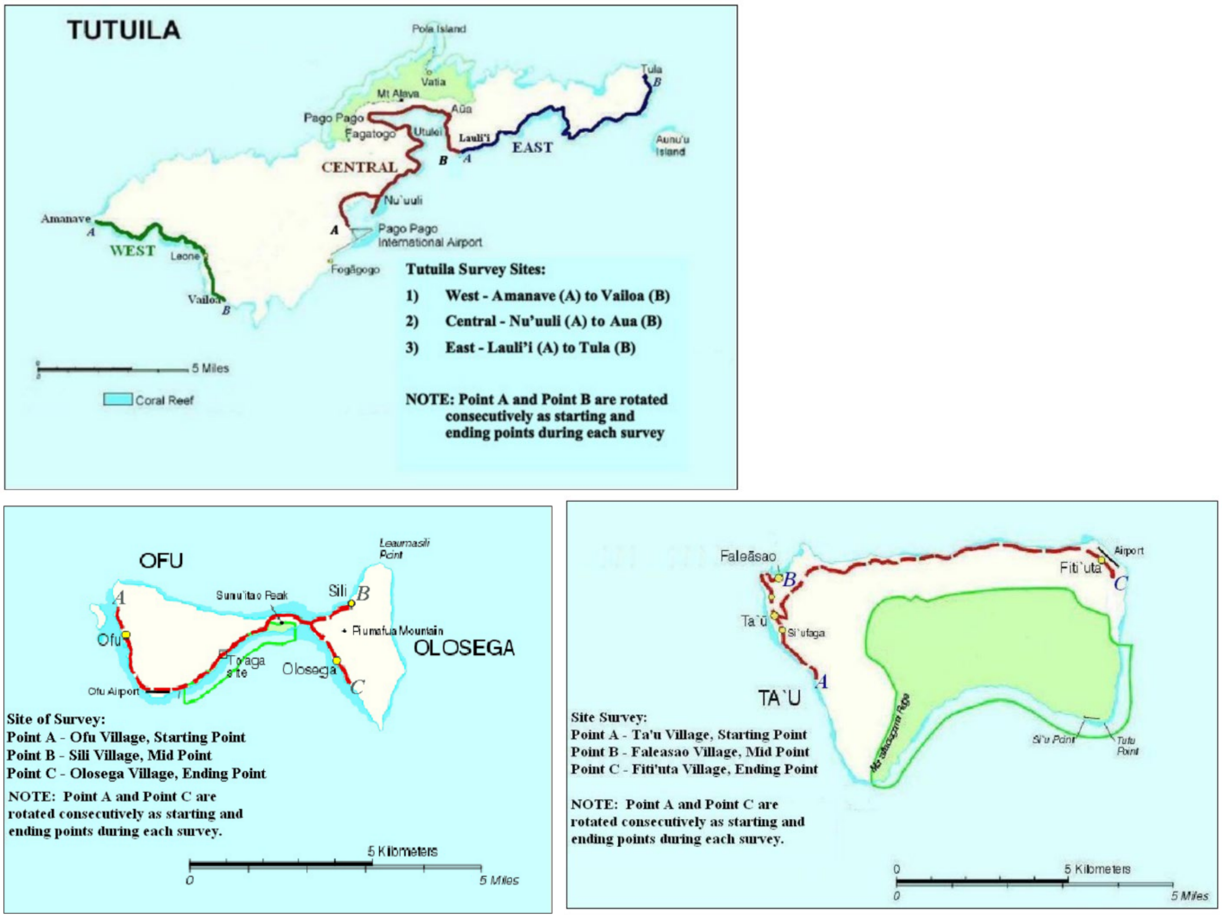

Figure 3-1. SBS survey routes.

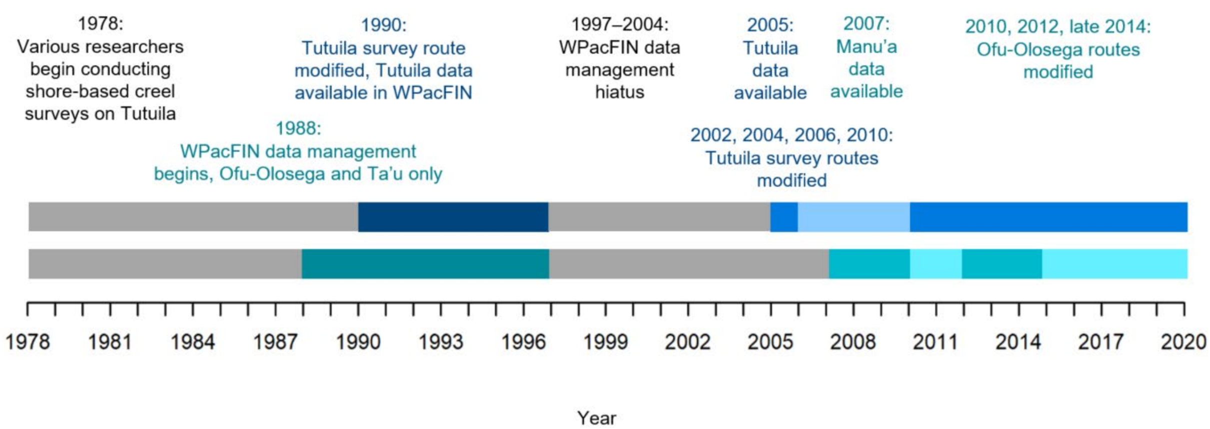

Figure 3-2. Timeline of SBS methodology and data management from 1978 to 2019.

3.1 Creel interviews

Participation in SBS interviews is voluntary, although many fishers choose to cooperate (Oram et al. 2013). Interviewers collect information on effort (hours fished, number and types of fishing gear, and number of fishers), areas fished, economic information (% of catch sold), bycatch (species and number thrown back), and catch. Catch information includes total catch per species in numbers and weight, and may also include individual fish length observations. Standardized staff training in fish species identification and scientific naming was implemented in 2016. Prior to 2016, catches were often described using only Samoan common names, which are ambiguous for many species. Species group identifiers (e.g., "fuga, fuga usi, laea/parrotfishes," "malau/squirrelfishes," "ume/unicornfishes," "gatala/groupers," "lupoka, ulua/jacks," etc.) were also often used within the SBS prior to 2016.

3.1.1 Spatial-temporal and fishing gear effort trends

During the 24 years of the SBS (i.e., excluding 1997–2004) 4,902 interviews were conducted, averaging 266 interviews/year during the early period (1988–1996, range 133–393) and 167 interviews/year during the late period (2005–2019, range 55–346). Hook and line (bamboo pole, handline, rod and reel, and troll) accounted for more than 40% of all interviews, and nets excluding gillnet (mosquito net, seining, and throw net), spear (including harpoon), and gleaning were also predominant gear types (Figure 3-3). Spearfishing replaced scuba in the late period because harvesting fish using SCUBA in American Samoa has been prohibited since 2001. There were 170 SBS interviews that contained identified BMUS over the 24 years of the survey, with BMUS being much less common during the late period of the timeseries (observed in an average of 2 interviews/year) than the early period (observed in an average of 19 interviews/year; Figure 3-4). Nets other than gillnets (mosquito net, seine, and throw net) were the most common gears used in interviews where BMUS were identified. In the early period, approximately 43% of interviews were from central Tutuila, and the remainder were split nearly equally between Ta'u and Ofu-Olosega Figure 3-5). In the late period, Tutuila accounted for 70% of total interviews, including eastern and western areas, and since 2015, very few interviews (N = 16) has been conducted on Ofu-Olosega.

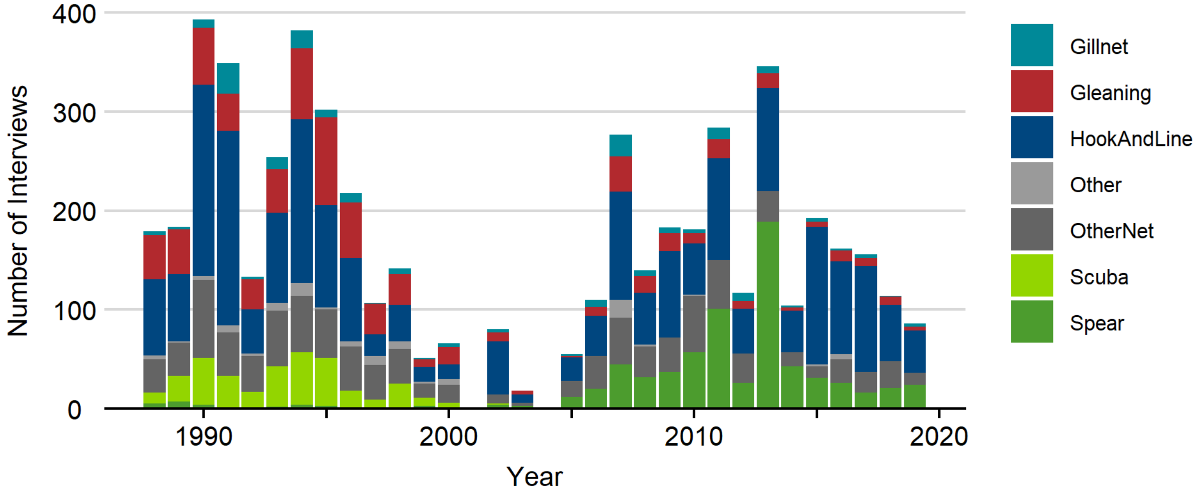

Figure 3-3. Total number of SBS interviews per year by fishing gear. Hook and line includes bamboo pole, handline, rod and reel, and troll; other nets include mosquito net, seining, and throw net; and other includes traps, unknown, weirs, and mixed gear types.

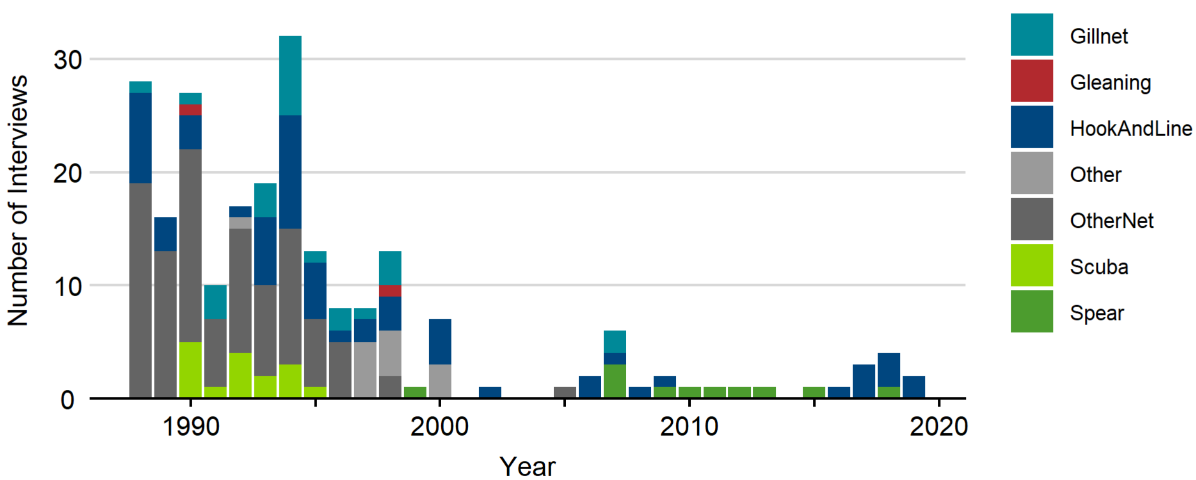

Figure 3-4. Number of SBS interviews per year containing identified BMUS by gear. Hook and line includes bamboo pole, handline, rod and reel, and troll; other nets include mosquito net, seining, and throw net; and other includes traps, unknown, weirs, and mixed gear types.

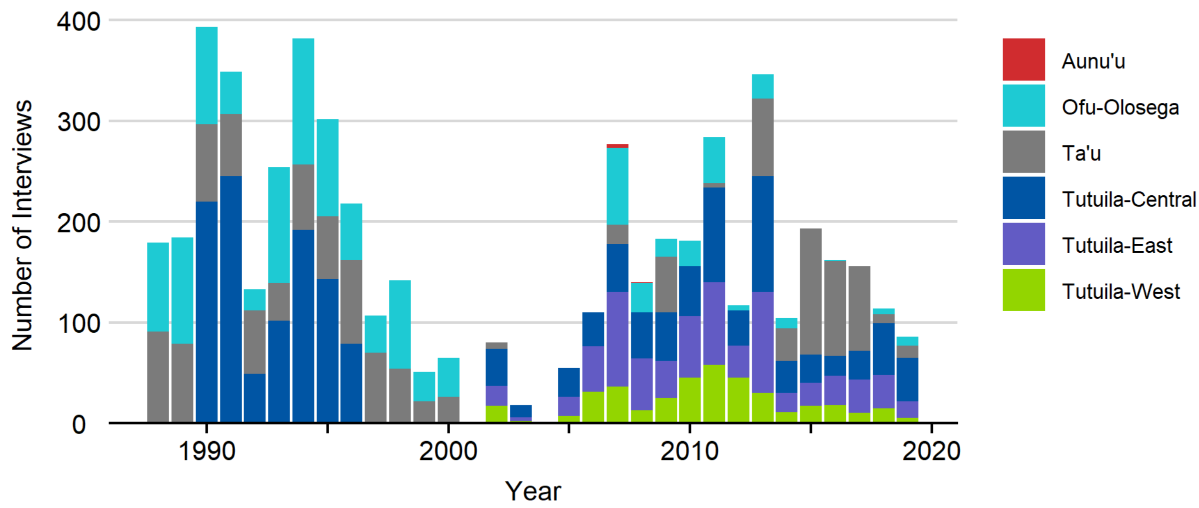

Figure 3-5. Total number of SBS interviews per year by area, all gears combined.

3.1.2 Species observed

In the late period of the SBS, 219 species and species groups were identified (Table 3-1). Fewer fish were identified to species level during the early years of the SBS, including 87 species and species groups, and 13.4% of total catch by weight was unidentified fish in the early period. Atule (*Selar cremenophthalmus*) accounted for 33.7% of total surveyed catch in the early period, owing to 24 large atule harvests (100 – 4,000 lb each), mostly in Ofu-Olosega from 1990 to 1994. In contrast, only 3% of total catch by weight was atule during the late period as there were no large atule harvests recorded in the SBS.

BMUS are rare in the SBS interview data. Three BMUS (*L. kasmira*, *P. zonatus*, and *V. louti*) comprised less than 2% of observed catch by weight during the early period and 7 BMUS (*A. rutilans*, *A. virescens*, *C. lugubris*, *L. rubrioperculatus*, *L. kasmira*, *P. zonatus*, and *V. louti*) comprised less than 0.3% of observed catch by weight during the late period. Four BMUS (*E. carbunculus*, *E. coruscans*, *P. filamentosus*, and *P. flavipinnis*) have never been observed in the SBS interview data.

Table 3-1. Surveyed catch by species (as percent total weight) from SBS interviews for each time period. Asterisks (*) denote BMUS.

Early Period (1988–1996)		Late Period (2005–2019)	
Species	**Percent Surveyed (%)**	**Species**	**Percent Surveyed (%)**
Selar crumenophthalmus	33.7	*Acanthurus lineatus*	14.0
Octopus spp.	13.4	*Octopus spp.*	11.4
Scarus spp.	5.0	*Scarus spp.*	8.1
Sargocentron spp.	4.5	*Seriola dumerilii*	4.6
Naso spp.	3.4	*Panulirus pencillatus*	4.5
Mugil cephalus	3.1	*Mugil cephalus*	4.0
Mulloidichthys spp.	3.0	*Sargocentron spp.*	3.6
Panulirus pencillatus	2.8	*Acanthurus nigrofuscus*	3.1
Epinephelus spp.	2.4	*Selar crumenophthalmus*	3.0
Acanthurus lineatus	2.2	*Naso spp.*	2.4
Acanthurus guttatus	1.4	*Epinephelus spp.*	2.4
Polydactylus sexfilis	1.1	*Turbo spp.*	1.9
Naso lituratus	1.0	*Acanthurus xanthopterus*	1.7
Turbo spp.	1.0	*Acanthurus guttatus*	1.7
Acanthurus spp.	0.9	*Kyphosus spp.*	1.5
**Pristipomoides zonatus*	0.7	*Crenimugil crenilabis*	1.3
Acanthurus nigrofuscus	0.6	**Variola louti*	0.1
**Variola louti*	0.6	**Caranx lugubris*	<0.1
**Lutjanus kasmira*	0.5	*All other BMUS[1]	<0.1
Unidentified	13.4	Unidentified	4.2
All Other Species and Groups (*N* = 69)	5.2	All Other Species and Groups (*N* = 196)	26.3

[1] *Aphareus rutilans*, *Aprion virescens*, *Lethrinus rubrioperculatus*, *Lutjanus kasmira*, and *Pristipomoides zonatus*.

3.1.3 BMUS species identification and occurrence

During the early period, approximately 9% of SBS surveyed catch by weight was identified to species that could potentially include BMUS, primarily jacks but also groupers, emperors, trevallies, deepwater snappers, and inshore snappers (Figure 3-6). In the late period, 95.5% of all SBS surveyed catch was identified to non-BMUS species or species groups (Table 3-1) and groups which could potentially include BMUS were not commonly used (accounting for <4% of total surveyed catch by weight).

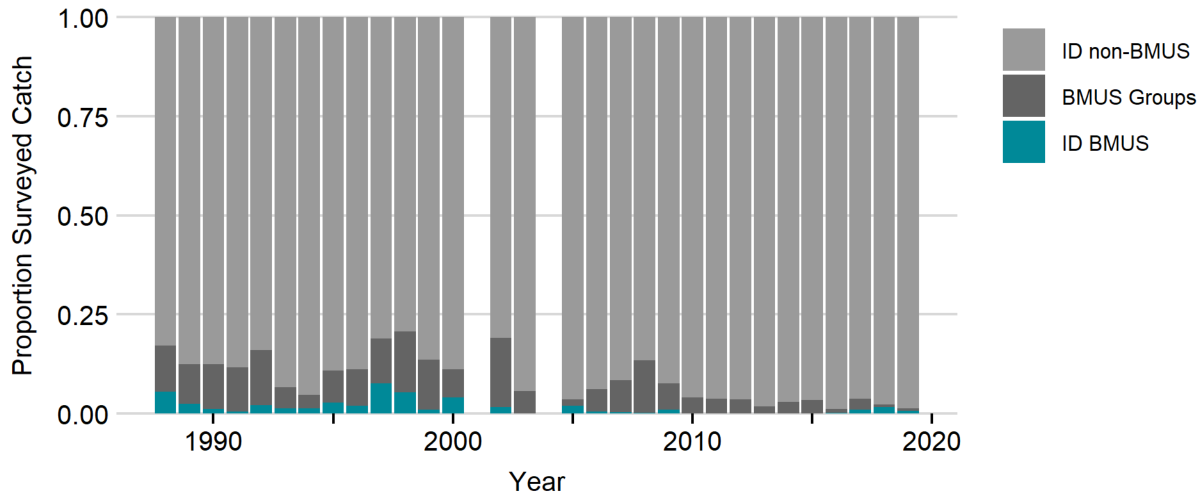

Figure 3-6. Proportion of SBS surveyed catch (weight) by level of identification and year, all gears combined.

There are notable differences in surveyed BMUS between the early and late period (Figure 3-7). In the early period, *P. zonatus* were commonly observed: 2,338 fish were reported from 131 interviews by at least 13 different interviewers. *L. kasmira* ($N = 522$) and *V. louti* ($N = 347$), though not as numerous, were also frequently reported in the early period. In contrast, during the late period, very few BMUS were observed, including 6 *P. zonatus*, 9 *L. kasmira*, and 23 *V. louti* over 15 years of SBS interviews.

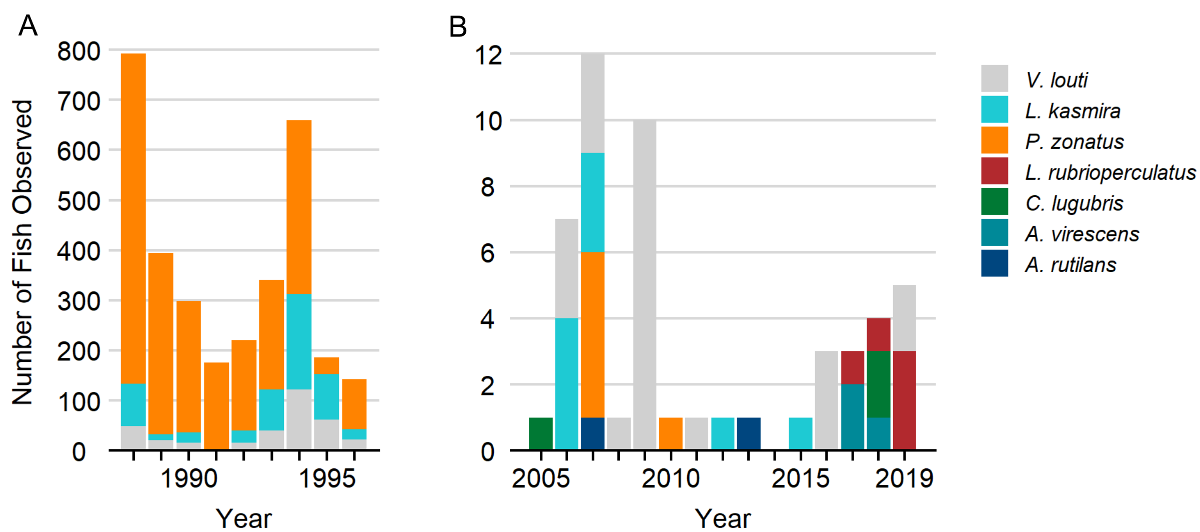

Figure 3-7. Number of BMUS observed by species and year during the (A) early and (B) late periods of the SBS.

3.1.4 Size data

P. zonatus were the only BMUS measured during the early period and had an average length of 11.8 cm FL (range 7.2–20.2 cm FL, $N = 245$; Figure 3-8A). Almost all BMUS captured during the late period were measured, including 23 *V. louti* captured primarily by hook and line and spear ranging from 21.5 to 42.5 cm FL (Figure 3-8B).

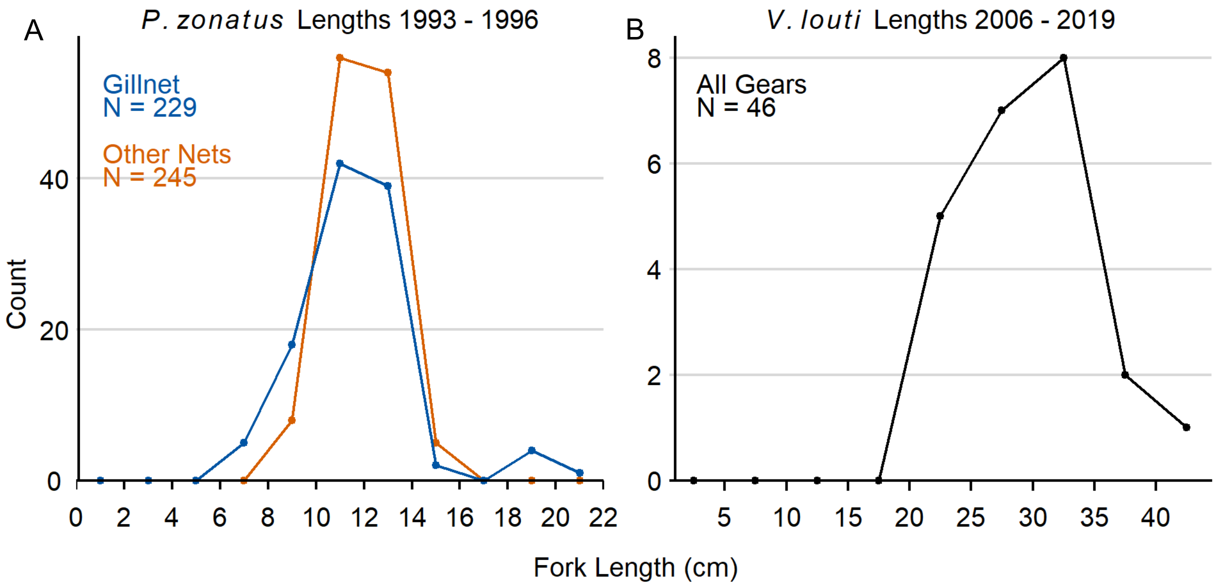

Figure 3-8. Length frequencies for (A) *P. zonatus* observed during the early period of the SBS and (B) *V. louti* observed during the late period of the SBS.

4 PIFSC Biosampling Program

The PIFSC Biosampling Program, described below, was primarily set up to efficiently collect size data and biological samples for life history studies. The primary use of this data set in stock assessment is therefore limited to generating size frequency data for bottomfishes and is not useable for other purposes (e.g., estimation of catch rates or landings).

The National Marine Fisheries Service (NMFS) developed and funded the Commercial Fisheries Biosampling Program in 2009 (Sundberg 2015). The Biosampling Program provided financial support to each of the six NMFS Science Centers to enhance data collections, especially in data-limited situations. The Pacific Islands Fisheries Science Center (PIFSC) contracted and trained biosampling teams in each of the western Pacific territories, working with the support of their respective marine resource agencies (Department of Marine and Wildlife Resources, DMWR, in American Samoa). These teams were tasked with acquiring length/weight metrics and collecting biological samples (otoliths, gonads, and fin clips) from key fish species. In each region, the biosampling teams implemented standardized sampling techniques outlined by PIFSC.

The primary effort of these teams was to establish cooperative relations with as many local fish markets, fishermen, and vendors as possible to acquire length and weight metrics. This could provide species composition and size data to support the development of stock assessments, after controlling for potential selectivity issues. In addition, targeted species were subsampled for hard parts and tissues to support life history studies. Otoliths, gonads, and fin clips were extracted from these species to determine growth rate, maturity, and longevity (Sundberg 2015). The Western Pacific Fisheries Information Network (WPacFIN) at PIFSC maintains and updates the database for biosampling data.

Biosampling surveyors in American Samoa began regular sampling of reef and bottom fishes in October 2010 at the Fagatogo marketplace in Pago Pago. All biosampling supplies, training, technical support, contracts for local fishermen, and external support for processing collected specimens (otoliths, gonads, and fin clips) were provided by PIFSC. All fish lengths and weights were obtained using a 75-cm fish measuring board, 1-m calipers or 150-cm tape measure (when needed for larger fish), and a digital bench scale. Most of the biosampling effort was geared towards documenting species composition and collecting length and weight measurements of the entire catch brought to market by individual fishers (Sundberg 2015).

To allow for easy acquisition of data for fish subsampled for otoliths and tissues, two separate data sets were created (i.e., “field” and “lab”). On sampling days, the entire commercial catch brought to market by individual fishers was measured to provide an unbiased sample of the size distribution of the market catch. These were categorized as “field” fish. In all territories, field fishes were identified to the species level, fork length (to the nearest 0.1 cm) and body weight (g) were recorded (Sundberg 2015). The moon phase, details about the seller, and fishing information (general area fished, start and end time, hours fished, trip type, fishing method, and fished date) were documented. After the entire commercial catch for each fisherman was measured, fishes identified as a priority for life history research were purchased or processed for otoliths and tissues. This subsample of fish was categorized as “lab” fish. The lab data set was created to provide a convenient compendium of the data on fish subsampled for otoliths and gonads. The “lab” data set does not necessarily represent a random sample of size structure and is not used to inform stock assessments.

Before April 2010, a centralized fish market did not exist in American Samoa. Biosamplers did not have transportation to visit the numerous small-scale markets and roadside stands scattered across the island selling locally caught fish (Sundberg 2015). Tracking down fish before they were sold was challenging and DMWR staff were unable to consistently measure or sample fish otoliths and gonads. When the Fagatogo marketplace in Pago Pago was established in 2010, collaborating fishermen brought their catch to the market or biosamplers transported fish from the fisherman’s home to the marketplace. Biosampling surveyors were able to measure a fishermen’s catch before it was sold and would purchase target species as lab specimens. Starting in 2014, most fishermen no longer brought their catch directly to the Fagatogo marketplace. Instead, biosamplers received fish at the DMWR laboratory located across the street from the marketplace. After the biosampling team purchased fish chosen for specimen extractions and fish lengths and weights were obtained, fishermen could sell their catch at the Marketplace or elsewhere.

Reef fish collection of length and weight measurements occurred twice a week either at the marketplace (2009–2013) or the DMWR offices (Ochavillo, 2012). The bottomfish fishery was less predictable, but bottomfish fishermen maintained good communication with biosampling surveyors, alerting them when their catch was to be offloaded. When notified, surveyors would meet with bottomfish fishermen to measure their catch and sample or purchase 6 target species. Fish were separated according to fisherman then grouped by species.

4.1 Size data

The biosampling data for American Samoa starts in October 2010 and ends in September 2015. During that time, a total of 257,110 fish were recorded in the data set, almost entirely from Tutuila (Figure 4-1). Most of these measurements (>240,000) are lengths from nearshore reef fish families, with some weight measurements as well. A smaller, yet non-negligible, number of size measurements (13,217) were made on BMUS species. Specifically, this data set contains close to or more than 1000 length measurements for *Aprion virescens*, *Lethrinus rubrioperculatus*, and *Lutjanus kasmira*; between 100 and 400 measurements for *Caranx lugubris*, *Etelis coruscans*, *Pristipomoides flavipinnis*, and *Variola louti*; and less than 100 measurements for *Etelis carbunculus*, *Pristipomoides filamentosus*, and *Pristipomoides zonatus* (Figure 4-1).

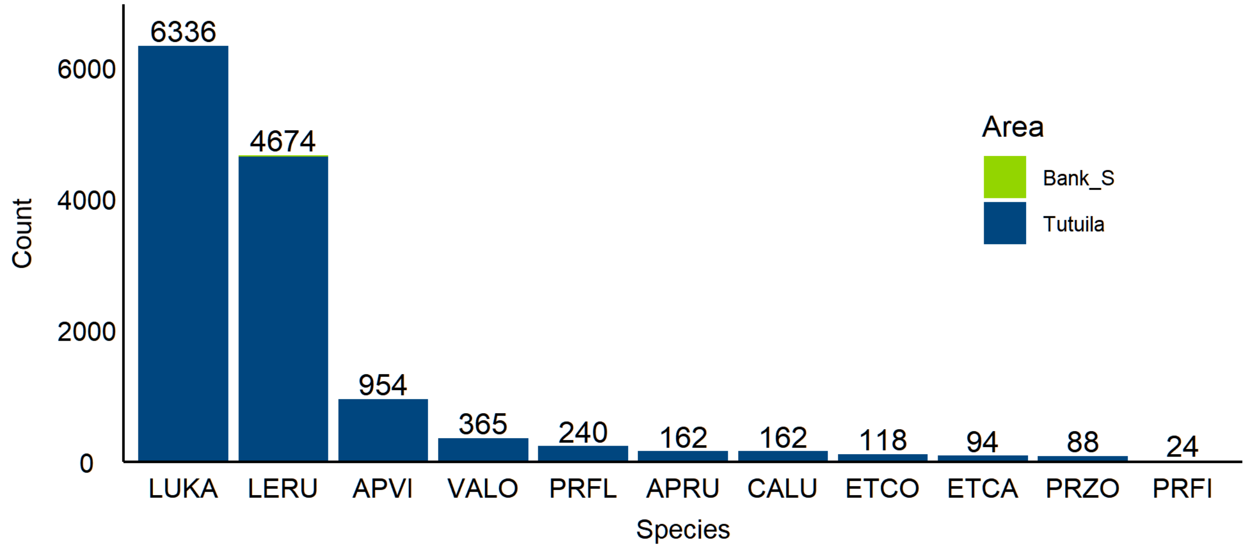

Figure 4-1. Species-specific length observations by area in the biosampling data set (2011–2015). Species abbreviations are specified in Table 1-1.

Unsurprisingly, all BMUS species except *V. louti* were caught mainly with bottomfishing gear, *V. louti* being primarily caught by spearfishing (Figure 4-2). The spearfishing records for *P. filamentosus* are likely misidentifications/data entry mistakes given that this species' primary habitat is too deep for even scuba spearfishing. Atule net fishing was only reported for a few records of *C. lugubris*.

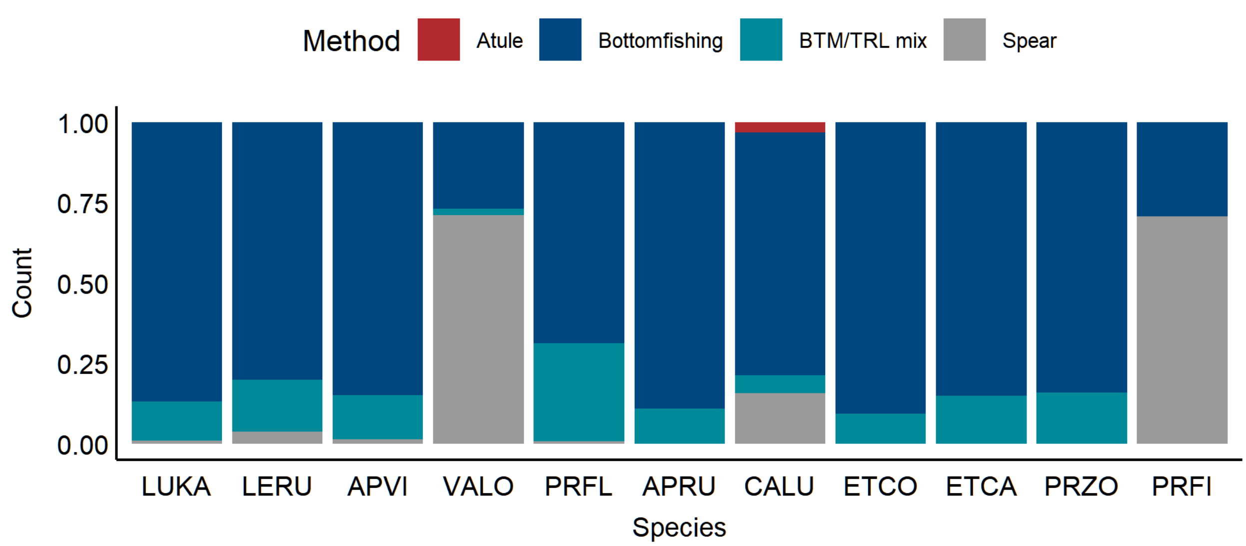

Figure 4-2. Species-specific length observations by fishing gear in the biosampling data set (2011–2015). Species codes are the first two letters of the genus and species name (see Table 1-1).

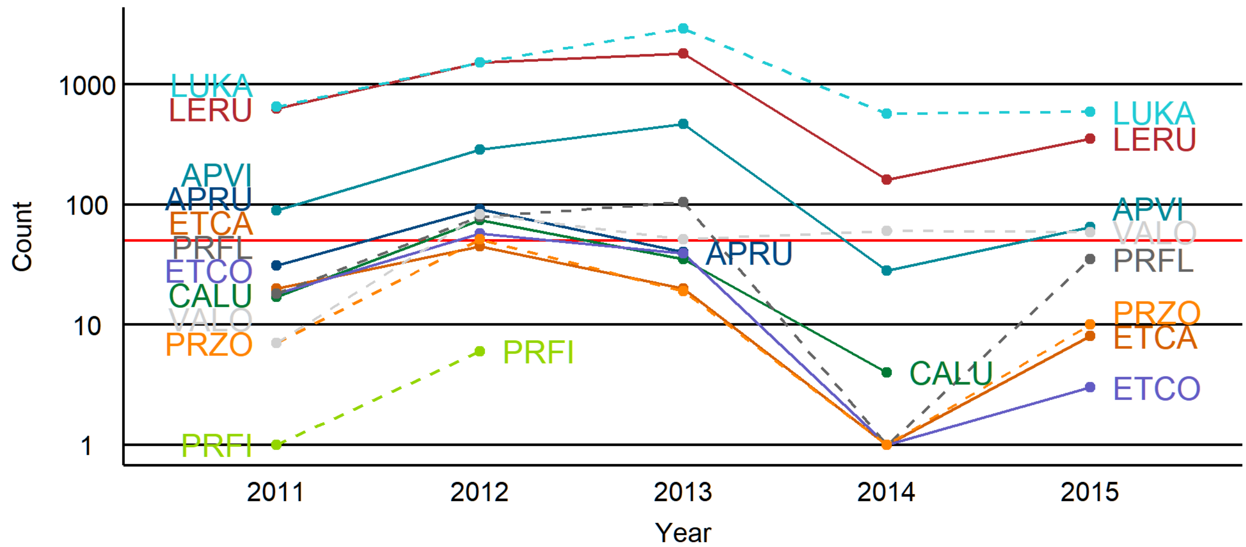

Figure 4-3. Species-specific length observations for their main associated fishing gear by year in the biosampling data set (2011–2015). The red horizontal line represents a rough cut-off point to run length-based analyses (50 observations/year). Species codes are the first two letters of the genus and species name (see Table 1-1).

Given the geographical limitations, the following data analyses are restricted to Tutuila and focused on the main fishing method for each species (i.e., bottomfishing for all species except for *V. louti* where spearfishing is the principal method). Figure 4-3 shows the number of length observations by species for their main fishing method around Tutuila, with a reference cut-off point at 50 observations/year.

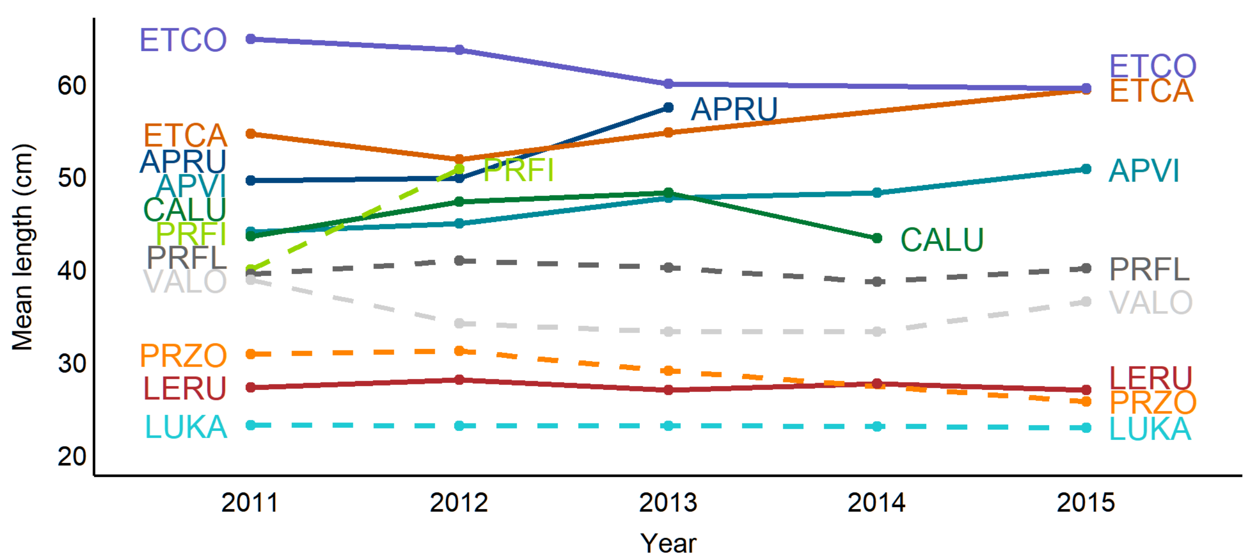

Figure 4-4. Species-specific mean length in the exploited size range for the main fishing gear (bottomfishing for all species except spearfishing for *V. louti*). Species codes are the first two letters of the genus and species name (see Table 1-1).

The average length in the catch is a useful metric that can either be used as a general stock health index or more directly as an input in stock assessment models. Figure 4-4 shows mean lengths by year from the biosampling data set for each BMUS. Unsurprisingly, species with low sample sizes have high year-to-year variability in mean lengths (e.g., *C. lugubris*, *E. carbunculus*, and *P. filamentosus*).

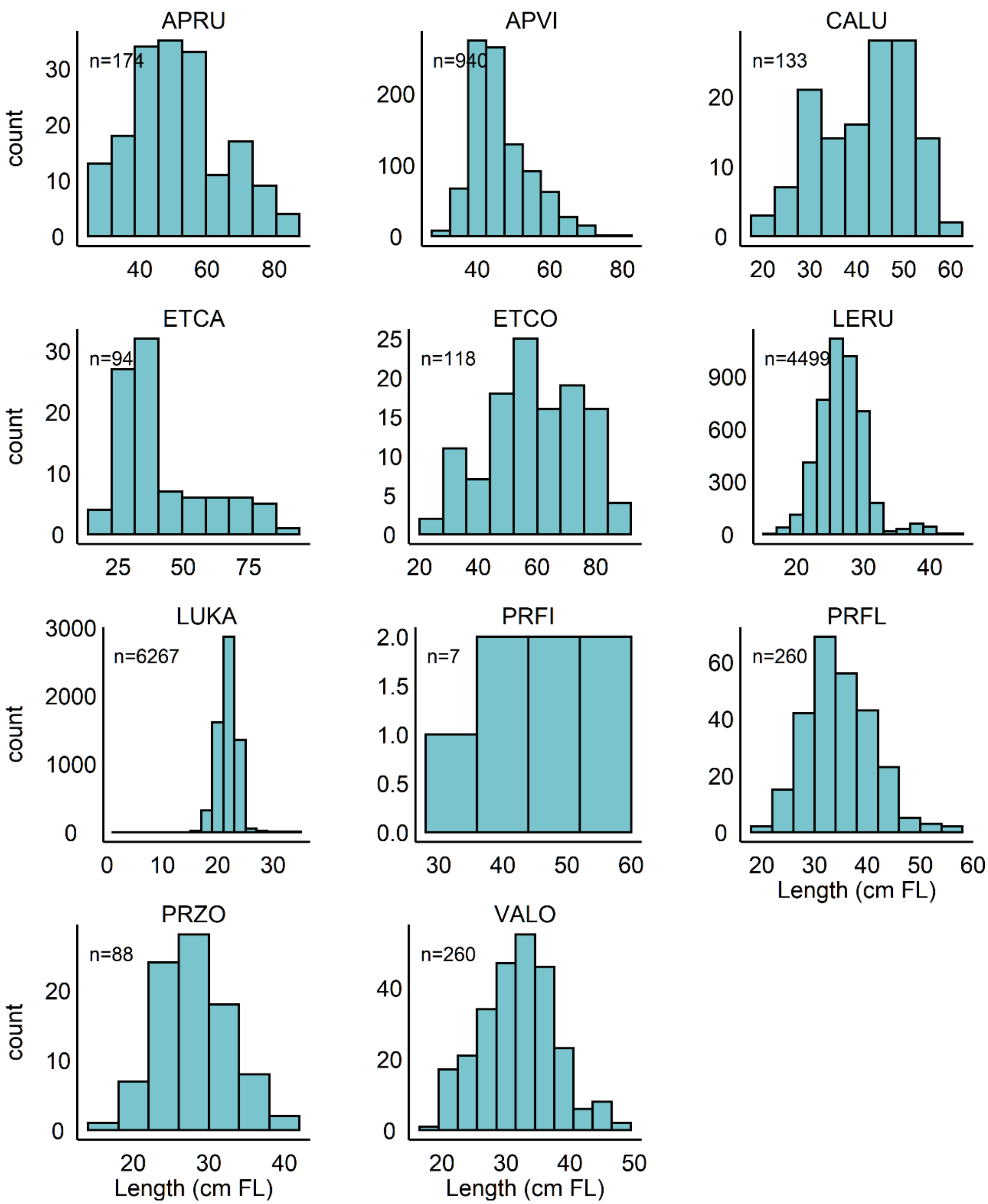

Figure 4-5. Biosampling data size structures around Tutuila for all years combined, using bottomfishing gear. Species codes are the first two letters of the genus and species name (see Table 1-1).

Figure 4-5 shows the size distributions from the biosampling data around Tutuila. All years (2011–2015) were combined to get large enough sample sizes and make the distributions clearer. Only the bottomfishing gear was used to limit gear selectivity effects on the distributions.

A total of 174 lengths were measured for *A. rutilans*. Its size distribution had a mode at around 50 cm and a maximum size slightly higher than 80 cm. Overall, 940 lengths were measured for *A. virescens*. Data were available for all years the biosampling program was operational, but sample sizes were relatively low in 2014 and 2015. Most of the length measurements were concentrated in 2012 and 2013. The length distribution had a mode around 40 cm and a maximum size near 70 cm. *C. lugubris* had a total of 133 lengths in the biosampling data for the bottomfishing gear. Data were available for 2011 to 2014 only, with no length observations for this species in 2015. The size distribution shows a somewhat bi-modal pattern, with modes at around 30 cm and 50 cm, combined with a maximum size around 60 cm.

For all years, 94 lengths were measured for *E. carbunculus*, with data available from 2011 to 2015 (most of the length records are concentrated in the first 3 years). The *E. carbunculus* size distribution showed a clear bi-modal pattern, with modes at around 40 cm and 65 cm, combined with a maximum size around 90 cm. This bi-modal pattern and large maximum size is due to the presence of a second, larger ehu species that was recently described (the giant ruby snapper, *Etelis boweni*; Andrews et al. 2021). The lack of differentiation between *E. carbunculus* and *E. boweni* is a major impediment to length-based assessment for either species.

A total of 118 lengths were measured for *E. coruscans* with data available from 2011 to 2015 (most of the length records are concentrated in the first 3 years). The size distribution shows a typical pattern, with a single mode at around 60 cm and a maximum size around 90 cm. *L. rubrioperculatus* had the second highest number of length measurements in the biosampling BMUS data set, with 4,499 lengths recorded around Tutuila using the bottomfishing gear. Data were available for all years the biosampling program was operational, with lower sample sizes in 2014 and 2015. The shape of the length distribution had a mode at around 27 cm and a maximum size near 35 cm. *L. kasmira* had the highest number of length measurements in the biosampling BMUS data set, with 6,267 lengths recorded. Data were abundant in all years the biosampling program was operational, with the highest sample sizes in 2012 and 2013. The shape of the length distributions had a mode at around 22.5 cm and a maximum size near 27 cm.

P. flavipinnis had 260 lengths with data available for 2011 to 2015, but most of the length records were concentrated in the first 3 years, with almost no measurements in 2014. The size distribution showed a typical pattern, with a single mode at around 33 cm and a maximum size around 60 cm. A total of 88 lengths were measured for *P. zonatus*. Data were available for 2011 to 2015, but most of the length records were concentrated in the first 3 years and there were almost no measurements in 2014. The *P. zonatus* size distribution showed a typical pattern, with a single mode at around 27 cm and a maximum size around 40 cm. Overall, 260 lengths were measured for *V. louti* using the spearfishing gear (the main gear by which they are caught). Data were available for all years the biosampling program was operational, but the sample size were very low in 2011. The shape of the length distributions showed a mode at around 34 cm and a maximum size near 50 cm.

5 Diver surveys

Fisheries-independent data are available from the diver surveys conducted by NOAA Fisheries Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD). These surveys provide both length and abundance data, mainly for nearshore species. Below is a brief description of the survey protocol. An in-depth description is available in Ayotte et al. (2015).

Starting in 2008, trained divers from the PIFSC have been conducting visual surveys around the islands of American Samoa following a stratified random design (some earlier surveys used a limited fixed site design). Survey sites were randomly selected within strata defined by depth bins (shallow, 0–6 m; mid, 6–18 m; and deep, 18–30 m). All coastlines around the archipelago were easily accessible since the survey effort used small boats deployed from a research vessel (Figure 5-1). For practical and safety reasons, surveys were limited to depths above 30 m. During a typical survey day, a NOAA ship deployed 3 to 5 boats with divers that sampled pre-determined random sites along a large section of coastline. The entire island could easily be covered in 2 or 3 deployment days. At each site, stationary fish counts were implemented by 2 paired divers inside contiguous 15-m diameter cylinders that extended from the bottom to the surface (Brandt et al. 2009; Smith et al. 2011; Williams et al. 2011). Divers first listed all observed fish species during an initial 5-minute period and then went through this list, one species at the time, recording number of individuals and estimating sizes of all fish seen within the cylinder. Fish sizes were recorded as total lengths to the nearest cm. Individuals from species not listed during the initial 5-minute period but observed later in the survey were also recorded but classified in a different data category (i.e. non-instantaneous count). Divers were continuously trained between cruises in size estimation using fish cut-outs of various sizes. Diver performance during research cruises was evaluated by comparing size and count estimates between paired divers.

Total numerical density estimates (individuals per 100 m^2) were obtained by dividing fish counts in each survey by the survey area (353 m^2 from two 15-m diameter survey cylinders) and multiplying by 100. An individual survey consisted of the combined fish counts from the 2 divers deployed at a single site. Standard deviations were obtained by bootstrapping the diver survey data set by re-sampling survey sites within sector and applying the weighted mean procedure described above to generate a distribution of mean numerical density.

One clear limitation of this data set is the potential mismatch between the survey domain (limited to 30-m depth) and the greater depth range of certain species. All bottomfish management unit species (BMUS) occur at depths greater than 30 m, with some also inhabiting depths shallower than 30 m.

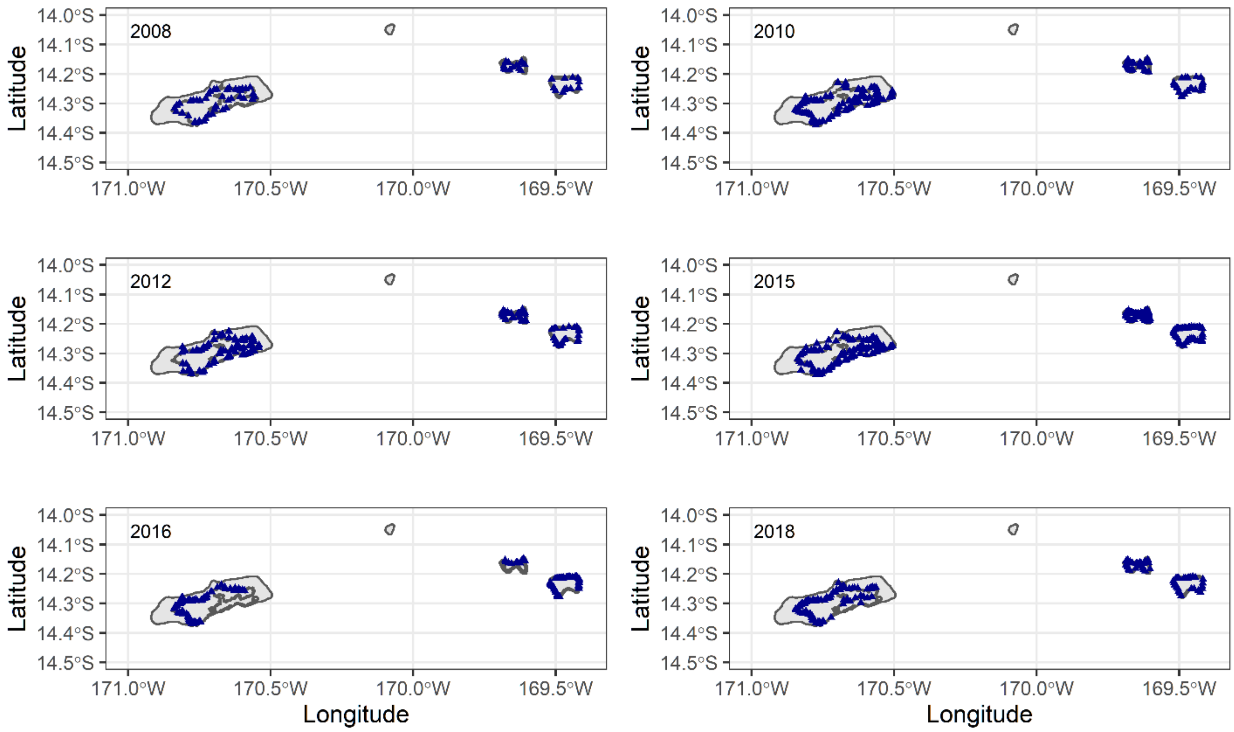

Figure 5-1. Location of diver survey sites in American Samoa, by year.

5.1 Size data

The diver survey data for American Samoa starts in 2002 and ends in 2018, with surveys occurring every 2 years at first and switching to a 3-year schedule after 2012. Further, a new fish counting method (stationary point count or SPC) and a better sampling design was implemented starting in 2008 and we therefore focus the current analyses on the 2008–2018 period. During that time, a total of 2,086 BMUS were recorded in the data set, although exclusively from the 5 nearshore species within that complex (Figure 5-2). Furthermore, nearly 75% of those records come from the Manu'a Islands (none from the banks). Most records were from *L. kasmira*, followed by *V. louti* and *A. virescens*. The other 2 species, *L. rubrioperculatus* and *C. lugubris* were rarely encountered by divers (Figure 5-2).

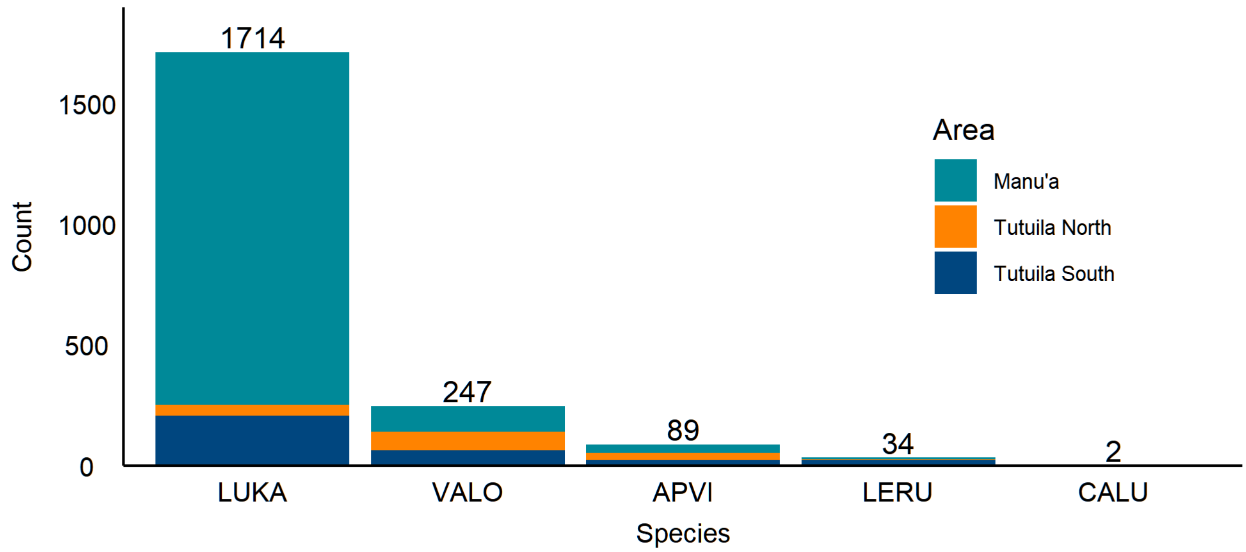

Figure 5-2. Number of observations of BMUS during diver surveys from 2008 to 2018. Species codes are the first two letters of the genus and species name (see Table 1-1).

Figure 5-3 shows the number of length observations by species and year for the Manu‘a Islands and Tutuila, with a reference cut off point at 50 observations/year. This figure suggests that length data would need to be aggregated across years to obtain sufficient sample sizes to be included in an assessment model. *L. kasmira* around the Manu‘a Islands is the only species with a consistently elevated number of size observation per year from diver surveys.

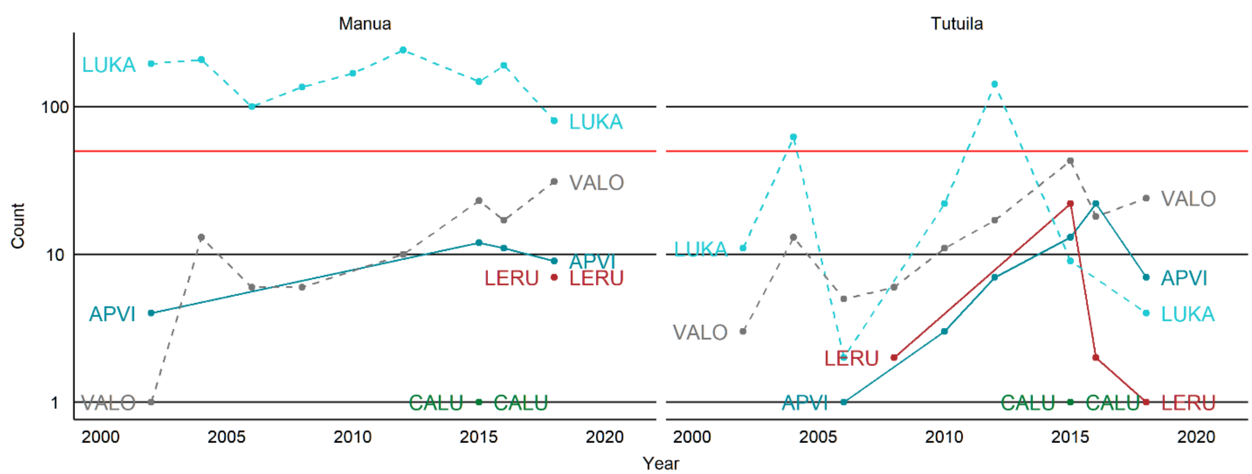

Figure 5-3. Number of observations of BMUS during diver surveys by year for the Manu‘a island group and Tutuila. The red horizontal line represents a rough cut-off point to run length-based analyses (50 observations/year). Species codes are the first two letters of the genus and species name (see Table 1-1).

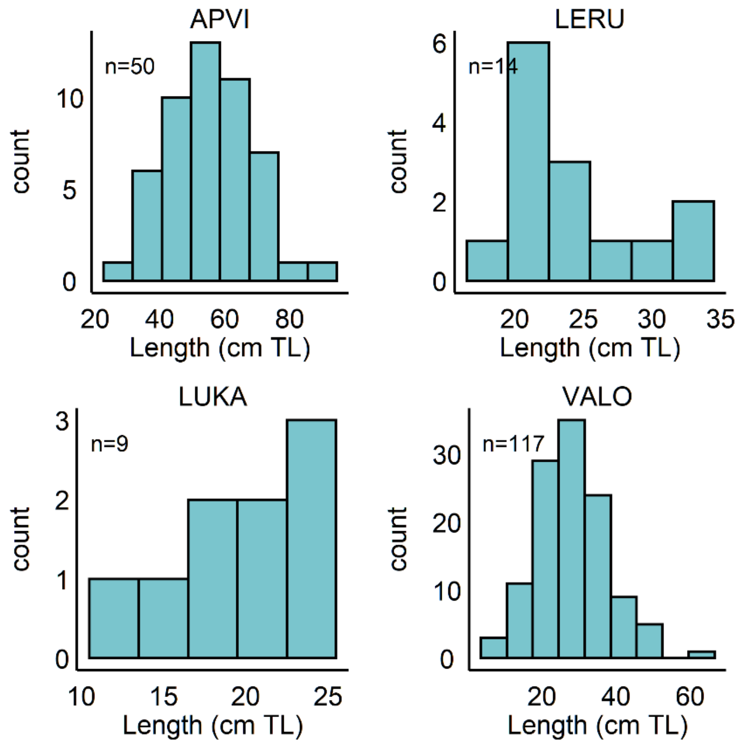

Figure 5-4. Size structures from diver surveys around Tutuila (2008–2018).

Figure 5-4 shows the size distributions from diver observations around Tutuila. All years where the SPC method was implemented (2008–2018) were combined to get large enough sample sizes and make the distributions clearer. Figure 5-5 presents the same observations from the Manu‘a Islands. Species codes are the first two letters of the genus and species name (see Table 1-1).

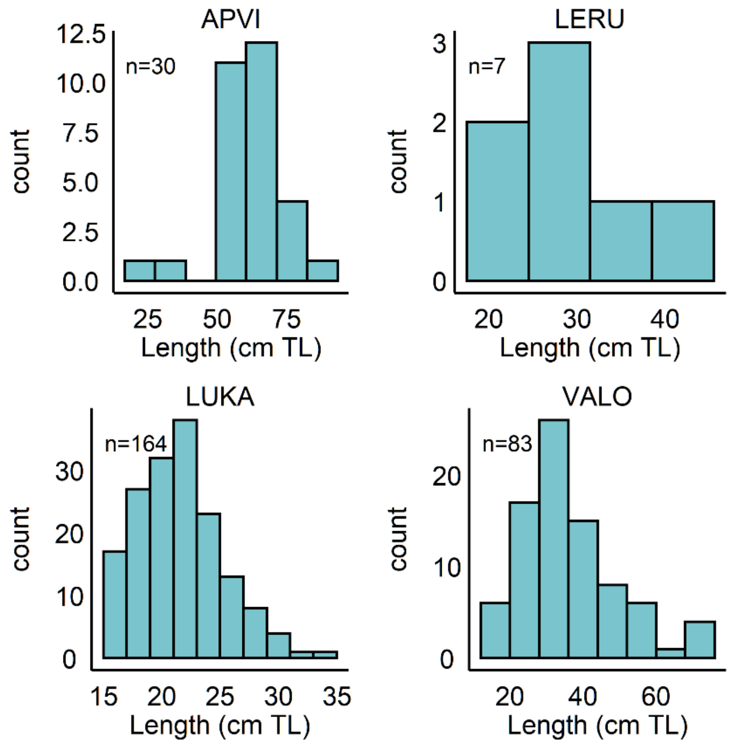

Figure 5-5. Size structures from diver surveys around the Manu‘a Islands (2008–2018). Species codes are the first two letters of the genus and species name (see Table 1-1).

A total of 50 lengths were measured for *A*. *virescens* around Tutuila from diver surveys while 30 lengths were recorded around the Manu‘a Islands. Both length distribution showed a typical pattern, with a single mode at around 60 cm and a maximum size around 90 cm. Overall, divers recorded only 18 length measurements for *L*. *rubrioperculatus* around Tutuila and 7 around the Manu‘a Islands. The low sample sizes for both regions makes it impossible to infer anything from diver length distributions for this species.

Overall, divers recorded only 9 individual length measurements for *L*. *kasmira* around Tutuila between 2008 and 2018, while they recorded 164 lengths around the Manu‘a Islands. The Manu‘a Islands size distribution shows a bi-modal pattern, with a mode at around 17.5 cm and another one around 24 cm. Finally, a total of 117 lengths were measured for *V*. *louti* around Tutuila and another 83 were recorded from the Manu‘a Islands.

5.2 Abundance index

Fish counts from diver surveys can be used as a fishery-independent index of abundance, in a similar fashion as CPUE. In fact, since diver surveys implement a controlled fish count method using trained divers, they do not necessarily need to be standardized to remove the effects of non-abundance related variables. The main weakness of these surveys in relation to BMUS is that they are limited to 30-m depths, which is outside the depth range of most BMUS and only covers a fraction of the habitat for a few of them.

Overall, 5 bottomfish species were observed by divers around American Samoa (*A. virescens, C. lugubris, L. rubrioperculatus, L. kasmira,* and *V. louti*). However, *C. lugubris* was only observed twice and is therefore not further discussed in this section. Of the other 4 species, *L. kasmira* and *V. louti* were most often observed by divers, with *L. kasmira* recorded on 37% of surveys around the Manu'a Islands (but only 2% of surveys around Tutuila) and *V. louti* recorded on about 12% of surveys in both regions (Figure 5-6). *A. virescens* was recorded on 4% of surveys in both regions, while *L. rubrioperculatus* was only seen on 1% of surveys in American Samoa.

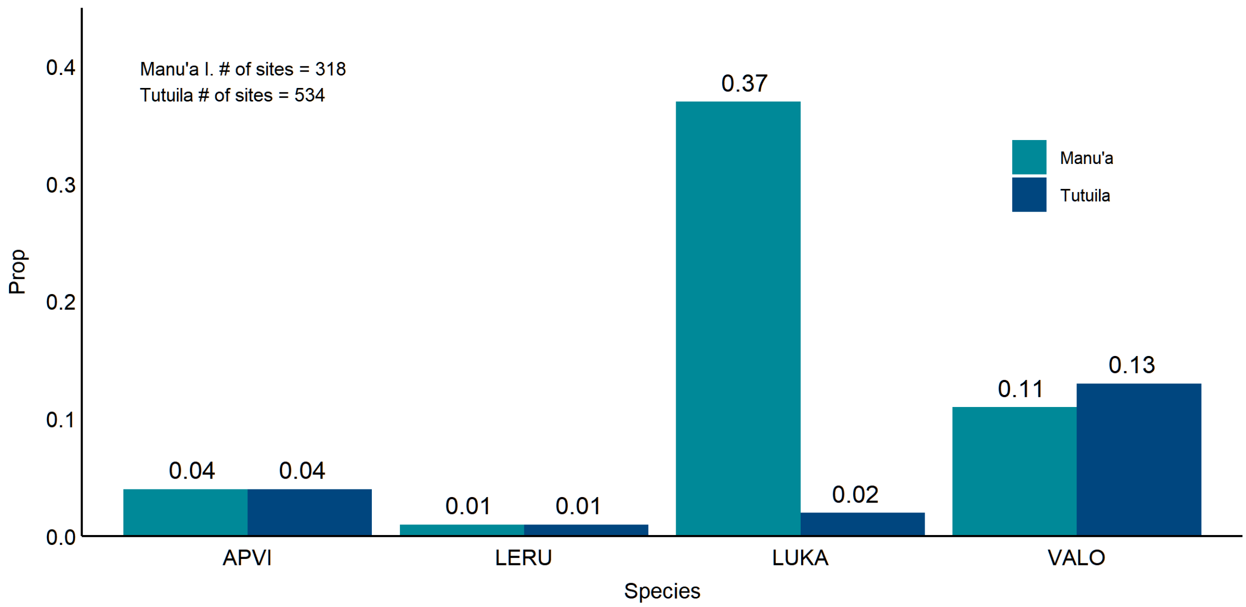

Figure 5-6. Proportion of diver survey sites with a positive species sighting for the Manu'a Islands and Tutuila. The number of the bars show the proportion. Species codes are the first two letters of the genus and species name (see Table 1-1).

The resulting coefficients of variation (CVs) for the diver abundance indexes are presented in Figure 5-7 (Tutuila) and Figure 5-8 (Manu‘a Islands). For most BMUS, the CVs were around 0.5 for most years, which is relatively high.

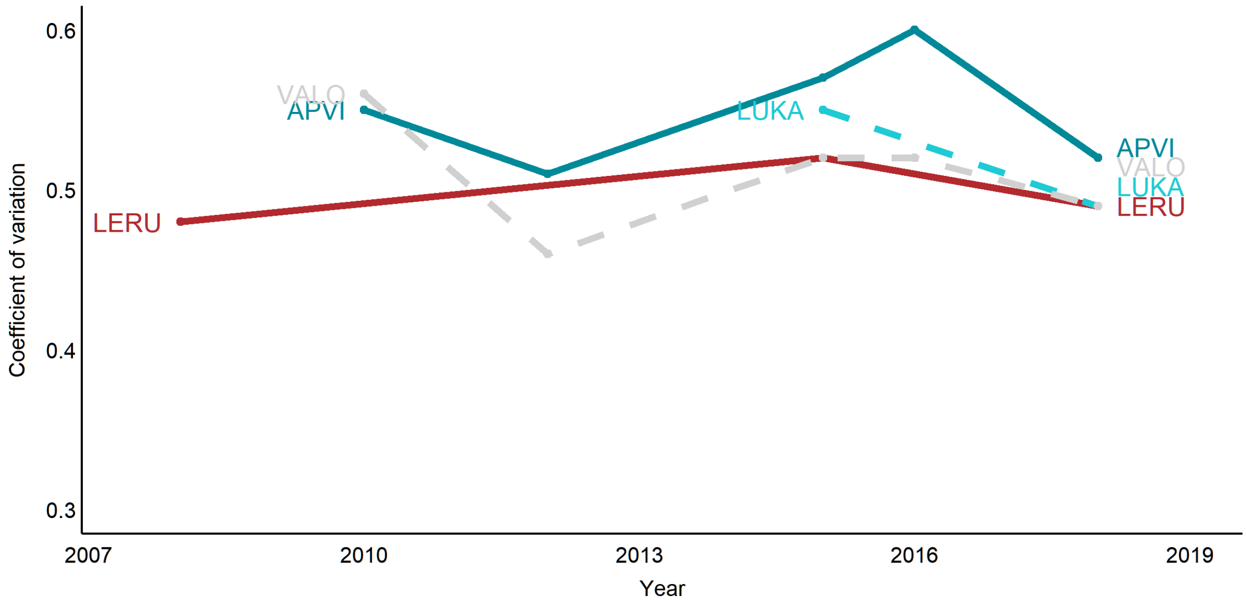

Figure 5-7. Coefficient of variation of abundance index from diver surveys around Tutuila by species. Species codes are the first two letters of the genus and species name (see Table 1-1).

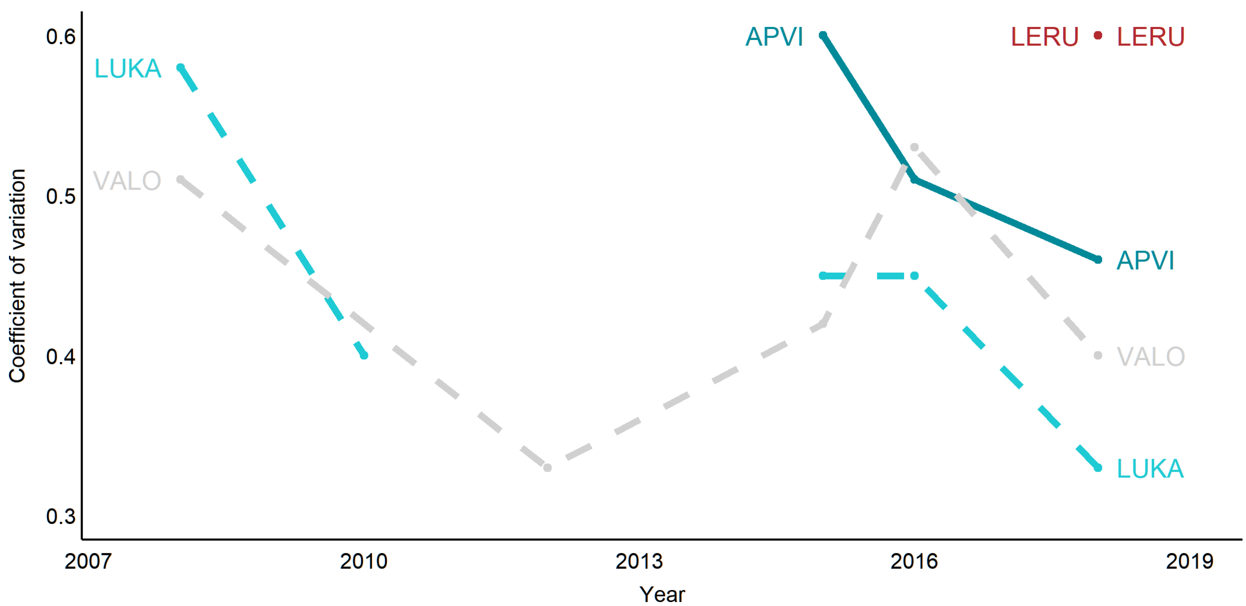

Figure 5-8. Coefficient of variation of abundance index from diver surveys around the Manu‘a Islands by species. Species codes are the first two letters of the genus and species name (see Table 1-1).

6 Commercial Purchase Program

Starting in 1990, the American Samoa government made it mandatory for local vendors to participate in this monitoring program. The American Samoa Department of Marine and Wildlife Resources (DMWR) issues numbered books of Fish and Shellfish Receipt forms to all wholesale buyers of fish who resell fish to the retail market, either whole or prepared. This receipt has evolved over time to include fish sales imported by local businesses from other islands such as Tonga or Western Samoa. Vendors are required to complete an invoice for each purchase and record the fisher (or boat) selling the fish, along with the species category, method used, weight, and price for the fish purchased. Invoices are submitted to DMWR staff who enter the data into the data processing system. The fishing activities occur close to the island of Tutuila as most of the boats that sell fish locally are small.

The commercial purchase data set for American Samoa contained information on the day of sale, an identifier of the seller, the fishing method used, species name and corresponding catch, and area fished, but lacked information on effort. Although many pertinent fields were available, not all values for each record were filled in, and information useful for standardizing catch per unit effort (CPUE) was missing from roughly 10–50% of records, depending on the field. Given the limited information in pertinent fields, as well as uncertainty around the proportion of catch that is sold or reported in the commercial purchase data set, it is likely not possible to use commercial purchase data for CPUE calculations. However, commercial purchase data also contains information on total weight in pounds, which could be used to obtain either weight frequencies or mean weight timeseries. The following section explores this possibility.

6.1 Size frequency

Commercial purchase data have been collected since 1990, opening the possibility for a size frequency timeseries from this data set, after accounting for potential market selectivity issues. Overall, 3,663 reports were made between the years 1990 and 2020 containing bottomfish management unit species (BMUS). However, 2,002 of these reports concerned either resales (i.e., fish already included in a previous report) or imported fish, which needed to be filtered out. This left 1,661 reports to be considered. Further, few reports contained information on the number of pieces caught (*Num_Pieces* field), which is crucial to convert the total reported weight sold (*Lbs_Sold* field) into either a mean weight (*Lbs_Sold* / *Num_Pieces*) or an individual weight (*Lbs_Sold* when *Num_Pieces* = 1). The top left panel on Figure 6-1 shows that 828 out of the 1,661 commercial purchases containing BMUS did not report the number of pieces, for the 1990–2020 period (50% of the total). It also shows that only 67 reports contained individual fish measurements (*Num_Pieces* = 1), which would preclude using this data set to generate size frequencies. However, 766 reports could be used to generate a mean weight timeseries. Another potential issue with this data set is that only 29% of receipts specified the area where the fish were caught (top right panel; Figure 6-1). Of the remaining reports, 91% are for fish caught around Tutuila (for recent years, all reports are from Tutuila).

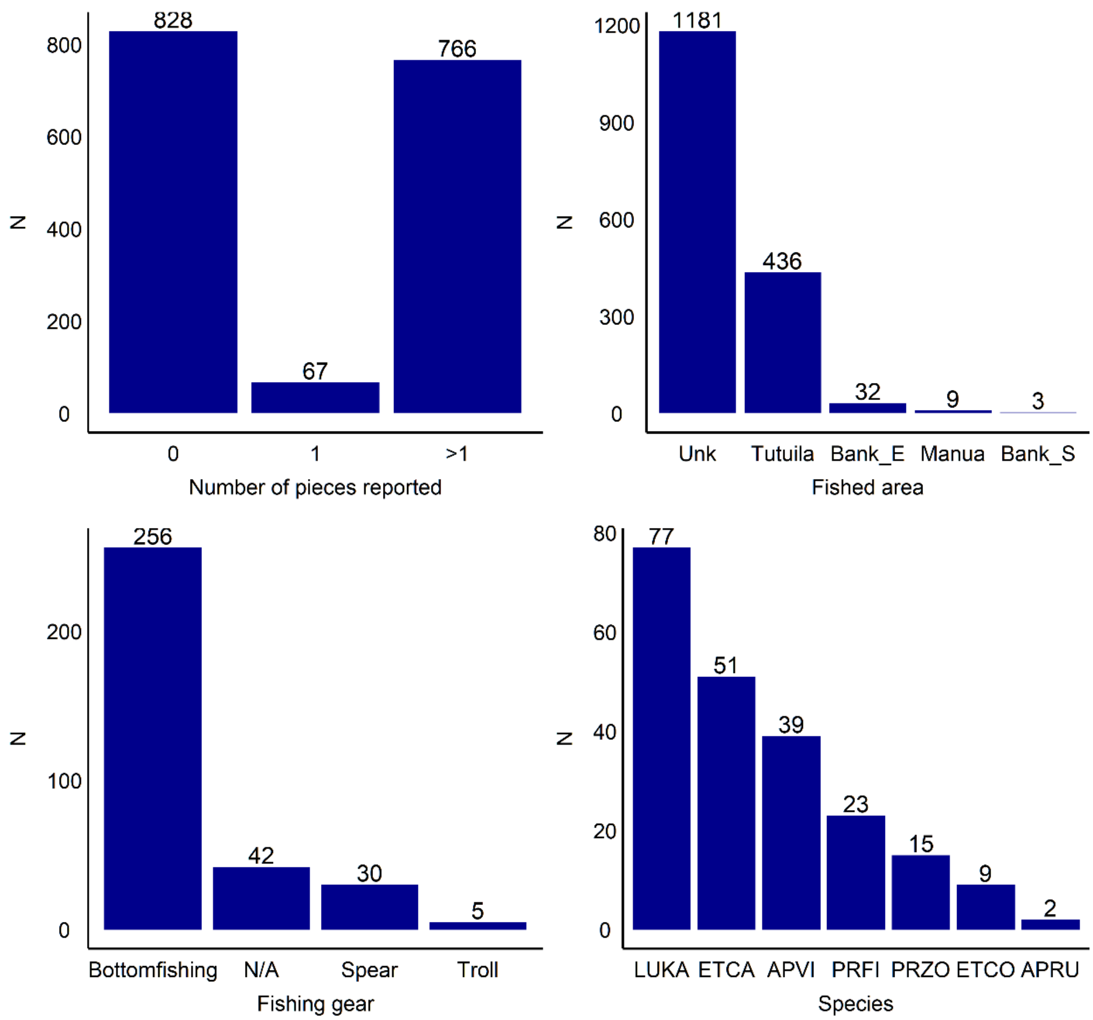

Figure 6-1. Number of dealer reports in various categories. The top left panel shows the number of reports with no fish count information (0), 1 fish reported (1), or more than 1 fish reported from 1990 to 2020. The top right panel shows the number of reports by area for the entire timeseries (1990–2020). The bottom left panel shows the number of reports by fishing gear (2010–2020) and the bottom right panel shows the number of reports by species where the number of fish reported was known (# of pieces > 0), from 2010 to 2020. Species codes are the first two letters of the genus and species name (see Table 1-1).

The numbers presented in Figure 6-1 suggest that it would not be possible to obtain weight frequencies from commercial purchases, but that a timeseries of mean weights for Tutuila may still be available. However, plotting the number of receipts by year and species shows that most years would have less than 10 mean weight observations (Figure 6-2). This leaves the option of simply aggregating mean weight observations across years for the 2010–2020 period. This could be sufficient to obtain a mean weight estimate for *L. kasmira* ($N = 77$), *E. carbunculus* ($N = 51$), and *Aprion virescens* ($N = 39$), but these data are likely insufficient to estimate mean weight of the other BMUS in this data set (Figure 6-1). As for other data sets, *E. carbunculus* commercial receipt size data would also suffer from being confounded with the newly described cryptic species *E. boweni*.

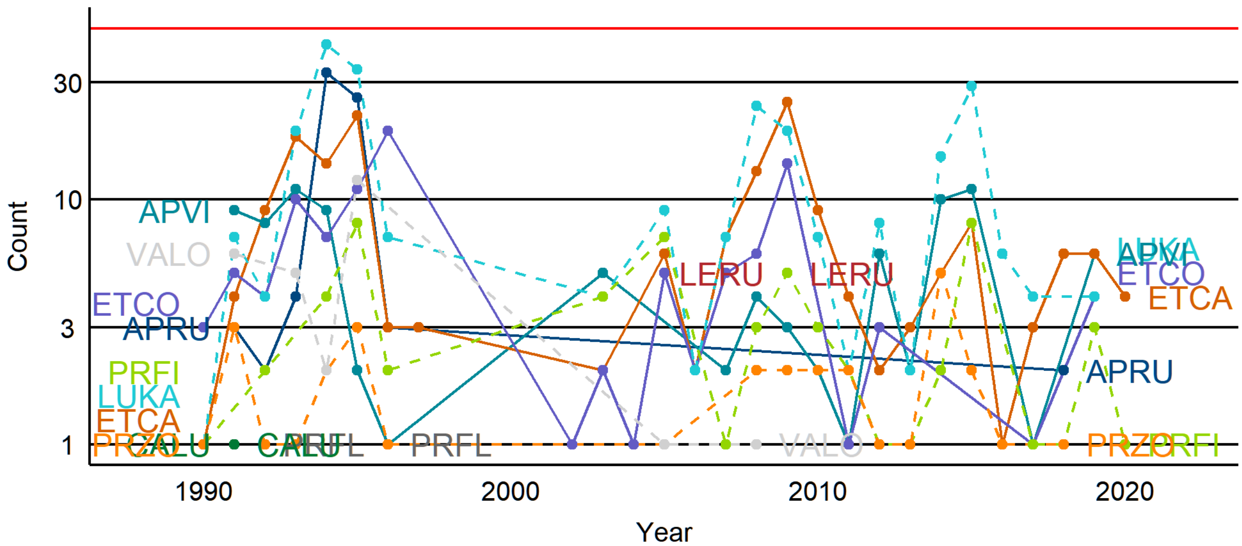

Figure 6-2. Number of commercial purchases with known number of pieces sold, by species. Species codes are the first two letters of the genus and species name (see Table 1-1).

7 Historical catch information

Fishing for bottomfishes in American Samoa was entirely non-commercial and performed close to shore using traditional canoes and techniques prior to the 1970 (Marr 1961; Itano 1996a, 1996b; Levine & Allen 2009b). There are no quantitative estimates of these subsistence landings, however, based on historical accounts and archaeological evidence, harvests of bottomfish management unit species (BMUS) were likely small and limited to the more shallow, near-reef species of Carangidae, Lethrinidae, and Lutjanidae (Nagaoka 1993; Herdrich & Armstrong 2008). During 1967–1970, the Government of American Samoa Office of Marine Resources, funded by U.S. Bureau of Commercial Fisheries Federal Aid Program, conducted an exploratory fishing survey of the ledges around Tutuila aboard the 33-foot fiberglass vessel *Tautai A'e*. Species composition and catch rates of bottomfishes suggested a small-scale local commercial bottomfish fishery would be viable (Ralston 1979). Since the commencement of the Dory Program in 1971, a succession of government-sponsored programs have been conducted in American Samoa to develop the local bottomfish fishery by providing boats, diversifying fishing practices, training fishermen, improving technology, providing hydrographic charts, and supporting the marketing and transport of bottomfishes to commercial buyers (Itano 1996a, 1996b).

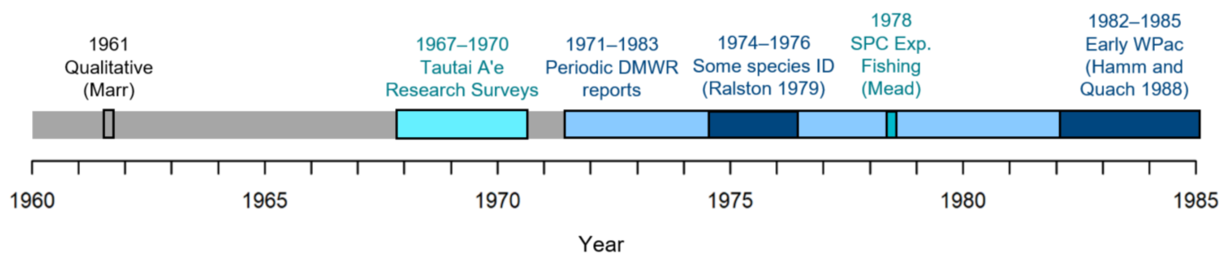

Figure 7-1. Timeline of American Samoa bottomfish fishery development and research projects with associated data collection efforts.

Many of the fishery development and research programs in the 1960s through early 1980s had associated data collection efforts that may provide early estimates of BMUS landings and fishery effort (Figure 7-1). A bibliography with citations to reports, indicating which documents have not yet been located, is included in Table 7-1. A partial count of the number of boats, trips, and total bottomfish landings for small boats in Pago Pago were routinely conducted by the American Samoa Office of Marine Resources from 1971 to 1983. However, many of the data records and regular reports summarizing these findings may have only existed in paper format and may be lost. "Statistical Analysis of American Samoa's Fisheries," a report by the Office of Marine Resources covering July 1, 1973 to June 30, 1976, reported monthly bottomfish landings for 6–12 participating dories each year, averaging 5174 lb per month, totaling 186,255 lb over the reporting timeframe (Figure 7-2; (Government of American Samoa Office of Marine Resources 1976). The report did not include any information on the species composition of the catch, however, a 1979 report to the Western Pacific Regional Fisheries Management Council (Ralston 1979) reported *Lutjanus kasmira* and *Lethrinus* sp. together represented the majority of the catch (Table 7-2). In addition, Ralston (1979) reported estimated bottomfish landings, the number of boats reporting catch, and the number of bottomfish trips, annually, for the July to June fiscal years beginning 1971–1976 (Figure 7-2). The Pacific Islands Fisheries Science

Center (PIFSC) Western Pacific Fishery Information Network (WPacFIN) began assisting American Samoa Office of Marine Resources in 1981 with data collection, processing, and reporting of commercial bottomfish landings, including some species composition information (Hamm & Kassman 1986; Hamm & Quach 1988). From 1982–1985, total bottomfish landings averaged 95,000 lb/year (Figure 7-2). The majority (78%) of bottomfish catch was unidentified at the species level (Figure 7-3), and of the identified BMUS, catches were highly variable between years, with *Etelis carbunculus* and *Etelis coruscans* being the most often identified (Figure 7-4). Estimates of bottomfish landings between July 1977 and the commencement of WPacFIN reporting in the calendar year 1982 remain elusive.

The 1972 report containing details on the *Tautai A'e* survey, which may contain catch by species, has not been located (Table 7-1). However, Ralston (1979) reported 104 bottomfishing trips of the *Tautai A'e* between September 1967 and March 1969 yielded 31,705 lb total bottomfish catch, and catch rates varied from 7.8 to 10.7 lb per line × hour, depending on location around Tutuila. It is possible this catch estimate represents the great majority of total catch of bottomfishes from 1967 to 1969, and is included in the timeseries of estimated landings (Figure 7-2). Ralston (1979) also note that *Lutjanus bohar* was "one of the most abundant species caught" but it was excluded from all analyses because this species is associated with ciguatera poisoning in American Samoa. Of the remainder of the catch, *Lethrinus* spp. and *Lutjanus gibbus* comprised 22.3% and 19.2%, respectively, by weight. *L. kasmira*, groupers, jacks, and *Gymnosarda unicolor* were noted as “species of importance.”.

From April 12 to June 31 (*sic*) 1978, Southern Pacific Commission (SPC) Master Fisherman Paul Mead conducted 36 experimental bottomfishing trips around Tutuila on two local fishing dories as part of the SPC Deep Sea Fisheries Development Project. A primary objective of the project was to introduce new gears and fishing methods to the fishery, including the Western Samoan type hand reel, which soon replaced the handline (Mead 1978). Mead (1978) identified the majority of fish caught to species and reported total weights and numbers. Total bottomfish catch during the project, which occurred during the fiscal year beginning in 1977 when total landings estimates from the Office of Marine Resources are not available, was reported as 3,378 lb. The dominant species in the catch, by weight, were: *E. coruscans* (28.0%, identified as *Etelis oculatus* within the report), unidentified emperors (20.6%), *E. carbunculus* (18.5%), *L. bohar* (10.5%), and *A. virescens* (4.6%).

By 1986, the American Samoa Department of Marine and Wildlife Resources (DMWR) Boat-based Creel Survey Program (BBS) was fully operational and served as the primary source for fisheries data from 1986–2019. Based on the history of the fishery, and the published reports available, it is clear the BMUS stocks sustained considerable exploitation and produced large harvests in the years before the BBS began. We present these data here in order to represent as accurately as possible the history of the resource.

Table 7-1. A partial bibliography of pre-1986 American Samoa bottomfish fishery information.

Citation	Description / Comments
Seeking Documents	
Swerdloff, S.N. 1972. A determination of the feasibility of developing off-shore commercial fishing in American Samoa. Completion Report H-8-D, Gov. Amer. Samoa. 14 pp.	*Tautai A'e* research surveys: catch (by species?) and survey effort, September 1967 – June 1970. Bureau of Commercial Fisheries Federal Aid Program June 1968, Project H-8-D awarded to James R. Holloway, Sr.
Wass Reports: "Statistical analysis of American Samoa's fisheries". Project H-18-D-2.	Landings (?), July 1971 – Jun 1973 for dories reporting. May contain species composition and nominal catch rates. Annual reports by R.C. Wass (1972, 1973). Similar project numbers to Bureau of Commercial Fisheries Federal Aid Program. Author may be listed simply as "Government of American Samoa Office of Marine Resources".
Wass Reports: "Statistical analysis of American Samoa's fisheries". Project 4-36-D (-2,-3,-4).	Landings, July 1976 – September 1980. May contain species composition and nominal catch rates. Annual reports by R.C. Wass (1977–1980). All of these reports of the Dory Program catches were funded by the Dingell-Johnson Wallop-Breaux (*a.k.a.* Federal Aid in Sport Fish Restoration) program and were submitted regularly to the U.S. Fish and Wildlife Service (FWS). U.S. FWS does not have copies of any of these reports.
Wass, R.C. 1982. Statistical analysis of American Samoa's fisheries. October 1, 1980 – September 30, 1981. Office of Marine Resources.	Landings (?), October 1980 – September 1981. Unknown project number.
Wass, R.C. and F. Aitaoto. 1983. Status of the domestic commercial fishery in American Samoa. Fiscal Years 1982 and 1983 (October 1, 1981 – September 30, 1983). Office of Marine Resources Annual Report. 18 pp.	Landings (?), October 1981 – September 1983. Unknown project number.

Citation	Description / Comments
Documents in Hand	
Marr, J.C. 1961 or 1962(?). Report on the possibility of increasing fishery production in American Samoa. Bureau of Commercial Fisheries, Honolulu Biological Laboratory. 27 pp.	Qualitative description of American Samoa fisheries (nearshore from canoes only). Suggests government support for a commercial fishery using the Oregon dory.
Swerdloff, S.N. and Yano, S. 1970. Status of the industry, American Samoa. Office of Marine Resources, Government of American Samoa. CONCOM/1/70/WP.6 Appendix IX.	Qualitative description for fisheries other than commercial longline in 1970, “Substantial subsistence – amount unknown.”
Wass Reports: "Statistical analysis of American Samoa’s fisheries". Project 4-26-D.	Landings, July 1973 – June 1976 for dories reporting. May contain species composition and nominal catch rates.
Ralston, S. 1979. A description of the bottomfish fisheries of Hawaii, American Samoa, Guam, and the Northern Marianas. Draft Report to the Western Pacific Regional Fisheries Management Council. 103 pp.	Total estimated landings and fishing effort, July 1971 – June 1977. Species composition of landings, 1974 – 1975 and 1975 – 1976. Tautai A'e research surveys total catch and catch rates, September 1967 – June 1970.
Swerdloff, S.N. 1973. Current fisheries projects in American Samoa. In: Sixth Technical Meeting on Fisheries Suva, Fiji, 23 – 27 July 1973. SPC/Fisheries 6/WP.5. 4 pp.	Total estimated landings from the Dory Project, 1971 – May 1973.
Office of Samoan Information. 1973. Fisheries Training Course for American Samoa. South Pacific Bulletin, Second Quarter, 1973. pp. 32-34.	Qualitative description of the “American Samoan Project” (Dory Project), 1971–1973, funded by the U.S. Office of Economic Opportunity. Total participation, overall catch rates.
Government of American Samoa Office of Marine Resources. 1976. Statistical Analysis of American Samoa's Fisheries Final Report. Project No. 4-26-D American Samoa, July 1, 1973 − June 30, 1976.	Reported landings, effort, and catch rates (aggregate bottomfish) by month for dories from Pago Pago, July 1973 – June 1976.
Mead, P. 1978. Report on the South Pacific Commission Deep Sea Fisheries Development Project in American Samoa (28 March – 2 July 1978). South Pacific Com- mission, Noumea, New Caledonia. 13 pp.	36 bottomfishing trips catch rates by species, April – June 1978.

Citation	Description / Comments
Howell, R.M. 1983. Air-shipping of fresh fish from American Samoa to markets in Hawaii. In: South Pacific Commission Fifteenth Regional Technical Meeting on Fisheries, Noumea, New Caledonia, 1 – 5 August 1983. 5 pp.	Exports of bottomfish to Honolulu fish auction by species, September 1982 – May 1983.
Hamm, D.C. and M.M.C. Quach. 1988. Bottom fish fisheries of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. Southwest Fisheries Center Administrative Report H-88-15. National Marine Fisheries Service, NOAA, Honolulu, Hawaii. 77 pp.	Estimated landings by species, 1982 – 1987. See also "Fishery Statistics of the Western Pacific" volumes I and III (Southwest Fisheries Center Administrative Reports H-86-4 and H-88-4 which contain the same data, but broken down by month).
Moffitt, R.B. 1989. Analysis of the depletion of bottom fishes at 2% Bank, American Samoa. Manuscript Report File MRF-002-89H. Southwest Fisheries Center Honolulu Laboratory. National Marine Fisheries Service, NOAA, Honolulu, Hawaii. 3 pp.	Depletion-based estimates of total biomass of onaga and ehu on 2% Bank. Dory CPUE in lb per man-trip provided for aggregate bottomfish, Aunu'u (1974 − 1978) and Taputapu (1974 − 1976).
Moana A. and L. Chapman. 1998. Unpublished Report No. 13. Report of second visit to American Samoa (3 February – 13 June 1988). Deep Sea Fisheries Development Project, South Pacific Commission, Noumea, New Caledonia. 33 pp.	6 bottomfishing trips catch rates by species, March – July 1988.
Itano, D.G. 1996. The development of small-scale fisheries for bottomfish in American Samoa (1961-1987). In: SPC Fisheries Newsletter 76:28-32 (part I) and 77:34-44 (part II).	Provides a narrative of the American Samoa bottomfish fishery 1961 – 1987, including some data on fleet size, landings, and catch rates with citations to original sources.

Table 7-2. Species composition of recorded catch by fiscal year from July 1974 to June 1976. Reproduced from Ralston (1979) Table II-2. Species level BMUS data is indicated with an asterik.

Species	% of Recorded Catch
July 1974 − June 1975	
**Lutjanus kasmira*	31
Lethrinus sp.	23
Lutjanus gibbus	16
Etelis spp. and *Pristipomoides* spp.	10
Misc	21
July 1975 − June 1976	
**Lutjanus kasmira*	30
Lethrinus sp.	30
Lutjanus gibbus	18
Etelis spp. and *Pristipomoides* spp.	5
**Aprion virescens*	3
Groupers (*Epinephelus* spp. and *Cephalopholis* spp.)	3
Squirrelfishes	1
Jacks (*Caranx* spp. and *Carangoides* spp.)	3
Others	8

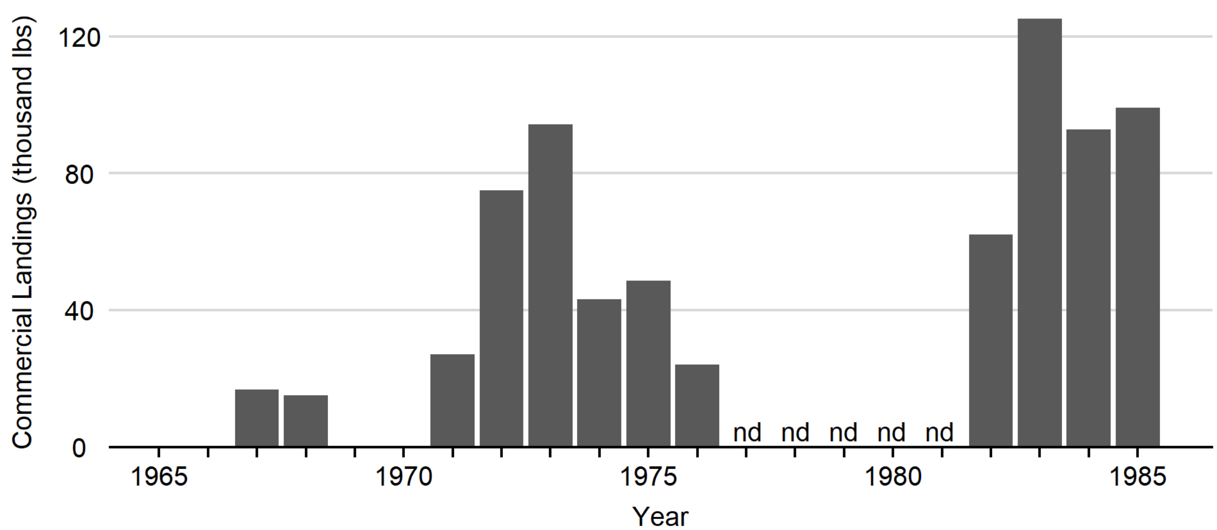

Figure 7-2. Estimated total bottomfish landings, thousands of lb, 1967–1985. Data from Government of American Samoa Office of Marine Resources (1976); Ralston (1979); Hamm and Quach (1988). Catches in 1967–1976 are for the fiscal year beginning in July, and 1982–1985 are for the calendar year. Total reported catch from the *Tautai A'e* survey September 1967–March 1969 was divided among years assuming an average catch of 1670 lb per month.

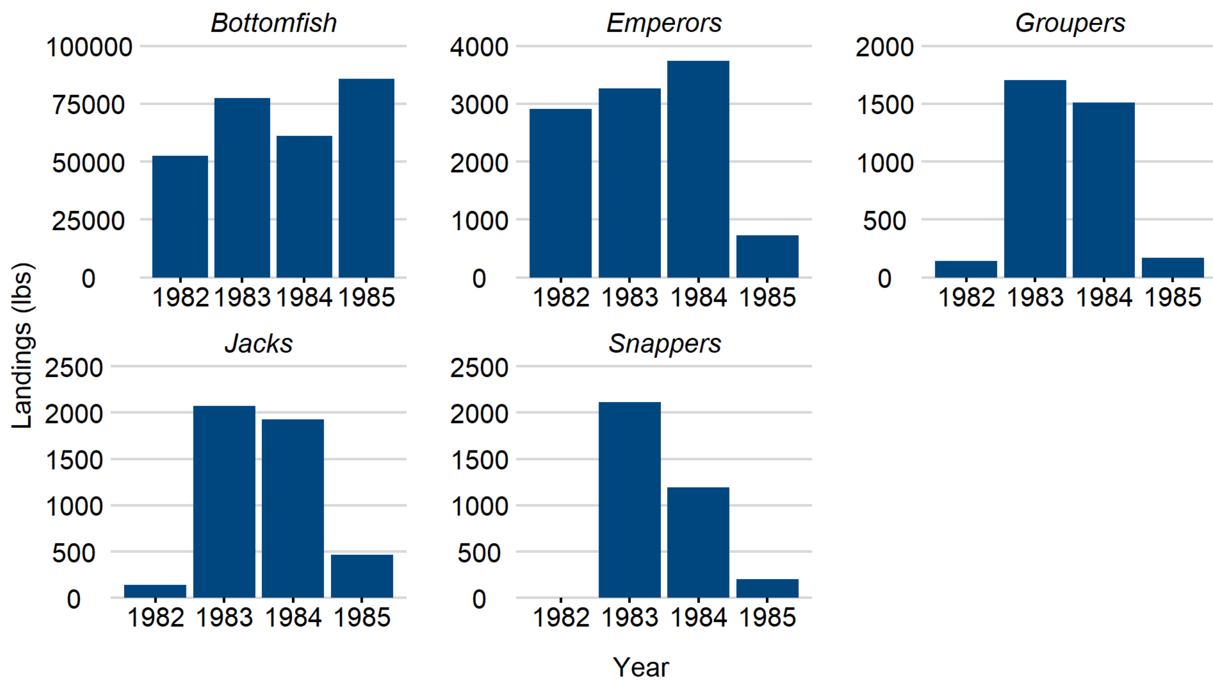

Figure 7-3. Landings by species groups which might include unidentified BMUS, as reported by WPacFIN, 1982–1985 (Hamm and Kassman 1986; Hamm and Quach 1988).

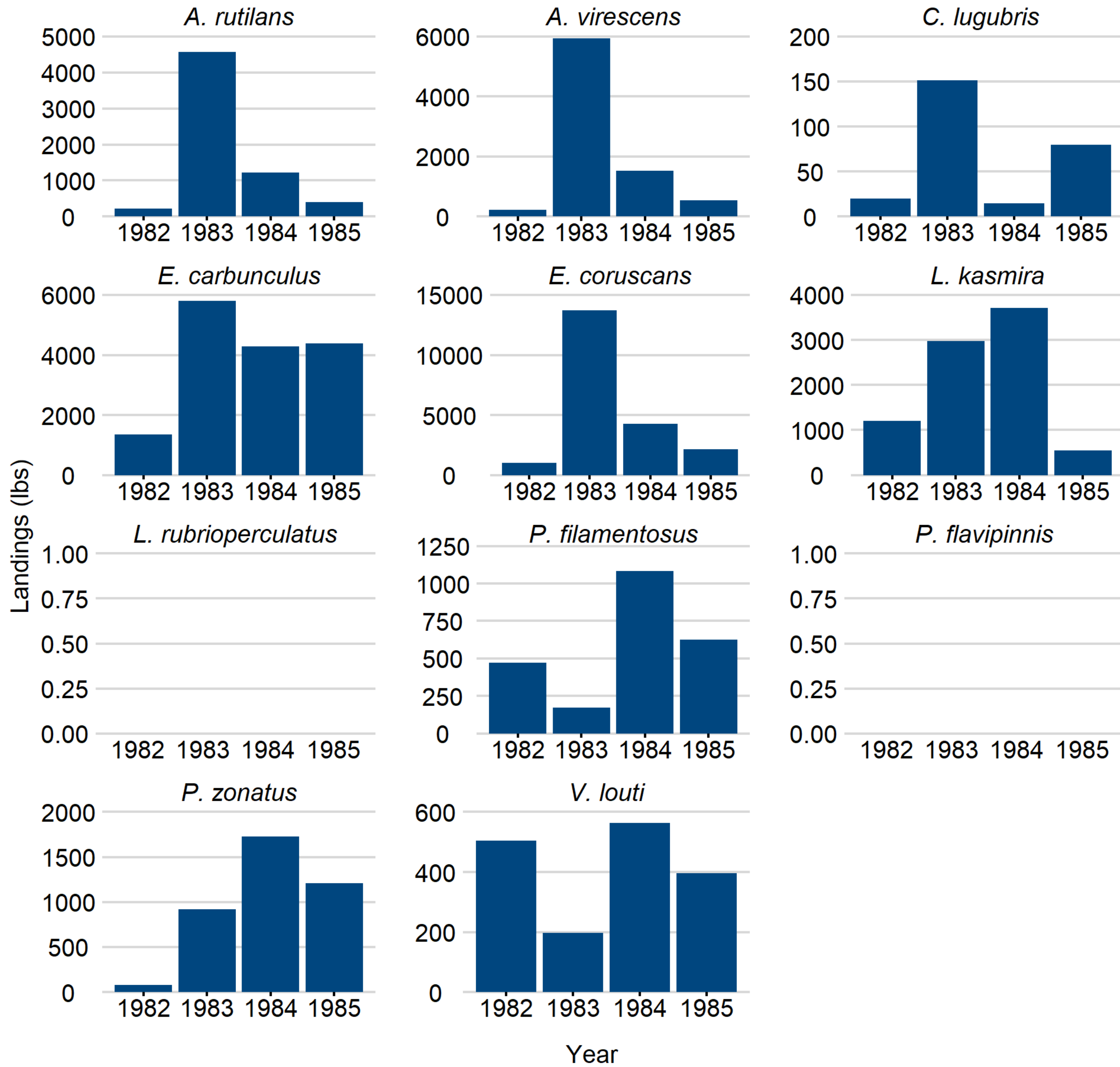

Figure 7-4. Landings of identified BMUS, as reported by WPacFIN, 1982–1985 (Hamm and Kassman 1986; Hamm and Quach 1988).

8 Summary

Since 2007, the NOAA Fisheries Pacific Islands Fisheries Science Center (PIFSC) Stock Assessment Program has conducted regular assessments of the American Samoa Bottomfish Management Unit Species (BMUS). The 2007 benchmark assessment first implemented a Bayesian surplus-production model which directly estimated maximum sustainable yield (MSY)-based reference points, as well as biomass and fishing mortality trajectories (Moffitt et al. 2007). This surplus-production model used estimated annual landings and a nominal catch-per-unit-effort (CPUE) index from the boat- and shore-based creel surveys. The 2007 benchmark assessment was updated with more recent data in 2012 and 2016 (Brodziak et al. 2012; Yau et al. 2016). In 2019, a new BMUS benchmark assessment was implemented also using a Bayesian surplus-production model but introducing a new software (JABBA), a standardized CPUE index from boat-based creel surveys, and an improved way of defining BMUS targeting trips (Langseth et al. 2019). All these assessments were conducted at the BMUS-complex level, with no species-specific information.

Following the 2019 assessment, the PIFSC stock assessment program began exploring the data available in American Samoa to identify the next steps in improving BMUS stock assessments. The current report is a key piece in this effort. One important improvement would be to split the BMUS complex into individual species. Moving to species-level assessments opens the possibility of implementing data-limited and data-moderate age-structure models that can use weight and/or length observations collected by various programs in American Samoa. Integrated stock assessment models can also use CPUE and catch data in combination with size data, when available. Figure 8-1 shows the 3 main categories of data that inform most stock assessment models with their sources in American Samoa (catch and CPUE timeseries, size composition, and life history data). Inside the different circles representing these data sources are the types of assessment models that can be implemented depending on the available data.

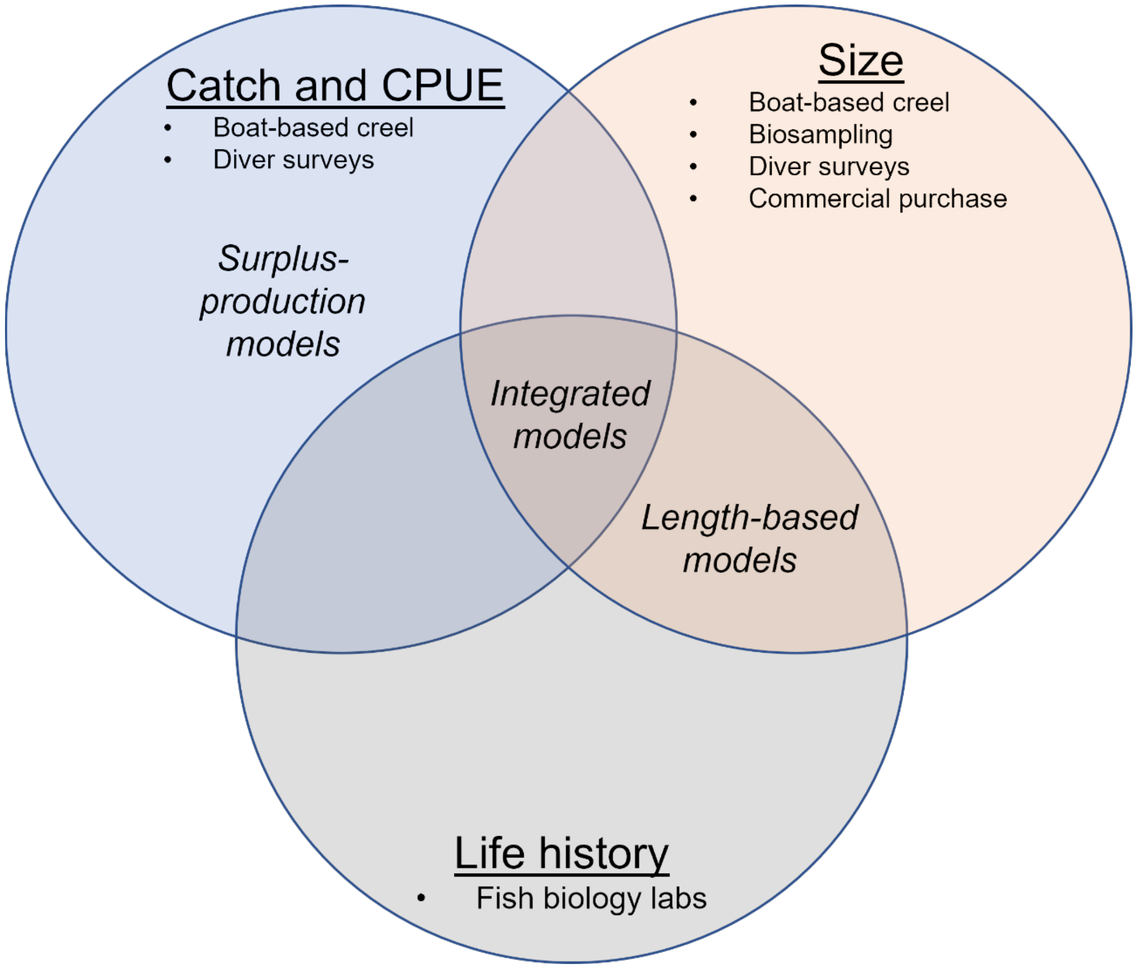

Figure 8-1. The 3 main categories of data used in stock assessments (catch and CPUE timeseries, size, and life history data) with their main sources in American Samoa. In italics are the different types of stock assessment models that operate on these different data types. Only surplus-production models can be used on complex-level assessments, the others requiring species-specific life-history information.

The objective of this report is to explore the different data sources in American Samoa for catch, CPUE, and size data to determine the types of assessment models that could be implemented in the next benchmark assessments. We evaluated seven criteria to characterize the overall amount and quality of available data for each BMUS in American Samoa. The seven criteria are: (1) reliability of species-level identification, (2) availability of historical catch estimates, (3) consistency of the spatial coverage of the data, (4) overall species occurrence in the main source of abundance indices (boat-based creel surveys), (5) magnitude of recent total catch, (6) number of individual size observations, and (7) availability of life history studies. For each criterion, we defined values or qualitative characterizations to categorize the level of information or usefulness in the available data as either low (red), moderate (yellow), or high (green). The 7 criteria, and the definition of the different levels, are presented here as approximations only. The intent is to establish an initial impression of the level of confidence we have in being able to assemble catch, CPUE, size data, and life-history information that will enable new assessment approaches for the BMUS.

Table 8-1. Criteria used to evaluate overall usefulness (amount and quality) of catch, CPUE, and size data for each BMUS in American Samoa.

Criteria	Level of Information / Usefulness		
	High	Medium	Low
1) Species-level identification Ease of identification / co-occurrence of similar-looking species. Routine aggregation with other species groups or use of ambiguous common names. Pronounced and abrupt shifts in occurrence over time.	Easily identified by field personnel. Consistently recorded throughout timeseries.	Potentially misidentified	Easily confused with other species. Abrupt shifts in occurrence over time.
2) Historical catch Recorded at species level in surveys and landings reports 1967–1985.	Routinely recorded in landings and surveys.	Occasionally identified in landings or surveys	No species-specific identification
3) Spatial distribution	Consistently observed across multiple areas.	More commonly observed in some areas	Rarely recorded in some areas
4) Overall species occurrence Proportion of BBS interviews with species-specific records.	> 0.2	0.10–0.2	< 0.09
5) Recent total catch Average landings 2016–2019.	> 200 lb	50–200 lb	< 50 lb
6) Individual size observations Maximum number of length observations from Biosampling Program (2011–2015) and BBS (2016–2019).	> 200	50–200	< 50
7) Life-history studies Location of life-history studies.	Samoan Archipelago	Pacific Ocean	Atlantic Ocean

8.1 General observations

Species-level catch, CPUE, and size data required for single-species stock assessments are only possible if BMUS are reliably identified. Species-level identifications are undermined if catch observations are recorded by broad taxonomic groupings (e.g., “bottomfish,” “deepwater snappers,” or “groupers”) or by common name, which often refers to multiple species. In addition, misidentification, for instance, mistaking an individual for a similar appearing species, may also occur. Species-level identification in the biosampling data set is likely reliable given that the primary aim of the program was to collect fish samples for life history studies, where species identification is primordial. However, this does not guarantee perfect accuracy when identifying species. Similarly, species-level identification for diver surveys is highly reliable given that the professional research divers performing the survey were trained and tested for their taxonomic identification skills. The use of broad taxonomic groupings was common in the boat-based creel survey prior to the implementation of standardized training of field personnel on species identification and use of scientific names in 2016. For the pre-2016 BBS, the disappearance and reappearance of species in certain periods suggest inconsistencies in the accuracy of identifying fish to the species level, which would have shifted as field personnel changed. It is important to note that some of these species' appearance/disappearance could be related to other factors aside from misidentification (e.g., shifts in fisher behavior, changing market preferences, or fluctuations in species abundance or distribution). Lastly, the reliability of species-level identification for commercial purchases is highly vendor-dependent (Tepora Lavata'i, pers. comm.) and most vendors will identify the catch at a broad taxonomic level (e.g., "bottomfish," which account for 40% of recorded species in the commercial purchase receipts, by number).

Early catch estimates between 1967 and1985 would be valuable for reconstructing the complete exploitation history for each BMUS. Although some traditional fishing for bottomfish occurred around Tutuila and the Manu'a Islands, it is likely that the heavy exploitation associated with the modern commercial fishery and exploratory fishing operations did not begin until this time. Estimates of total biomass removals and catch rates, beginning when the stock was essentially unfished, could be used to inform initial stock size estimates in age-structured population models and could also be used to scale total population biomass for equilibrium-based models. Most landings estimates in the available literature sources report aggregate bottomfishes (including BMUS and many other species) which could be used to estimate species-specific landings if assumptions are made regarding the relative proportions of each BMUS in the catch. Some of the more notable (unique or culturally valuable) BMUS were occasionally identified to species, particularly in reports available from July 1974 to June 1976 and as reported by WPacFIN from 1982 to 1985. As expected, BMUS that were not dependably identified in the more recent data sets are typically not recorded in the older historical records.

Consistent sampling coverage over time and space is an important criterion for developing reliable abundance indices and population size structures. All data sets available in American Samoa are heavily centered on Tutuila. While the boat-based creel survey had a significant presence in the Manu'a Islands starting in 1986, there have been no regular boat-based creel surveys in these islands since 2009. Furthermore, only 6% of boat-based interviews are from fishing trips on offshore banks located about 40 miles south and east of Tutuila. The past and current data generated by the Biosampling Program and commercial purchases are obtained almost solely from Tutuila. While the NOAA diver surveys do reach all islands in American Samoa, this data set is primarily aimed at reef fishes and is limited to a depth of 30 m, which is outside the depth range of most BMUS.

The boat-based creel survey is the most promising data timeseries to generate a standardized CPUE index for the BMUS. Although changing spatial distribution of sampling effort and species identification issues (section 2.1.3) may be challenging to account for in the standardization of a CPUE index, the boat-based creel survey includes the largest sample sizes (i.e., interviews per year), the longest-running timeseries (1986–2019), and consistently encounters most BMUS. The ongoing diver surveys (2007–2019) could also potentially generate an abundance index for a few species (*V. louti* and *A. virescens*), although with high variability. The shore-based creel survey rarely encountered BMUS, with an average number of interviews with a BMUS around 19/year in the early years and only 2/year after 2001. Obtaining a CPUE index from these data is therefore unlikely. While the biosampling data set did collect the necessary information to generate a CPUE index (hours fished, catch by weight), this program was only active from 2010 to 2015, which is too short to be informative in a stock assessment model. The commercial purchase data also could not be used to generate a CPUE index given that fishing effort is not recorded in this data set.

Total annual landings are estimated by combining the catch rates obtained from the boat- and shore-based creel surveys with the total annual effort estimates also generated by these programs. The annual catch estimates therefore have similar strengths and weaknesses as the survey data sets from which they are derived (i.e., Tutuila-focused, species misidentification issues in early years, high variability for certain species). While the commercial purchase landings typically represent only a fraction of the annual catch, in some years, landings recorded in commercial purchase receipts may be greater than estimated landings based on the creel surveys. This is likely caused by the high variability associated with the creel catch estimates. In previous assessments, the higher of the two values was taken for any given year, with the commercial purchase landings acting as a hard floor for the annual catch estimates.

In order of importance, size data for BMUS were available from biosampling, boat-based creel surveys, diver surveys, commercial purchases, and shore-based creel surveys. Diver surveys generated enough length observations for a few nearshore species (*A. virescens*, *L. kasmira*, and *V. louti*), while the commercial purchases may have enough observations for *L. kasmira*, *E. carbunculus*, and *A. virescens*. Since 2005, BMUS have rarely been encountered in the shore-based creel survey. It is important to note that the size data obtained from these various data sets are characterized by the same general strengths and limitations described in previous paragraphs (i.e., Tutuila-centered, species identification concerns, depth limits, etc.).

Life history data related to growth, maturity, and longevity are available for all 11 BMUS. Although few of them are from local studies, the Life History Program at PIFSC is continuously working on adding growth, maturity, and mortality information on BMUS. A family-level meta-analytical approach that can provide life history parameter estimates is also available for all BMUS families if needed (snapper, emperor, grouper, and jack; Nadon & Ault 2016; Erickson & Nadon 2021).

8.2 Species-specific observations

We believe there are sufficient data available to perform some form of single-species stock assessments on most of the 11 BMUS in American Samoa. However, our confidence in being able to estimate catch, CPUE, and size compositions, as judged by our 7 criteria for the amount and quality of available data, varies among species (Table 8-2). In this section, we summarize the data challenges and strengths for each BMUS separately.

Table 8-2. Summary of the data available for all 11 BMUS in American Samoa. The criteria definitions are presented in Table 8-1.

Species	1) Species identification errors	2) Historical catch estimates	3) Pre-2009 spatial coverage	4) BBS species occurrence		5) Recent total catch (lb)	6) Size observations	7) Life history
				1986 to 2015	2016 to present			
Aphareus rutilans	No	Challenge	High	0.26	0.32	2782	359	Pacific
Aprion virescens	No	Potential	High	0.41	0.29	2996	939	Pacific
Caranx lugubris	Potential	Challenge	Mostly MI	0.27	0.18	1154	134	Pacific
Etelis carbunculus	Yes	Potential	Mostly MI	0.24	0.23	1219	132	Pacific
Etelis coruscans	Potential	Potential	Mostly MI	0.27	0.26	2965	185	Pacific
Lethrinus rubrioperculatus	Potential	Challenge	Mostly Tut	0.17	0.34	1174	4475	Pacific
Lutjanus kasmira	No	Likely	High	0.50	0.34	824	6267	Pacific
Pristipomoides filamentosus	Yes	Challenge	Mostly MI	0.11	0.01	24	7	Pacific
Pristipomoides flavipinnis	Yes	Challenge	Mostly MI	0.10	0.06	197	238	Local
Pristipomoides zonatus	Potential	Challenge	Mostly MI	0.26	0.11	293	140	Pacific
Variola louti	Yes	Challenge	High	0.46	0.04	129	260	Pacific

8.2.1 *Aphareus rutilans*

This species commonly appears in boat-based creel interviews, both in Tutuila and the Manu‘a Islands throughout the timeseries. Its relatively high occurrence in BBS interviews suggests a standardized CPUE index of abundance could be constructed for 1986–2019. However, it is important to note that this species could be misidentified with *A. furca*, a shallower species and some investigation will need to be carried to insure this has not been the case. Aside from a few years, this species is generally encountered in around 20% of interviews. *A. rutilans* habitat is too deep for diver surveys, making a secondary abundance index impossible. Further, while the older catch timeseries generates variable estimates, the recent catch has been averaging around 2,500 lb/year consistently since 2014.

Size data are generally available for this species, with between 30 and 90 lengths recorded/year from both the boat-based creel surveys and biosampling program. This suggests that annual size structure timeseries could be used to inform population models from 2011 to 2019. Estimates of life history parameters are available from Papua-New Guinea, albeit from a low sample size analysis (Fry et al. 2006).

8.2.2 *Aprion virescens*

This snapper occurs in approximately 40% to 50% of boat-based creel survey interviews throughout the timeseries. It appeared commonly in the Manu‘a Islands interviews prior to 2009, when surveyors were still active there. Given this high encounter rate and temporal consistency, we believe the boat-based creel survey is likely sufficient to generate a standardized CPUE timeseries. Further, this species is seen in approximately 4% of diver surveys around both Tutuila and the Manuʻa Islands which might provide sufficient basis for an additional index of abundance from 2002 to 2018. *A. virescens* was occasionally noted in historical catches, and since 2013 catches have varied cyclically around 2,500/year.

Size data are available for *A. virescens* from all 4 data sets, with the boat-based creel survey and biosampling program providing the most observations (109 and 188 measurements/year, respectively). Lengths measurements from diver surveys (13/year) and commercial purchases (4/year) would have to be aggregated across multiple years to be useful. Growth and maturity parameters are available from Hawaiʻi (O'Malley et al. 2021) and other localities.

8.2.3 Caranx lugubris

This jack was commonly identified by boat-based creel surveyors in the Manuʻa Islands prior to 2009, appearing in more than 50% of interviews on average. It was also identified around Tutuila in about 10% of interviews. Since 2016, it is sighted in about 25% of interviews. The difference in encounter rates pre-2010 and post-2015 may suggest some difficulties in identifying this species in the older data set. This discrepancy would need to be investigated further if a CPUE index including the earlier period was to be used in a model. This discrepancy also translates to the annual catch timeseries, where annual catches were lower pre-2010 at around 500 lb/year before increasing to 1,000 lb/year in recent year. The recent catch estimates are also much less variable.

Size data are only available from the boat-based creel surveys and biosampling program, with an average of 34 and 27 lengths recorded per year, respectively. This species is not often recorded by divers, despite occurring in the survey's depth range (0−30 m). It is also not identified at a species-level by commercial vendors. There are some life history parameters available for this species from Papua-New Guinea (Fry et al. 2006).

8.2.4 Etelis carbunculus

The boat-based creel surveys patterns for this species closely follow those of *C. lugubris*. In short, this species was very commonly encountered around the Manuʻa Islands pre-2009 (~40% of interviews), but less so around Tutuila (~10% of interviews). Since 2014, it is identified in around 25% of interviews. The pre-2010 catch data showed a peak in catch in the early 2000s followed by a stable catch pattern around 1,000 lb/year.

While CPUE and size data are technically available for this species, a greater concern is the confounding presence of a newly reported species that had been previously identified as *E. carbunculus*. The new species, the giant ruby snapper (*Etelis boweni*), is similar in appearance to *E. carbunculus* but reaches greater lengths (max lengths around 115 cm vs 47 cm, respectively; Andrews et al. 2021). The DMWR creel surveyors have been trained on the identification of this species and new data should become available that differentiates between these two species. However, assessment models likely will not be implemented on the older data.

8.2.5 Etelis coruscans

Similarly to the 2 previous species, *E. coruscans* was commonly seen around the Manu'a Islands. when surveyors were present (40% of interviews), while being seen in less than 10% of interviews around Tutuila prior to 2010. Since then, it has been recorded in roughly 20% of interviews. This change in interview encounter rate in these 2 periods could be related to changes in fishery targeting or misidentifications. This would need to be investigated further if a complete CPUE index was to be used. The recent CPUE and catch data are stable in recent years, with catches at around 3,000 lb/year.

Size data for this species are available from the boat-based creel surveys (46 lengths/year) and biosampling program (24 lengths/year). This species occurs too deep to be encountered by divers during their surveys. It is also not commonly identified in the commercial purchases (only 9 observations). Life history parameters related to growth and maturity are available from New Caledonia (Williams et al. 2013), Okinawa Islands (Uehara et al. 2020), and Hawai'i (Everson et al. 1989).

8.2.6 Lethrinus rubrioperculatus

This species was very rarely seen in the Manu'a Islands creel interviews (<1%) while being common in the Tutuila interviews (~25%). However, the Tutuila interview encounter rates were variable, with this species being encountered in 50% of interviews in certain periods and disappearing entirely in other periods. This may be related to misidentifications in certain periods which would need to be clarified before using this data for a CPUE index. In recent years, the annual catch estimates have stabilized, with a slow decline (older catch estimates are more variable, given the CPUE patterns described above).

This species had the second highest BMUS length measurements in both the biosampling (900/year) and boat-based creel surveys (202/year). However, this species was not identified in the commercial purchases and was rarely encountered by divers (21 observations overall). Growth and maturity parameters are available from the Northern Mariana Islands. (Trianni 2011).

8.2.7 Lutjanus kasmira

This species was the most encountered BMUS in the boat-based creel surveys (50% of interviews). It was encountered at a slightly lower rate around the Manu'a Islands, when surveyors were active prior to 2009. This encounter rate, while varying from year to year, was mostly stable across the timeseries, suggesting that surveyors had little trouble identifying this species (a distinctive yellow snapper with blue stripes). A CPUE timeseries is likely possible for this species for both the creel survey and the diver surveys, where this species was commonly encountered by divers, especially around the Manu'a Islands. The catch data in recent years has been stable at around 1000 lb/year.

This species had the highest number of length measurements in both the boat-based creel surveys (253/year) and the biosampling (1,253/year) data sets. The commercial purchases also measured 18 lengths/year, on average, which could be used if aggregated across years. The diver surveys recorded about 286 *L. kasmira*/year, however many of these sightings were around the Manu'a Islands. Further, many of the sightings involved fish schools, where length measurements are binned. For individual fish sightings, the diver surveys record only about 29 lengths/year. Life history parameters for this species have been reported from Hawai‘i (Morales-Nin & Ralston 1990).

8.2.8 *Pristipomoides filamentosus*

This species periodically appears in the creel interviews, especially around the Manu‘a Islands. It has rarely been recorded in recent years. This periodical appearance suggests some difficulties in identifying this species. In addition to the low number of observations, this could make generating a CPUE index challenging. The recent catch estimates are either very low or null.

Only 4 and 7 lengths were measured for this species in the boat-based creel surveys and biosampling data set, respectively. This species occurs too deep for diver surveys. Further, the commercial purchases have very few records of this species (23). While there are some life history parameters available for this species (from Hawai‘i), it is highly unlikely that much can be done with so few length measurements.

8.2.9 *Pristipomoides flavipinnis*

Similarly to *P. filamentosus*, this species is periodically encountered during creel interviews, appearing and disappearing in different periods. It was commonly recorded around the Manu‘a I. and Tutuila in the early 2000s, before almost disappearing until 2016, where it appears in around 10% of interviews. This would make generating a long CPUE timeseries unlikely for this species, given the likely issues with species misidentification. The catch data follows a similar pattern, with a few recent estimates at around 300 lb/year.

Size data for this species are available only from the boat-based creel surveys (13/year) and the biosampling program (52/year). It occurs too deep for diver surveys and is not identified at the species-level in the commercial purchases. Life history parameters are available from Samoa for this species, following a NOAA Life History Program study (O’Malley et al. 2019).

8.2.10 *Pristipomoides zonatus*

This species was very commonly recorded in creel interviews around the Manu‘a I. (70%), but very rarely around Tutuila (<5%). It also periodically disappears from the Tutuila surveys. These patterns suggest some potential misidentification issues. This would make generating a CPUE index for the 1986−2020 period challenging. This encounter rate has been more stable in recent years at around 15%, which has helped generate some stable annual catch estimates of around 250 lb/year.

Size data for this species are reported by the boat-based creel surveys (35 lengths/year) and the biosampling program (18 lengths/year). This snapper is found well below typical diver depths and has never been recorded by these surveys. A few weights are reported in the commercial purchases data set every year (2 on average). Growth and maturity parameters are available for this species from Papua-New Guinea (Fry et al. 2006) and Guam (Schemmel et al. unpublished).

8.2.11 *Variola louti*

This species was commonly seen in creel interviews around both the Manu‘a Islands and Tutuila at a constant rate around 50% for most of the creel survey timeseries, but suddenly disappeared around 2010. Since 2014, it is observed at a much lower rate (10% of surveys). This suggest a distinctive switch occurred in 2010 in the way this species was identified. This species can be confused with *V. albimarginata* and it is possible that it was identified as such in the early years. This pattern could also be related to fisher behavior, which will need to be investigated. This pattern will make it challenging to obtain a CPUE timeseries from this data set. However, it is also commonly seen by diver surveys (12%) which could be used to generate an abundance index. In terms of annual catch estimates, unsurprisingly, the catch drops drastically after 2009, when it almost disappears from creel surveys. In recent years, this catch has been estimated at around 100 lb/year.

Size data for this grouper are available from boat-based surveys (7 lengths/year), the biosampling program (52 lengths/year), and the diver surveys (33 lengths/year, from both Tutuila and the Manu‘a Islands). They are not recorded at the species level in the commercial purchases. Life history parameters are available from the Seychelles (Grandcourt 2005) and Guam (Schemmel, in prep.).

8.3 Conclusions

The goal of this report was to evaluate the data available for the next generation of BMUS stock assessments in American Samoa. One important step in improving these assessments would be to move from complex- to species-level population assessment models. This would open age-structured modeling options, beyond surplus-production models, that can incorporate size and life history information. Overall, we found that 10 out of 11 BMUS likely have sufficient data to run integrated or length-based assessment models. There are likely not enough data to run any assessment models for *Pristipomoides filamentosus*. Further, *E. carbunculus* has the additional challenge of having confounding data with a new species (*E. boweni*).

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