Pilot surveys at unsampled ports and shoreline to calibrate adjustment factors in the expansion of catch, effort and CPUE from the existing creel survey in Guam

FY 2013 Proposal

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1. Overview

1.1. Sponsor
Joshua DeMello

1.2. Focus Group
Survey Design and Evaluation

1.3. Background
The creel surveys being conducted in American Samoa, Guam and Northern Mariana Islands that aims to collect fishery dependent information are based on a stratified systematic sampling design on periods and areas representative of the different fisheries. These surveys generate catch, effort, CPUE, and species composition information based on samples from a subset of sampling frame. These subsamples are then expanded on a larger scale based on adjustment factors (p1 – for temporal adjustment and p2 – for spatial adjustment) from expert opinion.The evaluation done by Bak (2012) on the sampling design and creel survey methods showed the current sampling design is not capable of generating an estimate of total island-wide catch because the sampling frames are not complete. There are some areas and periods not sufficiently covered by the existing design. Those unsampled periods (evening) and areas (military bases in Guam) are accommodated by using the p1 and p2 adjustment factors. Since the adjustment factors are based on expert opinion, they constitute unverified assumptions that may infuse unknown biases in the final estimation. One cannot generalize the level of fishing and fishery characteristics that would be represented in the samples if there is no information available to infer such generalizations. Several factors could contribute to the differences between areas covered and not covered ranging from population number, economic status, topography and accessibility of the fishing grounds etc. These have to be considered prior to any assumptions that the fishery dynamics between these areas and periods are similar.The utility of other data sources need to be evaluated as the bases of adjustment factors for areas that are not surveyed. Guam had a long time series of aerial surveys that is not being utilized to inform the expert opinion for the spatial and temporal adjustment factors built into the expansion algorithm to estimate catches in non-surveyed areas.These island areas have been provided exemptions to the National Saltwater Angler Registry based upon these creel surveys. In order to report accurate data on the recreational fisheries in these areas, the creel surveys need to be improved in the same fashion as the MRFSS/MRIP surveys, including the removal of bias due to private access and night fishing.

1.4. Project Description
The overall goal of this project is to improve the estimation of total catch and effort from existing creel survey efforts. Non-commercial landings make up most of the shoreline fisheries in Guam and Northern Mariana Islands (Walker et al. 2012). The ratio between the commercial and non-commercial landing from the boat-based fisheries would depend on the fishing method but are generally non-commercial in nature. Estimating a total island-wide catch is important for both science (e.g. stock assessment) and management (e.g. specification of annual catch limits).This project aims to quantify effort and catch in areas and periods not currently covered by the existing creel survey. Quantifying these parameters can provide a more informed judgment on whether these areas are significant in terms of fishery landing and whether the current landing estimates are underestimated. This project could also provide an insight on whether the current sampling areas are representative of the fisheries for Guam.Making use of the adjustment factor feature of the catch expansion allows for estimation of total island wide catch. Informing this adjustment factors based on actual data and integrate this in the current expansion algorithm is important in order to minimize the uncertainties in terms of underestimation of the catch.

1.5. Public Description

1.6. Objectives
The goal of the project is provide calibration estimates to inform the adjustment factors for a more accurate estimation of total catch, effort and CPUE. The project objectives are:1.Conduct a statistical review of alternate data (e.g. Guam aerial survey) as sources of adjustment factors for non-surveyed areas; 2.Formulate and conduct a sampling design compatible with current creel survey to cover areas and periods not addressed by the current creel surveys;3.Collect catch, CPUE, species composition, and other meta-data associated with fishing activity;4.Calibrate adjustment factors (p1 and p2) taking into account spatial/temporal coverage;Feeding these adjustment factors with statistically valid means using actual data will significantly enhance the confidence in the data being generated by the creel surveys. This will minimize the over-reliance on expert opinion that infuses bias and subjective depending on who provides the opinion.

1.7. References
Bak S. 2012. Evaluation of Creel Survey Program in the Western Pacific Region (Guam, CNMI, and American Samoa). Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, USA. 96813. Pp. 59. Walker R, Ballou L, Wolfford B. 2012. Non-Commercial Coral Reef Fishery Assessments for the Western Pacific Region. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, USA. 96813. Pp. 191.

2. Methodology

2.1. Methodology

The project will employ an independent contract in close collaboration with the local fishery management agencies (Division of Aquatic and Wildlife Resources), US Navy base in Guam and Pacific Island Fisheries Science Center - WPacFIN. A statistical review of the Guam aerial surveys will be conducted to determine variabilities and reliability as adjustment factors for areas not covered by the current creel surveys. Expanded data will be simulated using the current adjustment factors expert opinion and will be compared to simulations based on the aerial surveys alone. Parametric or non-parametric statistics will be used to determine significant differences between the two simulations.This project will cover areas and ports not regularly accounted for by the current creel survey. This will also cover periods that are not adequately sampled by the current survey. A survey design will be established for this independent data collection that is comparable to creel surveys (i.e. another creel survey) or a data collection system that is compatible (i.e. statistically designed opportunistic survey, observations, or community interviews) with the current collection system. The survey design will depend on the logistics involved in conducting the data collection. The critical condition is that the results should be statistically comparable with the existing creel survey design.A team of data collectors will be hired as temporary staff under this project and will be trained in fish identification and survey protocol. This will be done in collaboration with the data collection staff of the local fishery management agencies in the respective territories. The data collection team should be versed with the species normally caught in the different fisheries. A review of the species composition list and close communication with the local data collection agents will provide good support for the getting the team up to speed.The team will coordinate the surveys with the local data collection agents in terms of scheduling for the area-calibration study. The surveys will be conducted simultaneously to have instantaneous estimates of effort and CPUE to estimate the calibration between areas to provide an informed area adjustment factor. The temporal calibration study will be in relation to the schedule of the local data collection team. If the team is scheduled to cover periods between 5 am to 10 pm then the contractual team will cover 11pm to 4 am the following day at the same route/ports the local team covered previously.The survey will be conducted regularly spanning for a whole year to capture the seasonality in catch landings and changes in species composition. All data will be inputted into the WPacFIN database to ensure that the data is treated similarly but will be separated from the data gathered by the local data collectors. The data gathered by the contract team will be compared against the data gathered local data collectors. Calibration ratios for each parameter (catch, effort, CPUE) would be determined for every fishing method - species/species group combination. The adjustment factors will not be used in determining the calibration ratios. These calibration ratios will be used to inform the adjustment factors.Once the adjustment factors have been calibrated, the time series of catch, effort and CPUE will be simulated using the calibrated and non-calibrated (expert opinion) adjustment factors. This would determine how the accurate the expert opinion is in adjusting for areas not covered by the survey.

2.2. Region

Western Pacific Islands

2.3. Geographic Coverage

Island of Guam

2.4. Temporal Coverage

Data collection will run for one year and stat analysis will continue for another 6 months

2.5. Frequency

Data collected weekly as in accordance with existing creel survey design

2.6. Unit of Analysis

Spatial unit of analysis – island scale (Guam)

2.7. Collection Mode

Using creel survey

3. Communication

3.1. Internal Communication

The project team will be updated on the status of the project by the contractor on a monthly basis. The contractor will submit a progress report at the end of each month. The project team will be on conference call to discuss the progress of the project on a bi-monthly basis.

3.2. External Communication

The Project team will be submitting monthly progress report on a standardized template. This report will be based on the report submitted by the contractor to the project team.

4. Assumptions/Constraints

4.1. New Data Collection

Y

4.2. Is funding needed for this project?

4.3. Funding Vehicle

Existing Administrative Cooperative Agreement between NMFS PIRO and WPRFMC

4.4. Data Resources

none

4.5. Other Resources

Completion of the project will be dependent upon existing data collected through surveys conducted by DAWR and archived/summarized by WPacFIN for comparison with the results of this project.

4.6. Regulations

Success of the project will be dependent upon the Department of Defense providing regular access for surveyors.

4.7. Other

5. Final Deliverables

5.1. Additional Reports

5.2. New Data Set(s)

5.3. New System(s)

6. Project Leadership

6.1. Project Leader and Members

First Name	Last Name	Title	Role	Organization	Email	Phone 1	Phone 2
Gretchen	Grimm	Natural Resources Program Manager	Team Member	DoD, Naval Base Guam			
Kimberly	Lowe	Program Manager	Team Member	NMFS PIFSC Western Pacific Fisheries Information Network			
Marlowe	Sabater	Marine Ecosystem Scientist	Team Leader	Western Pacific Regional Fishery Management Council	Marlowe.Sabater@noaa.gov	(808) 522-8143	(808) 522-8220
Brent	Tibbats	Marine Biologist	Team Member	Guam Division of Aquatic and Wildlife Resources			

7. Project Estimates

7.1. Project Schedule

Task #	Schedule Description	Prerequisite	Schedule Start Date	Schedule Finish Date	Milestone
1	Hiring of data collection contractors and statistician; It will take at least a month to identify		02/01/2013	02/28/2013	
3	Training of survey team on protocol	1, 2	04/01/2013	04/15/2013	
5	Submit mid-progress report with preliminary results and analysis	4	10/15/2013	11/16/2013	Y
2	Design of survey and protocol; Develop MOA to access military base	1	03/01/2013	03/31/2013	
4	Conduct data collection in the Navy and Airforce base	1,2,3	04/16/2013	04/15/2014	Y
6	Submit final project report	4,5	04/16/2014	05/15/2014	Y

7.2. Cost Estimates

Cost Name	Cost Description	Cost Amount	Date Needed
Contractual Services for statistical design, analysis and report writing	This line item includes contracting of personnel that will conduct statistical anal	$25000.00	01/01/2013
Contractual Services for data collection	This line item includes contracting of personnel that will collect data	$75000.00	01/01/2013
TOTAL COST		$100000.00	

8. Risk

8.1. Project Risk

Risk Description	Risk Impact	Risk Probability	Risk Mitigation Approach
The foreseeable risk to this project is the ability to secure a memorandum of agreement with the US Navy to allow data collectors access to the base. The Base	The impact of this risk to the project is the inability to access the project area.	Medium	The Project Team is working with the Navy Environmental Division to facilitate the memorandum of agreement. The team is engaging them early in order to get this in place

Risk Description	Risk Impact	Risk Probability	Risk Mitigation Approach
Commander changes every 1.5 years and the incumbent commander is scheduled to be replaced in a year's time. However, the project team includes a staff from the Environmental Division of the Navy and could facilitate connection and provide guidance to increase the chance of securing an MOA. We are currently scoping with the Navy staff on the process to which the MOA can be attained and options for continuity of the agreement even beyond the project.			as soon as possiible. Another approach is to refocus the project towards the temporal adjustment factor (p1) on areas that are currently being survey. This would document fishery landings on ports and shoreline that are within the spatial sampling frame but the unsampled temporal sampling frame..

9. Supporting Documents

"Non-commercial Coral Reef Fishery Assessments for the Western Pacific Region", page 1

Non-commercial Coral Reef Fishery Assessments for the Western Pacific Region

Rebecca Walker, Lauren Ballou, Bryan Wolfford

Hawai‘i Pacific University

Executive Summary

This report assesses the non-commercial coral reef fisheries of the Western Pacific region using data from the creel survey programs of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI) and data from the Hawai‘i Marine Recreational Fishing Survey (HMRFS) in Hawai‘i. Because creel surveys were not originally designed to distinguish between commercial and non-commercial catch at the species level, data manipulations and estimating algorithms were required.

In order to determine the optimal assessment methods, interviews were conducted with National Oceanic and Atmospheric Administration (NOAA) Pacific Islands Fisheries Science Center (PIFSC) staff and the HMRFS program director, and program documentation was reviewed. Diagnostic analyses were performed to assess the quality of the data and quantify the level of estimating and “pooling” associated with the catch data. Interviews were conducted with local fisheries specialists to aid in interpreting the results. For American Samoa and Hawai‘i, estimated catch data were analyzed directly, but for Guam and the CNMI, an algorithm was developed and applied to estimate the non-commercial landings.

The results show that most shore-based fishing is non-commercial in American Samoa, Guam, and the CNMI. Non-commercial fishing accounts for a much smaller proportion of the boat-based versus shore-based coral reef fishery catch. The shore-based fishing gear associated with the most catch in all regions is some form of hook and line. Bottomfishing is the most important method for catching coral reef species in the boat-based fisheries. *Selar crumenophthalmus*, jacks, and surgeonfish are the top components of the catch in all regions. In Hawai‘i, the availability of weight data is too sparse to support weight based analyses so only number of fish can be assessed. Bait fish species are caught in the highest numbers.

Sampling and survey design limit the accuracy of the analysis of the non-commercial sector. Incomplete sampling frames of non-commercial fishing activity in all regions may introduce error and bias into the estimation procedure. Large changes in estimated catch across time suggest that sampling of pulse fisheries or rarely encountered methods can cause large variances. In Guam and CNMI, because the percent of catch kept versus sold (i.e., disposition) is available by method/gear type but not at a species level, estimates of species level non-commercial catch are subject to additional error and uncertainty. In American Samoa, the same holds true for the shore-based survey, however the boat-based survey does capture disposition of the catch at the species level.

In the creel survey programs of the Western Pacific region, estimation of catch occurs during the sampling of CPUE, data expansion process (combining CPUE with estimated effort), and in the non-commercial algorithm developed for this report. These three estimation components introduce potential error and uncertainty which can be multiplicative. Based on the non-representative nature of sampling frames and feedback from local fishery specialists, the results in this report must be interpreted with caution due to these limitations.

NON-COMMERCIAL CORAL REEF FISHERY ASSESSMENTS
FOR THE WESTERN PACIFIC REGION

1. Introduction

Non-commercial fishing in the Western Pacific region may account for significant take of coral reef species. The nationwide Marine Recreational Fisheries Statistics Survey (MRFSS), and newly instated Marine Recreational Information Program (MRIP), produce estimates for catch landings in Hawai‘i. While a recreational fishing survey is not in place in American Samoa, Guam, or the Commonwealth of the Northern Mariana Islands (CNMI), non-commercial data can be extracted from creel surveys taken by island agencies. The Western Pacific Fisheries Information Network (WPacFIN) stores the data from these creel surveys and expands them to produce annual catch and species composition estimates. Non-commercial in this report is defined as any landings that are kept, and not sold, with the exception of Hawai‘i data which is all data captured by the MRFSS. This report summarizes the non-commercial catch of coral reef species by insular region, fishing mode or method, and Coral Reef Ecosystem Management Unit Species (CREMUS). It is an initial report intended to inform the Western Pacific Regional Fisheries Management Council of the capabilities and limitations of WPacFIN, MRFSS, and MRIP expansion estimates for analyzing the non-commercial coral reef fishery, and provide summaries of existing data.

1.1. Considerations for analysis of non-commercial fisheries

1.1.1. Guam and CNMI Creel Survey Data

WPacFIN provides the best data available for fisheries in the Western Pacific region. The data collection and expansion methods, however, were not originally designed for collecting data specifically on non-commercial fisheries. In the Guam and CNMI data sets, the only data describing the non-commercial fishery are the fisher’s own estimate of what will be sold from his catch given as a percentage of total trip catch. These data are not included in the expansion estimates because they are not considered reliable enough (Michael Quach, personal communication, October 27, 2011) or because there are no data collected that can be used to estimate non-commercial effort (Penglong Tao, personal communication, August 30, 2011). The non-commercial catch, however, can be characterized by applying percent kept data from the intercept surveys to WPacFIN’s annual data expansions by stratum. The Guam and CNMI boat-based surveys are stratified by expansion period, port, method, type of day (weekday or weekend/holiday), and chart/non-charter. The CNMI shore-based survey is stratified by expansion period, method, type of day, and day/night, while the Guam shore-based survey is also stratified by region (Oram et al., 2011a-f and Penglong Tao, personal communication, December 28, 2011). Data are separated by method and charter boat status after collection, and as such can be said to be post-stratified beyond the stratified sampling level. In this report, comparisons between expanded and interview strata are referring to the year/method/type of day/day or night/charter level, not the sampling level. Expanded strata are built from the participation counts. Note that strata may exist in the interview files and not in the expanded files if a method was not recorded in the participation counts but was interviewed (David Hamm, personal communication, February 2, 2012).

A major limitation of using the creel survey data for a non-commercial analysis is that the non-commercial ratio is given at the method level, not the species level. All estimates of non-commercial species composition are extrapolations of the estimated percent kept by method and should be used with caution. That is, the same percentage of fish caught using a certain gear type that is kept is assumed to be the percentage of each species that is kept. This is an unverified assumption.

The last major consideration that should be taken when using these data is that the pooling algorithm in the expansion process borrows data without identifying the exact interview source of the borrowed data. The expansion process needs three interviews per expanded stratum to calculate catch rates and variances, and the pooling algorithm will look in order of most closely related strata until it finds at least three interviews (Graham, 2011b; Penglong Tao, personal communication, December 13, 2011). The strata parameter that lent the interview is flagged, but the interview itself is not flagged, so the non-commercial ratios from pooled interviews are not transferred to the estimated files. In this analysis, the ratio of non-commercial coral reef landings to total landings as calculated using only two or one interview is applied to the expanded stratum, even though the catch rate has been calculated by WPacFIN's pooling algorithm using more interviews.

Data quality is dependent on the island agencies in charge of the creel surveys (Michael Quach, personal communication, October 27, 2011). There were some changes in survey methodology over the years of the creel surveys, but data are only expanded when the methodologies are consistent. These changes, according to WPacFIN documentation, are summarized in Appendix 3. Sunny Bak's report to the Council evaluates the statistical validity of expansion estimates for the Guam, CNMI, and American Samoa creel survey programs (Bak, 2012). The concerns about sampling frame, fidelity to sampling protocol, and unverified assumptions made by the estimation algorithm explained in Bak's report should be taken into consideration when interpreting the results of this report.

1.1.2. American Samoa Creel Survey Data

The American Samoa creel survey datasets are similar to the Guam and CNMI datasets but there are some important differences that ease analyses of non-commercial catch data. The data that allows for separation of the commercial and non-commercial components is included in the expansion process, so the estimated species composition file includes pounds caught and pounds sold. In the shore-based survey, these data are disposition codes taken by method from 1990-1996 and percent unsold data taken by method since 2006 (American Samoa DMWR: Shore-Based Creel Survey Interview Form, all). In the boat-based survey, these data are disposition codes taken by species over all years of the survey's existence (*American Samoa DMWR: Boat-Based Survey Interview Form*, all). This means that CREMUS group summaries are more representative of the actual fishery in the American Samoa boat-based analysis.

Data collection methods were not as consistent in American Samoa as in Guam and CNMI, and evolved over the life of both the shore-based and boat-based creel surveys (Graham, 2011a; Graham, 2011b). However, WPacFIN only expands data that was collected consistently, as in Guam and CNMI's creel surveys. The shore-based survey is only expanded in years when zero-participation runs are accurately documented and are expanded by matching consistent routes as much as possible (Graham, 2011a). The shore-based survey is stratified by route as well as expansion period, method, type of day, and day/night (Oram et al., 2011b and Michael Quach, personal communication, February 2, 2012). The boat-based survey is stratified by expansion period, method, day type, and day/night (Oram et al., 2011a).

1.1.3. Hawai‘i Marine Recreational Fishing Survey Data

The creel surveys of the Western Pacific region and the HMRFS are both randomized, stratified sampling surveys where interview data are collected by local island agencies. These catch data are combined with effort data to produce annual landings estimates (Oram et al., 2011a-f, and MRFSS Data User’s Manual, n.d.). The surveys have several important differences. Unlike the creel surveys for WPacFIN, HMRFS is designed to capture recreational data. MRFSS only includes finfish while the other surveys also cover marine invertebrates. Another difference is that real-time estimates of participation are part of the surveys in American Samoa, Guam, and CNMI, but participation in Hawai‘i’s recreational fisheries is estimated through a telephone survey.

The sampling strata are also different from the creel surveys. Instead of having separate surveys for shore-based and boat-based fishing, all fishing activity is post-stratified by “mode,” which is shore-based fishing or different types of boat-based fishing. Fishing method (within a fishing mode) data are collected during the telephone survey. Data for gear types/fishing methods are also collected in the intercept surveys. Ma et al. (2011, an MRIP project report dated in Dec 2011) analyzed the fishing method data from telephone and onsite intercept surveys. There is also never any night surveying, in contrast to the shore-based creel surveys which are stratified by day or night. Estimated strata are defined by year, expansion period (6 waves annually), state, mode, and fishing area (greater than three or less than three nautical miles from shore). As such, the sampling and expanded strata are courser than those of the creel surveys.

A difference in data structure is that estimated and measured data are expanded separately, while in the creel surveys it is expanded together with only a quality flag separating them in the intercept data. If there is not enough data to calculate weight estimates, the weight for that species and stratum is left blank. If only one fish weight is available for a stratum, there will be no variance estimate (MRFSS Data User’s Manual, n.d.). The creel survey expansion process pools interviews when there is not enough data and post-stratifies by species to get a species composition estimate, while MRFSS leaves it blank and lets the data user decide what weight should be used for each fish species without an estimated weight. This is a considerable challenge in analysis of MRFSS data.

The MRFSS Web site has Coastal Household Telephone Survey (telephone effort survey), intercept, and estimated data available for download, and an online query tool for quick access to the estimated data. Intercept data are divided into type 1, type 2 and type 3. Type 1 data describe the fisher and trip. Type 3 data are catch verified by an interviewer to the species level and are measured and weighed in the field if possible. All other landings are Type 2 data, whether an interviewer did not have time to count each individual fish, could not identify each fish to the species level, or the fisher did not allow inspection of his catch (Tom Ogawa, personal communication, October 17, 2011). Type 3 intercept data verified by an interviewer becomes “Type A” data in the expansion process and Type 2 unverified intercept data becomes “Type B1” or “Type B2” data. Type B2 data refers to those fish that were released alive. Type B1 includes fish released dead, filleted, used as bait, or otherwise unavailable for an interviewer to inspect (NOAA Fisheries: Office of Science & Technology, n.d.). For the purposes of this report, Type A + Type B1 data will be called "harvest." Type B2 data are not included in the Hawai'i figures.

There is commercial and recreational data overlap and separating the two presents some challenges. Survey data are kept in the expansion process unless the fisher identifies himself as a full-time commercial fisher. Part-time commercial fishermen are still included. No question on the HMRFS survey indicates whether or not a fisherman holds a commercial marine license (CML). Some fisherman with a CML may not report all of the fish they catch on their reports; standard procedure is to report all fish caught, but in practice fishers may only report the catch that is sold. Overlap can occur if a part-time commercial fisher holding a CML reports fish caught in the recreational survey and also reports the same fish in his commercial report. Disposition codes taken at the species level reveal that some fish caught and covered by the survey are sold, but it is unknown if these fish are reported in other fishery dependent data systems. Fish that are planned to be sold could still be considered part of the non-commercial harvest if the fisher is selling the fish to cover expenses. Downloadable HMRFS data do not include fishermen type answers; these data must be requested from HDAR or PIFSC. Fish with a disposition to be sold are included in the data expansion, and are kept in this analysis in an effort to use all data captured by the recreational survey.

Expansion procedures under MRFSS have many potential areas of bias. The three primary areas of bias are: (1) sample frames for catch rate estimation and effort estimation are either incomplete or have errors (or both), (2) fidelity to sampling protocols used in phone and intercept surveys are not monitored adequately, and (3) the MRFSS survey design makes assumptions of unknown validity that are used in the expansion of estimates over the non-sampled segments of the fishing population. When considering temporal trends, there may be variation in estimates among years; fluctuations may in fact be real or could be artificial due to potential bias (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006).

2. Methods

2.1. Data Acquisition and Comprehension

2.1.1. Guam and CNMI

Creel data collection documentation and metadata were received for each creel survey, along with expanded catch and species composition files as well as combined interview, catch, and size flat files from Penglong Tao (NOAA Pacific Islands Fisheries Science Center). After consultation with Tao, new files were received with only the data relevant to non-commercial analysis. Records in the interview/catch flat file with effort data, but no catch data, were excluded, as well as records from years when the percent unsold/sold data conflicted or was not collected (Penglong Tao, personal communication, August 19, 2011). Supporting tables including the CREMUS species for all insular regions from Marlowe Sabater, and PMUS and BMUS tables for all insular regions and the region table for Guam from Penglong Tao were acquired in order to build a database for analysis. An interview was conducted with staff members of PIFSC including David Hamm, Kimberly Lowe, Michael Quach, and Penglong Tao to share preliminary results from Guam and CNMI as well as American Samoa. Results were also shared with Guam DAWR and CNMI DFW staff. A phone interview was conducted with Guam's DAWR staff that included Tino Aguon (Division Chief), Jay Gutierrez (Division Chief Assistant), Thomas Flores Jr. (Boat-based Program Leader), and Brent Tibbatts (Shore-based Program Leader). Comments on the CNMI results from Ray Roberto (Data Manager) and Michael Tenorio (Acting Chief of Fishery Division) at the CNMI DFW were received through e-mail. Insight from PIFSC, DAWR, and DFW staff is included in the results section.

2.1.2. American Samoa

Data from the American Samoa creel surveys were received from Michael Quach of PIFSC along with descriptions of the expansion process written by Craig Graham, the programmer of the American Samoa expansion. Summaries of the expansion process in American Samoa, Guam, and CNMI to a degree of detail as can be gleaned from these documents and Guam and CNMI metadata, are included in Appendix 2. Sunny Bak includes a list of variables and description of the expansion process in her Council report as well (Bak, 2012). As in Guam and CNMI, interview and catch data, as well as expanded catch and species composition files, were received for this analysis. An interview with Michael Quach was conducted in order to gain insight into the American Samoa creel surveys. An interview with Domingo Ochavillo from American Samoa DMWR (Fishery Division Chief) was conducted to share preliminary results. His insight and those from the meeting with PIFSC are included in the results section.

2.1.3. Hawai‘i

The online query tool provided by the MRFSS was used to gain initial insight into the available data. Initial data review interviews were conducted with Hongguang Ma (PIFSC) and Tom Ogawa (Hawai‘i DAR) to help assess the data design and usability for analysis of the recreational catch of coral reef species. Further understanding of MRFSS and HMRFS was gained by reviewing the following references: "Hawai‘i Marine Recreational Fisheries Survey: How analysis of raw data can benefit regional fisheries management and how catch estimates are developed, an example using 2003 data" by Allen and Bartlett (2008) and "Review of recreational fisheries survey methods" by the Committee of the Review of Recreational Fisheries Survey Methods, National Research Council (2006). Intercept and estimated CSV files were downloaded from the MRFSS Web site. The relevant data for Hawai‘i was extracted and loaded into an Access database. Since coral reef species are the only species of interest to this study, the CREMUS species identified from Hawai‘i's commercial codes (received from Marlowe Sabater) were cross-referenced with the MRFSS species codes and this table was added to our database. A second interview with Tom Ogawa and Hongguang Ma was conducted to review the preliminary results. Their insight is included in the results section.

In order to properly assess the data for our needs, the "FSHINSP" column, in the available intercept data, was adjusted. For each unique ID code, the "FSHINSP" column records the number of fish of a certain species caught in each record of that species within an interview. A column was created from the original "FSHINSP" using a formula that inserted a 0 in all but the first record within a distinct interview and species group of records in order to make this column additive across all records.

2.2. Quality Control

2.2.1. American Samoa, Guam and CNMI

While the data are subject to quality control upon entry into the database, this specific project required some cleaning of the data. For the temporal trends analysis, Tao excluded interview records that had some effort data but no catch data, as well as records in which the percent sold and percent kept data did not add up to 100%. Interviews that had negative hours spent fishing, which originated from a keypunch error, were brought to the attention of Tao.

2.2.2. Hawai‘i

Data are subjected to an initial quality control process using programs submitted by MRIP to HDAR. Errors identified by the program are fixed accordingly. (Tom Ogawa, personal communication, March 14, 2011). Typos in the downloadable database that were addressed included an incorrect state code, a duplicate ID code, and an incorrect species length. Harvest records for *Scarus psittacus* and *Scarus taeniurus* were combined as both Latin binomials refer to the same species (Randall, 2007, p.364).

Ma et al. (2011) identified an error in the telephone data expansion for fishing effort. In this analysis, estimated harvest for all species was adjusted by a factor of 1/1.22.

For all graphs considering numbers of fish, values of ‘999’ were removed from the “NUM_FISH” and “FSHINSP” columns. ‘999’ is the code for refusal of a question (HMRFS Procedures Manual). There were only two instances of this code in the data; one type 2 record of *Apogon kallopterus* and one type 3 record of *Decapterus macarellus*. After review of preliminary results with Ogawa, it was discovered that the two records with this code were expanded as if 999 fish were actually caught. Since *A. kallopterus* does not have a specialized fishery (Tom Ogawa, personal communication, February 24, 2012), estimates from this wave were deleted and catch was assumed to be zero. Since the harvest estimate from wave 6 of 2003 was clearly an outlier, the harvest estimate of *Decapterus macarellus* from wave 6 of 2004 was substituted for wave 6 of 2003. These decisions were made based on the recommendation of Tom Sminkey (personal communication, February 28, 2012).

Data are considered from 2003-2010 aside from the diagnostic figures 1.b.1, 1.b.2, 1.b.3, 1.b.4, 1.b.10, 1.b.11, and 1.b.12. There were no data available for 2002 in the intercept or estimated data downloads. In 2001, there were very little data available; the survey did not sample the whole year and only two islands were sampled (Tom Ogawa and Hongguang Ma, personal communication, February 24, 2012). The data from 2001 were left in some of the diagnostic figures because their purpose was to assess the data quality in its entirety. 2001 was left out of other figures because it is incomplete and cannot be directly compared to other years; data from 2003 onward are most usable.

2.3. Diagnostics

Diagnostics include data for all species, not just coral reef species, unless otherwise stated, to provide insight into the entire dataset as it was received for analysis of non-commercial landings.

2.3.1. American Samoa, Guam, CNMI

2.3.1.1. Coral Reef Taxa Identification

Coral reef species were the object of this study. Coral reef species are defined in this report as species that are included in the CREMUS lists for each archipelago, and those reef-associated species that are not included in the CREMUS, Bottomfish Management Unit Species (BMUS), or Pelagic Management Unit Species (PMUS) lists but are found in the creel survey interview and expanded data sets or HMRFS.

A CREMUS list was received from Marlowe Sabater for American Samoa, Guam, CNMI, and Hawai‘i. Bottomfish management unit species (BMUS) and pelagic management unit species (PMUS) lists for American Samoa, Guam, and CNMI were obtained from Penglong Tao.

To determine what species were caught in the creel surveys but did not belong to any management unit groups, the coral reef, pelagic, and bottomfish management unit species lists with codes were put into a database with the intercept data. A select query using Access SQL code was then run that selected distinct species names found in the intercept files but not in the CREMUS, BMUS, and PMUS lists. These species were then placed in appropriate management units and then CREMUS groups if they were reef-associated species and summarized into Table 1.a.1. All Access SQL code can be found in Appendix 5.

2.3.1.2. Quality of intercept landings data

The creel surveys record the method used for determining the weight of each taxon in an interview. They are measured, calculated, or estimated. The data were split into these three categories and the sum of the intercept landings for each category was recorded.

In the CNMI and Guam databases, the weight of each taxon recorded in the interview catch files is flagged as actual, calculated, or estimated and recorded in the “TYP_CAT_KGS” field (Brousseau et al., 2010 and 2011b). The calculations used to produce the landings’ weights use previously measured length and weight data (Penglong Tao, personal communication, December 13, 2011). In the American Samoa shore-based creel survey, the “HOW_CALC” field is analogous to the “TYP_CAT_KGS” field, but has more detailed flags. The weights are measured; calculated from the measured length; calculated from an average of all fish of that species in the interview; or calculated from the database average length of that species (Brousseau et al., 2011a).

Table 1.a.2 was produced by filtering the “TYP_CAT_KGS” or “HOW_CALC” fields in Microsoft Access and totaling the “CAT_LBS” or “CALC_LBS” fields to determine the count and total pounds of each flagged category. In the CNMI and Guam intercept data, a zero means that a flag was not entered (Michael Quach, personal communication, February 2, 2012). A blank in the American Samoa shore-based intercept data means that a flag was not entered, or that

there is no catch data but there was effort data (Michael Quach, personal communication, October 27, 2011).

2.3.1.2.1. American Samoa boat-based condition landed

In the American Samoa boat-based creel survey, the "HOW_CALC" field was not provided. Like the shore-based survey, this field describes how the weights were calculated, with the options of calculated from an interview species average or calculated from a database average (Brousseau et al., 2011a). The metadata do not indicate that there is a flag for weights calculated from lengths, but Craig Graham documents that this can be the case (Brousseau et al., 2011a and Graham 2011b). Measuring the length and calculating the weight using a standard regression formula has been common for larger fish since 2000 (Graham 2011b). If the fish were landed in the gilled and gutted condition, weight is calculated to a rounded number "using standard conversion factors for all species" (Graham 2011b). A flag for the condition each taxon was landed in serves as a proxy for quality of the weight data because all taxa landed in a condition other than whole must have calculated weights.

Table 1.a.3 was produced by filtering the condition landed field ("COND_CODE") and totaling the "RND_LBS" field in Microsoft Access to determine the count and total pounds of each flagged category.

2.3.1.3. Number of interviews and landings per stratum

The number of interviews per stratum shows the sample size that was used to calculate a CPUE per stratum for the expansion process. The landings per stratum show the relative importance of each stratum to the fishery. Two steps of code were written and used in a Microsoft Access SQL query to find the number of interviews and landings per stratum. The first step creates a table of all strata defined by the species composition files and intercept files. The second piece of code counts all interviews in each stratum using the unique interview key, and sums all of the landings in each stratum using the catch kilograms field and expanded kilograms field for the intercept and estimated data, respectively. It also converts the kilograms to pounds using a conversion factor of 2.20462 pounds/kilogram. The table produced from the code was then summarized into Table 1.a.4 in Microsoft Excel.

2.3.1.3.1. CNMI pool flag

Strata in the expanded files are flagged when the pooling algorithm uses an interview from a different stratum. These flags indicate which strata dimension the interview was borrowed from (for instance, opposite type of day, previous expansion period), but not the actual interview. It is expected that strata with three or more interviews will not have a pooling flag while strata with two or fewer interviews will have a pooling flag. To see how much data were pooled and if the expected expanded strata were flagged, this diagnostic was performed. The data were split by stratum into the pool flag categories found in the database using Access SQL code and the total estimated landings were recorded. The count of strata that were expected to be blank and associated expanded landings were recorded by counting strata with three or more unique interview codes using an Access SQL query. The results are summarized in Table 1.a.5.

2.3.1.4. Comparison of number of taxa in expanded and intercept strata

In order to show how representative the species composition file is and indirectly show the effects of the pooling algorithm, the number of taxa in the expanded and intercept strata were compared. The comparison of number of taxa found in intercept and expanded strata was produced using code that calculates the difference between the number of unique taxa recorded per stratum in the intercept files and the number of unique taxa recorded per stratum in the expanded species composition files. The table produced from the code was then summarized into Table 1.a.6 in Microsoft Excel.

2.3.1.4.1. Taxa found in intercept files but not expanded files

In order to investigate the source of variations between numbers of species found in the intercept and expanded strata, taxa not found in the expanded files were identified using queries. Distinct taxa names found in the intercept files but not in the expanded files, and vice versa, were selected. The taxa in the results of the queries were then filtered in Microsoft Access and the weight column was totaled to produce Table 1.a.7.

2.3.1.4.2. Guam shore-based taxa found in expanded, but not intercept file

The Guam shore-based data were the only expanded file that returned results confirming that there were taxa found in the expanded species composition file but not in the intercept file. Those species making up greater than 1% of the estimated total landings were filtered and the weight column was totaled to produce Table 1.a.8.

2.3.1.5. Methods found in intercept, but not expanded files

Methods not included in the expansion were found using a query that selected distinct method names found in the intercept file but not the expanded file, and vice versa. The methods in the results of the queries were filtered and the weight column was totaled to produce Table 1.a.9.

2.3.2. Hawai‘i

For all figures including type 2 and type 3 data, codes “1” and “2” were left out of the type 2 data. Disposition code 1 is labeled as “thrown back alive/legal” and disposition code 2 is labeled as “thrown back alive/not legal/legality refused” (HMRFS/MRIP Intercept Survey Form, 2011).

2.3.2.1. Coral Reef Taxa Identification

The Hawai‘i CREMUS list received from Marlowe Sabater included only species codes from Hawai‘i’s commercial data. A species list with codes corresponding to the recreational data was received from Tom Ogawa. Species names were cross-referenced with the CREMUS list to categorize the species found in the recreational codes into CREMUS groups. Coral reef associated species found in the recreational list and not on the commercial list, and therefore not on the CREMUS list, were placed in the proper family level CREMUS group or “other.” This table was added to our database.

2.3.2.2. Level of verification of type 3 (verified) intercept data

Type 3 (verified) data were checked for completeness of weight and length data. Type 3 data were exported to Excel and then filtered accordingly. Figure 1.b.1 shows the percentage of the data complete for length and weight, blank for both, or complete for only length or weight.

2.3.2.3. Number and frequency of type 3 intercept records by species complete for length and weight

The type 3 (verified) data contains measurements of length and weight of individual fish. Table 1.b.2 was produced using SQL code in an Access database. The code counted the number of cells that were complete for both length and weight within a species. The complete records as a percent of total are the number of complete records over the total number of records for a species.

2.3.2.4. Frequencies of type 2 unverified fish

In order to determine the frequencies of fish found only in type 2 (unverified) data, a query was run to determine distinct species between the estimated catch, type 2 (unverified), and type 3 (verified) data. All taxa that are present in type 2, type 3, or both type 2 and type 3 are also present in the estimated catch data. Taxa present in only type 2 data are presented in Table 1.b.3. All fish that occur in the intercept data were considered for this table except those with an error code of '999,' signifying that the number of that fish harvested is unknown. The sum of the "NUM_FISH" column was taken for each taxon name only occurring in type 2 data. Then the sum of all fish that occur in the intercept data that the unique type 2 taxa name encompassed was taken. This number was found by filtering the type 2 and type 3 data for each sub-family, genus, or species name that could potentially be categorized taxonomically under the unique type 2 name, and summing the number of fish found in these families, genera, or species. For instance, 31 mullet were identified only as "Mugilidae" in the type 2 data. But, 452 mullet have been harvested and recorded by the survey in all years. Of that 452, 31 were labeled as only "Mugilidae," 362 as *Mugil cephalus*, and the rest as other species within the Mugilidae family. The percentage of unique type 2 fish compared to all fish of that taxa and the percentage of that taxa to the overall (all species, all years) intercept harvest are shown.

2.3.2.5. MRIP and MRFSS query-able species comparison

In order to determine the change in species available for online query after the transition from MRFSS to MRIP, species found on the MRFSS query and MRIP query were compared. A list of species was created for both queries and then cross-referenced. Those species found using the snapshot tool were considered. This query tool yielded the highest number of Hawai'i species. Table 1.b.4 shows those species present in MRIP, MRFSS, or both.

2.3.2.6. Comparison of type 2 and type 3 species composition and harvest

In order to show the relative contribution of type 2 and type 3 data to the intercept harvest of the most caught species, these data were graphed by numbers of fish over all years. A relationship was built between the updated CREMUS list and both the type 2 and type 3 datasets in order to easily group and filter species. Data were exported from Access to Excel and then filtered accordingly; data were filtered to include only coral reef species since 2003 and exclude type 2 fish with the disposition codes 1 or 2. Species included in this graph were chosen based on their abundance. Figure 1.b.5 shows the 20 most numerous species from type 2 and type 3 data.

2.3.2.7. Total intercept harvest of type 2 and type 3 by year

In order to show the relative contribution of type 2 and type 3 data to the intercept harvest year by year, these data were graphed. Intercept harvest (numbers of fish) was split into type 2 and type 3 catch for each year. These data were exported to Excel and then filtered accordingly; data includes only coral reef species since 2003 and type 2 data do not include disposition codes 1 and 2. Figure 1.b.6 shows the intercept harvest for each year.

2.3.2.8. Intercept harvest of type 2 and type 3 by year and CREMUS group

In order to show the relative contribution of type 2 and type 3 data to the intercept harvest of the top three CREMUS groups, these data were graphed. Annual type 2 and type 3 intercept harvest (number of fish) were combined to determine the top three most numerous coral reef species groups. The most numerous group was identified as “other” and Figure 1.b.7 was created including only this CREMUS group. Type 2 data do not include disposition codes 1 or 2. The second most numerous group was identified as jacks. Figure 1.b.8 shows this CREMUS group. The third most numerous group was identified as akule. Figure 1.b.9 shows this CREMUS group. Data are shown from 2003 onward.

2.3.2.9. Completeness of estimated catch data

In the Hawai‘i estimated data, weight is not additive across all strata because weight data are left out when there are no verified weights of a taxon in that stratum (Data User’s Manual, Chapter 8). The data user must decide what taxa weight to use and fill in the missing weight data if landings by estimated weight instead of abundance are desired. Directions for weight substitutions can be found in Chapter 8 of the Data User’s Manual.

In order to quantify estimated catch data completeness, a table was compiled showing the percentage of cells in weight and abundance columns that had null or zero values. Table 1.b.10 was produced by filtering for values not equal to zero, or blank, in an Access database. The columns pertaining to abundance and weight were presented in a table in Excel. The table shows the percentage of records that were blank or had a value of zero compared to those that were complete.

In order to quantify the completeness of estimated catch data by species, weight and variance columns were summarized by complete or null content by species. Table 1.b.11 was produced using SQL code in an Access database. The code first counted the number of expanded strata in which each taxon occurred. The frequency was given by dividing this number by the total number of strata. The number of records for each taxon complete for harvest weight was produced by counting each cell within a species in the “WGT_AB1” column that was not null. The same code for the “ESTWTVAR” column produced the count of records complete for variance. A count of null cells in both of those columns produced the counts of records incomplete for weight and variance and incomplete for variance. A record that is incomplete for weight is always incomplete for variance as well. The counts of null cells over the count of occurrence in strata give the frequency of incompleteness. Figure 1.b.12 was produced by filtering a pivot table in Excel for only those species occurring in greater than 25% of expanded strata. These frequencies were graphed as well as frequency of records incomplete for weight and variance.

2.4. Landings Reports

2.4.1. American Samoa

The expansion process in American Samoa facilitates non-commercial analysis. Data from the expanded species composition file were graphed to summarize year-to-year landings by gear type and CREMUS group. The expanded species composition files provided by Michael Quach were opened in Microsoft Access. A relationship was built between the updated CREMUS list and the species composition file to easily group the species. A query was performed that produced a table with the year, fishing method, species, CREMUS group, pounds caught, pounds sold, and non-commercial pounds (pounds caught—pounds sold) records. This query was exported to a pivot table and pivot chart in Excel, and each graph was produced by filtering the data accordingly. The methods and CREMUS groups with the most landings over all years were considered to be the top one to six methods or CREMUS groups.

2.4.2. Guam and CNMI

In order to produce year-to-year landings summaries by gear type or CREMUS group from the Guam and CNMI creel survey data, an algorithm was written to apply the percent kept and sold data from the interview files to the expanded species composition files. The commercial and non-commercial landings reports are produced from the intercept and estimated species composition files in an Access database using a series of queries. This estimation algorithm is detailed in Section 2 of Appendix 5. In general, the ratio of the non-commercial coral reef species landings to the total landings is applied to the expanded species composition file by stratum to produce an estimate of the non-commercial coral reef landings. Bycatch are excluded from the data expansion (Penglong Tao, personal communication, September 19, 2011), and are excluded from this analysis. Bycatch are defined in this report as fish that were caught, but thrown back.

First, a table was produced that contained all strata found in the intercept or expanded species composition file. Then, the expanded kilograms were summed over each stratum to give total expanded kilograms per stratum. A series of steps follow to calculate the ratio of coral reef taxa and non-commercial coral reef taxa to total intercept landings per stratum. First, the percentage of landings attributable to each taxon is calculated by interview. The sum of the coral reef taxa percentages gives the percentage of coral reef landings by interview. The percentage of non-commercial coral reef landings *by interview* is calculated by multiplying the percentage of unsold landings (collected at the interview level) by the percentage of coral reef landings. The percentage of non-commercial coral reef landings *by stratum* is calculated by summing the products of each interview's non-commercial coral reef landings percentage and total landings then dividing by the total landings in the stratum. The percentage of non-commercial coral reef species is hard-coded as zero when there are interview records, but the sum of the catch is equal to zero.

For expanded strata without interview data, a weighted average of the percentage non-commercial coral reef species of the same year and method was taken. If an expanded stratum did not have sibling year/method interview data, the weighted average was calculated over all years for that method. The weighted average was calculated using the estimated landings.

The estimated non-commercial coral reef landings ratios were then applied by stratum to the expanded species composition file that was filtered to include only coral reef species. Because the percentage of coral reef landings per stratum was retained as well as non-commercial coral reef landings, commercial coral reef landings were also included in the summary file. This summary file was exported to Microsoft Excel and pivot tables and charts were used to produce landings summaries by filtering appropriately. The landings over all years were used to find the top six methods or CREMUS groups.

2.4.3. Hawai‘i

2.4.3.1. Intercept Harvest Reports

2.4.3.1.1. Relative contribution by coral reef taxa to total intercept harvest (number of fish)

Figure 3.g.1 shows a comparison between coral reef and non-coral reef species by each individual year. Both type 2 and type 3 data were combined to create this chart. The relationship built in Access between the CREMUS list and the type 2 and type 3 datasets was used to determine coral reef and non-coral reef species. Type 2 data do not include disposition codes 1 and 2. Coral reef species were also depicted by group for all years combined. Figure 3.g.4 shows coral reef species groups, by type 2 and type 3 harvest, from 2003 to 2010.

2.4.3.1.2. Intercept landings (number of fish) by gear type

Gear-type analysis was performed using intercept data because gear type is not included in the MRFSS estimation procedure. Analysis of fishing method (bottomfishing, trolling, etc.) is not provided because it is not provided in the downloadable data. Two graphs summarize the intercept harvest. Type 2 and type 3 data are shown by gear type for the combined years of 2003 through 2010 in Figure 3.g.2. Type 2 data do not include disposition codes 1 and 2 and only coral reef species are shown. To create this chart, type 1 data had to be merged with type 2 data and type 3 data; there were two mergers done in Access, type 1 by type 2 and type 1 by type 3. This step was necessary because gear type data are solely located in type 1 data while species composition and catch data are located in type 2 and 3. This can be seen in Figure 3.g.2. Based on this figure, the top three gear types were identified and depicted annually. Type 2 and type 3 data were combined. For each year, rod and reel, hand pole, and spear methods are shown. This can be seen in Figure 3.g.3.

2.4.3.2. Estimated Harvest Reports

The estimated data were summarized by boat-based or shore-based fishing and CREMUS group. A relationship was built in Access between the CREMUS species list and the estimated catch file in order to group and filter for coral reef species. Data were exported to Excel and a pivot table was used to filter accordingly. Estimated harvest data do not include fish that were released alive. The six CREMUS groups with the highest number of fish harvested for all years were determined. Figure 3.h.1 shows the top one to three coral reef species groups in the shore-based recreational fishery for each year. Figure 3.h.3 shows the top four to six coral reef species groups in the shore-based recreational fishery for each year. Since the CREMUS group “other” has the most fish harvested, a figure was made to show the top five “other” species. Figure 3.h.2 shows these five species by each year. The same procedure was conducted for the boat-based harvest. Figure 3.h.4 shows the top one to three coral reef species and Figure 3.h.5 shows the top four to six. The overall harvest, shore-based and boat-based, is shown by CREMUS group for all years combined in Figure 3.h.6.

A table was built that tabulated the rank of the top seven harvested species overall by year from 2003-2010. Figure 3.h.7 shows the changes in ranking by year to a rank of 12.

2.4.3.3. 2010 Harvest Reports

2.4.3.3.1. 2010 Intercept Harvest

The 2010 intercept harvest data were summarized by CREMUS group, gear type, and species or CREMUS group within a gear type. A relationship was built in Access between the CREMUS species list and intercept data files in order to group and filter for coral reef species. Data were exported to Excel and a pivot table was used to filter accordingly. Type 2 data do not include disposition codes 1 and 2. The intercept harvest of each coral reef species group is shown for 2010 in Figure 3.i.1. Harvest by each gear type is depicted in Figure 3.i.2. In order to show harvest by gear type, type 1 data had to be merged with type 2 and type 3. There were two mergers: type 1 by type 2 and type 1 by type 3. This step was necessary because gear type data are solely located in type 1 data while species composition and catch data are located in types 2 and 3. The top three gear types were identified from Figure 3.i.4. Two charts were created for each of the top 3 gear types; the first chart depicts harvest by species and the second depicts harvest by coral reef species group. These can be seen in Figures 3.i.3 through 3.i.8.

2.4.3.3.2. 2010 Estimated Harvest

The 2010 estimated harvest was summarized by boat-based or shore-based species harvested. A relationship was built in Access between the CREMUS species list and the estimated catch file in order to group and filter for coral reef species. Data were exported to Excel and a pivot table was used to filter accordingly. The 20 most numerous coral reef species harvested in the shore-based and boat-based fishery in 2010 were graphed. Figure 3.i.9 depicts the estimated shore-based harvest by species; the primary y-axis shows estimated harvest and the secondary y-axis shows the cumulative percent of harvest. The boat-based estimation can be seen in Figure 3.i.10.

2.5. Non-commercial algorithm percentage error

Determining the percentage of coral reef species by strata was an intermediate step in the non-commercial algorithm written for this analysis. It was used to produce an estimate of the percentage of non-commercial and commercial coral reef species landings by stratum. The coral reef landings estimated by this analysis could then be compared to the coral reef landings estimated in the species composition file. This shows the error associated with the estimation algorithm, introduced by estimating the total percentage of non-commercial coral reef landings using a weighted average for strata without interview data.

First, only coral reef species were selected from each creel survey's species composition file. The expanded weight column was totaled and recorded. Then, the estimated CREMUS kilograms column from each summary file produced in this analysis was totaled and recorded. The percentage error between the coral reef species composition selection and the summary estimated coral reef species landings was then calculated as the absolute value of the difference between the two sums divided by the sum from the coral reef species composition selection.

3. Results

3.1. Diagnostics

3.1.1. American Samoa, Guam, and CNMI

3.1.1.1. Coral reef taxa identification

In general, the data matched the coral reef species list received from Marlowe Sabater. The species not listed in the coral reef, pelagic, or bottomfish lists are presented in Table 1.2.1. The cigar wrasse in the CNMI shore-based creel survey is the only species making up greater than one percent of the landings. By definition, species should not exist in the creel survey databases without existing on a management unit species list (David Hamm, personal communication, February 2, 2011). This may mean that the coral reef species list received from Marlowe Sabater is not the most recent list from WPacFIN. All reef-associated species identified by this query were added to the CREMUS lists and included in this analysis.

3.1.1.2. Quality of intercept landings data

A majority of the weights are calculated in Guam and CNMI but the quality of the data in American Samoa are unknown. In Guam, about one third of the landings by weight are estimated in the boat-based survey and 15% in the shore-based survey. The method of weight determination is unknown for 11% of the Guam shore-based landings. CNMI has less estimation, and about one-third of the shore-based landings are measured weights. In the American Samoa shore-based survey, 99% of the intercept landings by weight are reported as actual weights. However, the creel survey documentation states that the total weight of fish can be actual, calculated, or estimated while these data can only be stored in the database as actual or calculated, with three options for calculation (Oram et al., 2011b). A flag for estimated data do not exist, so it is not known to what extent estimation occurs. An analogous field in the American Samoa boat-based catch file was not available for all years of the survey, but the condition landed serves as a proxy for calculated values. These results are shown in Table 1.a.2.

3.1.1.2.1. American Samoa boat-based condition landed

Most (80%) of the fish that were sampled by the boat-based survey were landed whole. The proportion of these fish that were measured for length and not weight is unknown. However, it is known that 20% of the fish were landed in the gutted and gilled condition and must have calculated total weights. These results are shown in Table 1.a.3.

3.1.1.3. Number of interviews and landings per stratum

More expanded strata without interview data exist in the boat-based surveys than the shore-based surveys. The CNMI boat-based survey has the most pooling and the CNMI shore-based the least. Table 1.a.4 shows how many strata are sampled by the intercept surveys and participation surveys combined and summarizes them by how many interviews were conducted in the strata. The relative importance of each interview range is shown in the intercept landings and estimated landings columns, and their percentages of the total intercept or expanded landings. When methods are not recorded in the participation count, they will not be expanded even if they are present in the interview files (David Hamm, personal communication, February 2, 2012). Close to one-quarter of the boat-based landings in Guam and CNMI are concentrated in expanded strata that do not have any interview data from which to calculate a catch rate. The CNMI boat-based survey shows the most pooling (strata with 0-2 interviews) with 55% of the estimated landings by weight falling in the pooled strata. The other creel surveys have 15-29% pooled landings. It was learned that Guam shore-based creel survey does not have a “POOL_FLAG” column (Penglong Tao, personal communication, February 2, 2012). At the writing of this paper, the Guam shore-based data were pooled directly from a reference table in every instance of pooling, instead of first using more closely related strata.

It was found that Penglong Tao provided the daytime only expansion of the CNMI boat-based creel survey, as estimated landings exceed intercept landings in the 12 strata with greater than 50 interviews used to calculate catch rate. In the boat-based survey, a nighttime sampling shift was added in August 2005. There is an option of expanding the data using daytime only or using the full day. Penglong Tao usually provides only the daytime expansion (Penglong Tao, personal communication, February 2, 2012).

3.1.1.3.1. CNMI pool flag

Eleven percent of the estimated landings in the shore-based survey and 32% in the boat-based survey are calculated with catch rates pooled from related strata, according to Table 1.a.5. Based on only the count of interviews in each stratum, it was expected that 15% of the landings in the shore-based survey would be in pooled strata and 60% in the boat-based survey. The discrepancy comes from some interviews belonging to sampling strata that were not expanded, and possibly errors in the “POOL_FLAG” column. It was learned that the portion of the year (January to April in the shore-based survey, and January to March in the boat-based survey) that was not surveyed during the first year of the time series was filled in with the following year’s data (David Hamm, personal communication, February 2, 2012).

3.1.1.4. Comparison of number of taxa in expanded and intercept strata

Between half and three-quarters of expanded strata have a different number of taxa found in sibling expanded and interview strata, according to Table 1.a.6. The numbers of taxa found in each stratum were used to show the results of the pooling algorithm because the expanded species composition file is used for this non-commercial analysis. It was found that in the shore-based creel surveys, the number of taxa differs in 59% of the strata in CNMI and 75% of the strata in Guam. In the boat-based surveys, the number of taxa differs in 71% of the strata in CNMI and 49% of the strata in Guam. Further diagnostics were performed to investigate the source of the differences in taxa present.

3.1.1.4.1. Taxa found in intercept files but not expanded files

In all creel surveys, only small numbers of taxa recorded for a small number of interviews were not found in the expansion. Therefore, species exclusions should not be considered an important factor in explaining the differences in the numbers of taxa between the expansion and intercept files, presented in diagnostic 3.1.1.4. These can be attributed to pooling in most instances. The expanded strata are built from the participation files. Methods not counted in an expansion period in the participation survey but that were recorded in the interview will be represented as interview strata but not expanded strata. This accounts for some of the deviation in species, but was only identified for species or methods that never occur in the expansion. The option to exclude species only exists in the Guam shore-based expansion (Penglong Tao, personal communication, February 2, 2012). Table 1.a.7 shows species found in the intercept files but not in the expansion.

In the CNMI shore-based data, three taxa (clam/bivalve, eel [freshwater], and sea cucumber) that only occurred in three interviews for a catch of 17.9 pounds are excluded from the expansion. These three taxa are only recorded as caught by gleaning, and they are the only three taxa in the gleaning method that are not caught using any other method. Gleaning is not found as a method in the expanded data.

In the CNMI boat-based creel survey, five taxa (clam/bivalve, eel [freshwater], sharks, shrimp [saltwater], and spiny lobster) in only five interviews were excluded from the expansion. The eel was bycatch and therefore not included in the expansion. Shrimp [saltwater] and clam/bivalve belonged to a method not recorded in the participation sampling strata. Spiny lobster belonged to an interview that was discarded and it is unknown why sharks were discarded. Weights were recorded as 0 for these five taxa, but other taxa have weights recorded as 0 and many records in the expanded species composition file are expanded to weights of zero.

In the Guam boat-based creel survey, *Caulerpa racemosa, Charonia tritonis, Gymnothorax meleagris, Heterocarpus* spp.*, Lambis chiragra,* Manåhak spp.*, Plectorhinchus albovittatus,* and *Strombus taurus* are not expanded. These taxa are found in only 21 interviews and make up less than 0.01% of the overall catch. *Caulerpa racemosa, Charonia tritonis, Heterocarpus* spp., *Lambis chiragra,* Manåhak spp., and *Strombus taurus* were only caught using methods that were not recorded in the participation stratum. *Gymnothorax meleagris* is recorded as caught only in 1994 at Agat Marina. Sampling began at Agat Marina when it opened in 1994 (Oram et al., 2011c) but it is only expanded from 1995 onward, according to the data received for this analysis. Two interviews exist for this port before it opened; one in 1982 and one in 1991. *Plectorhinchus albovittatus* was caught only at a port that was not in the expansion for the stratum in which the interview occurred.

In the Guam shore-based creel survey, 10 taxa were not found in the expansion. *Aetobatis narinari, Actinopyga* spp., and Serranidae were excluded on the basis that they were only recorded as bycatch. Of the remaining taxa, *Caranx* i'e', Manåhak ha'tang, and *Mulloidichthys* ti'ao each make up greater than 2% of the overall shore-based intercept landings. It was learned that database users have the option of excluding *Caranx* i'e, *Mulloidichthys*, Manåhak lesso, Manåhak ha'tang, Manåhak spp. and *Selar crumenopthalmus* from the expansion because they are pulse fisheries and may mask trends in the overall fishery if included in the expansion (Penglong Tao and David Hamm, personal communication, February 2, 2012). These species are only left out in the Guam shore-based survey. However, *Selar crumenopthalmus* was included in the expansion received for this analysis. Also, the scientific names of the pulse manåhak species (*Siganus argenteus* and *S. spinus*) are not excluded from expansion. It is unknown why *Aeoliscus stribatus*, *Caranx lugubris*, *Halichoeres* spp., and *Limnichthys donaldsoni* were not found in the expansion.

In the American Samoa shore-based data, 25 taxa were not found in the expansion. Sixteen of these were only recorded in years when the creel survey was not expanded. Data on sand and coral rubble is stored in the interview files so that it is accounted for in a data storage system, but it is not expanded (David Hamm, personal communication, February 2, 2012). Not enough data were provided to determine if the remaining taxa were not found in the expansion because participation counts from the expansion period did not include the method used to harvest the taxa. It is unknown why these remaining taxa are not found in the expansion. In the boat-based data, the blue shark is the only species not found in the expansion, and it is only found in one record.

3.1.1.4.2. Guam shore-based taxa found in expanded but not interview files

One hundred fifty-seven taxa were found in the Guam shore-based expanded species composition file, but not the interview file, in the year range of 2003-2010 for both files. *Lambis* spp., assorted reef fish, and five other taxa each make up greater than one percent of the estimated landings, as can be seen in Table 1.a.8. It was learned that the pooling algorithm in the Guam shore-based creel survey fills expanded strata from the reference table with data from all years before looking in closely related strata, as in the other expansion (David Hamm, personal communication, February 2, 2012).

3.1.1.5. Methods found in intercept files but not expanded files

There is some mismatch between what methods are found in the expansion and in the intercept files. This is because the expanded files are created from participation counts, so methods not recorded in the participation counts will not exist in the expanded file, but rarely may exist in the interview files (David Hamm, personal communication, February 2, 2012). The mismatch is small but significant in some cases. These results can be seen in Table 1.a.9.

It was found that the CNMI shore-based fishing methods in the expansion file include only cast net, hook and line, spear/snorkel, and octopus hooking. The octopus hooking method was only expanded in 2008 using the pooling algorithm, although only three interviews, which took place in 2005 and 2006, use the octopus hooking method. This means octopus hooking was recorded in participation counts in 2008, but no interviews were collected using that method in 2008. Gleaning, gill nets, and traps are methods also found in the intercept file, accounting for 5% of the total intercept landings. These methods are not found in the expansion. Traps are only recorded in one interview. In the boat-based creel survey, hook and line and shallow bottomfishing methods are not found in the expansion. These methods do not account for a significant portion of the landings. Comparison of interviews where these methods occurred with the species composition of the "other" method indicates that hook and line and shallow bottomfish were not in the expansion, and not aggregated into the "other" methods category.

In the Guam shore-based survey, unknown method was the only method category not found in the expansion. The records with an unknown (blank) method make up less than 0.01% of the landings since 2003. It was found that the boat-based expansion does not contain the fishing methods of atulai net, manåhak, octopus snagging, pelagic gill driftnet, scuba with handline, shrimp trap, or snorkel with handline. These methods account for less than 1% of the overall intercept landings, and most of those landings are attributed to the manåhak method. Since manåhak species are excluded from the expansion, it is expected the method would be excluded as well. The methods were not aggregated into the "other" methods category, according to comparison of the species composition of the landings from each method in the species composition and intercept files.

It was found that in the American Samoa shore-based creel survey, methods not found in the expansion include diving-boat, enu (traps), gill net-boat, harpoon, harpoon-boat, mixed inshore, other shore based, sand mining, seining-boat, troll-boat, and weir fishing. Excluding boat-based methods and sand mining, these methods account for about 4% of overall intercept landings, with traps as the most important. In the boat-based survey, "blank" and "unknown" boat-based methods were not found in the expansion. These methods account for less than 0.01% of the catch. Spear (boat- no tanks), spear (boat-tanks), and spear (boat-w/wo tanks) were aggregated into one spearfishing group in the expansion. Spear fishing without tanks accounts for a majority of total spear fishing landings with 89% of the spearfishing landings, while spear fishing with tanks makes up 11% of the landings. CPUE is likely different for spear fishing with SCUBA tanks and without, so combining these methods may introduce bias into the estimation procedure. Spearfishing with SCUBA gear is now illegal in American Samoa and Saipan (David Hamm, personal communication, February 2, 2012).

3.1.2. Hawai‘i

3.1.2.1. Level of verification of type 3 (verified) data

Relative completeness of available catch by number of fish in the Hawai‘i non-commercial fishery for all years is shown in Figure 1.b.1. Both coral reef and non-coral reef species are included. The majority of records, 60%, were incomplete for length, weight, or both. There were 40% of records complete for length and weight and 24% percent of records blank for both length and weight.

The 40% of records that are complete for length and weight are considered by species. Pelagic species have the highest sample size of unique fish measurements. There are 13 coral reef species with greater than 50 unique length and weight combinations. Of these species, records of *Hemipteronotus pavoninus, H. baldwini. Mulloidichthys vanicolensis,* and *Caranx ignobilis* are complete in more than half of the records. Fish of the genus *Hemipteronotus* (now accepted as *Iniistius* according to Randall, 2007, p. 349-353) occur with high frequency in type 2 unverified data, however. There were 42 coral reef species with no complete records. These results can be seen in Table 1.b.2.

3.1.2.2. Frequencies of type 2 unverified fish

Most of the fish that occur only in the type 2 data are found with very low frequency in the intercept data. Of the fish that occur with higher frequency (between 1% and 15%) in multiple taxonomic levels, only fish of the genus *Hemipteronotus* (*Iniistius*) occur with a significant unverified frequency (23%). Jacks represent 15% of the intercept harvest by number of fish, but only 2% of the total jacks were placed in type 2 data because they were only verified to the family level. Results can be seen in Table 1.b.3.

3.1.2.3. MRIP and MRFSS query-able species compositions

The online query tool can be used to retrieve catch type (landings, harvest, or catch) by year, wave, fishing mode, fishing area, and species. However, weight data are less complete than abundance data. Weight and variance estimates are additive across strata, but when values are missing, sums will be underestimated (MRFSS Data User's Manual, n.d.) Another limitation with the query tool is that the species listed are not all inclusive and not all of the CREMUS species are available. A particular species may not be listed on the online snapshot query if they are not as common or if there is limited data available (Hongguang Ma, personal communication, October 19, 2011). The online query changed under new MRIP estimation procedures. For species, the MRIP query has less specificity compared to the MRFSS query.

There are fewer species available on the MRIP query. There is an "other fish" category in both queries. For the MRFSS query, there was a total of 51 species listed in the "other fish" category in the MRFSS query snapshot. In the MRIP query, there was a total of 110 species listed in the "other fish" category. These results can be seen in Table 1.b.4. It is unknown why the MRIP query is less specific than the MRFSS query (Hongguang Ma, personal communication, February 24, 2012).

3.1.2.4. Comparison of type 2 and type 3 species composition and harvest

The proportion of type 2 to type 3 data making up the harvest of each taxon is variable. The intercept harvest of *Selar crumenophthalmus* is twice that of the second most harvested species. The top five coral reef species (number of fish), when combining type 3 (verified) and type 2 (unverified) intercept landings, are: *Selar crumenophthalmus, Decapterus macarellus, Mulloidichthys flavolineatus, Acanthurus triostegus,* and *Herklotsichthys quadrimaculatus*. When considering the top five by type 3 harvest, the most numerous species are: *S. crumenophthalmus, D. macarellus, Priacanthus meeki, A. triostegus, and M. flavolineatus*. If sorting by type 2*: S. crumenophthalmus, D. macarellus, M. flavolineatus, Ctenochaetus strigosus,* and *A. triostegus*. These results can be seen in Figure 1.b.5. In this figure it is possible that the species *Iso hawaiiensis* was mis-identified (Tom Ogawa, personal communication, February 24, 2012). The two commonly caught species belonging to the genus *Hemipteronotus* (*Iniistius)* occur in the top twenty species and when all species identified in this genus are grouped together, the genus becomes one of the top five harvested taxa.

3.1.2.5. Total intercept harvest by year

Total intercept harvest is variable by year. The year with the highest number of coral reef species intercept landings was 2009, with 7,051 combined type 3 (verified) and type 2 (unverified) fish. This is followed by 2003 with 6,827 verified and unverified landings. For all years combined, there are 20,355 verified landings and 16,379 unverified landings, totaling 36,734. The year with the fewest landings was 2008 with 2,161. There is a range of 4,890 between years. These results can be seen in Figure 1.b.6.

3.1.2.6. Intercept harvest by year and CREMUS group

The coral reef species group that is most harvested is "other." The majority of intercept landings, type 2 (unverified) and type 3 (verified), took place in 2003. As seen in Figure 1.b.7, there are fluctuations in landings between years. The range observed between the lowest and highest year is 2,711. The second most harvested group is the jacks. There are considerable fluctuations between years for this group; 2008 with 366 intercept landings and 2009 with 1,611 intercept landings. The third most harvested group, akule, is the most inconsistent between years. The years 2004 and 2008 had 97 and 162 landings for this group respectively. This contrasts 2010 with 1,687 landings and 2007 with 1,635 landings. These results can be seen in Figures 1.b.7, 1.b.8, and 1.b.9. In several figures a decrease is seen in 2008. It was communicated that 2008 was generally a bad year for fishing (Tom Ogawa, personal communication, February 24, 2012).

3.1.2.7. Completeness of estimated catch data

Abundance data are much more complete than weight data. When considering the estimated total catch by number of fish (A + B1 + B2), the data are 94% complete. The percentage of records in the estimated data that are complete for type A, type B1, or type B2 can be seen in Table 1.b.10. 57% of the records are complete for type A, meaning they do not contain a value of zero or are blank. The estimated total harvest records (A + B1) are 82% complete. Estimated weight of type A fish is 65% incomplete. Sixty-two percent of all taxa records are incomplete for harvest weight and variance. Eleven percent are incomplete for harvest variance, meaning that only one fish in the year/state/wave/mode/area stratum was measured. Harvest landings are left blank when no fish are measured (Data User's Manual, Chapter 8). Of the 17 species occurring in over one quarter of strata, six species have records with missing harvest weights with greater than 50% frequency. These are *Lutjanis kasmira*, *Selar crumenopthalmus*, *Lutjanis fulvus*, *Sphyraena barracuda*, *Acanthurus triostegus*, and *Mulloidichthys flavolineatus*. These results can be seen in Tables 1.b.10 and 1.b.11, and Figure 1.b.12.

3.2. Non-commercial and commercial landings reports

3.2.1. American Samoa shore-based

Most of the shore-based fishery is non-commercial, with very little reported commercial fishing occurring from 2005-2010 in these gear type fisheries. The most important gear type in the non-commercial fishery is the rod and reel, followed by gleaning and then throw net. A large difference in landings occurs in each gear type fishery during the two expanded time periods, with much less activity occurring from 2005-2010 than from 1990-1996. The graphs show a significant decline in fishing activity between the two expansion time periods, but there have not been any significant social or economic events that would explain such a significant decline (Domingo Ochavillo, personal communication, February 28, 2012). The rod and reel fishery spiked in 1991, with about 80 thousand pounds of non-commercial and about 20 thousand pounds of commercial landings. The only other year with reported commercial landings was 1990, with about five thousand pounds of commercial landings and 38 thousand pounds of non-commercial landings. The gleaning fishery has the greatest proportion of commercial landings of the three gear type fisheries, but no trend is apparent. Non-commercial landings in 2008 are comparable to those in 1991 and 1994, but the overall landings in 1991 and 1994 are higher due to commercial fishing. The throw net fishery has the least commercial fishing of these gear type fisheries, with very little landings attributed to the commercial fishery. Ochavillo confirmed that most landings by throw net are for personal consumption (personal communication, February 28, 2012). However, the proportion of non-commercial landings to commercial landings is unknown for all gear types and overall in American Samoa. Theoretically, all commercial activity is covered by the creel surveys because there are only a few landing sites that the survey does sample. However, the creel survey on Tutuila only covers the southern portion of the island, while there is non-commercial fishing activity occurring on the northern part of the island. Therefore, non-commercial fishing activity is underestimated to an unknown magnitude (Domingo Ochavillo, personal communication, February 28, 2012).

3.2.2. American Samoa boat-based

Most of the estimated boat-based landings are overwhelmingly commercial landings, and the non-commercial landings do not follow trends in the commercial landings. The bottomfishing, spearfishing, and mixed method bottomfishing/trolling fisheries are the most important boat-based fisheries covered by the creel survey. The industrial longline fleet is not covered by the creel survey (Graham, 2011b). The bottomfishing fishery shows the most non-commercial activity, with the most activity occurring at around ten thousand pounds annually from 2001 to 2005. Trends in the overall non-commercial fishery follow trends in the bottomfishing non-commercial fishery. The spearfishing fishery shows very little non-commercial activity, with variable overall activity in the fishery. As spearfishing interviews are hard to obtain, it is unknown whether the variability in the graph is actual or an artifact of the survey (Graham 2011b). The fact that spearfishing with a snorkel and with SCUBA gear are combined as the same fishing method in the expansion also likely contributes to the variability. The bottomfishing/trolling mixed fishery shows a decline in overall fishing activity in the 2000s compared to the 1990s. Non-commercial fishing is variable overall and as a percentage of overall landings. It is known that the creel survey does not capture data on American Samoa’s sport fishery. There are some boats that are purely recreational, but participation counts for weekends/holidays are only done on some Saturdays (David Hamm, personal communication, February 2, 2012). The mechanism for sampling the sport fishers does not exist within the creel survey yet (Domingo Ochavillo, personal communication, February 28, 2012). As with the shore-based survey, it is difficult to identify trends in the creel survey expanded data because the results cannot be explained by what is known about fishing activity in American Samoa (Domingo Ochavillo, personal communication, February 28, 2012).

3.2.3. Guam shore-based

It is unknown to what extent the Guam shore-based expansion was affected by the pooling algorithm filling directly from a reference table. Almost all of the shore-based fishing activity is non-commercial, and this was expected by Brent Tibbatts, the shore-based program leader (personal communication, February 27, 2012). The hook and line fishery is the most important gear type in the Guam shore-based fishery, followed by gill nets and then spearfishing with a snorkel. The hook and line fishery dives in 2010. Brent Tibbatts reported that 2010 was an exceptionally rainy year, especially for a non-typhoon year, so fishing activity was down due to high surf, heavy rain, and strong winds (personal communication, February 27, 2012). The gill net fishery spiked to about fifty thousand pounds in 2010, and the spear/snorkel fishery declines over the past seven years. There is probably an increase in boat-based spear/snorkel activity in recent years but it is unknown whether this would correspond with a decrease in shore-based spear/snorkel activity (Brent Tibbatts, personal communication, February 27, 2012).

The Guam shore-based expansion also has the option of excluding certain species that belong to pulse fisheries (Penglong Tao, personal communication, February 2, 2012). The names of the taxa in the creel surveys are *Caranx* i‘e‘, *Mulloidichthys* (formerly *Mulloidichthys* ti‘ao), manåhak lesso, manåhak hatang, manåhak spp., and *Selar crumenopthalmus*. The option exists to exclude some or all of these, and the data received for this project excluded all of these except for *Selar crumenopthalmus*. However, manåhak appear in the data we received under their scientific names (*Siganus argenteus* and *S. spinus*) and can be seen in the results in CREMUS group “rabbitfish.” Penglong Tao was notified of this.

3.2.4. Guam boat-based

Boat-based fishing of coral reef species in Guam trends upwards, reaching a peak in the late 1990s, then trends downward to the end of the time series. Most of the estimated boat-based landings are non-commercial, but the fishery has a significant commercial component which has also declined since the late 1990s. The bottomfishing, spear/SCUBA, and spear/snorkel fisheries are the fisheries responsible for the most boat-based landings. The spear/SCUBA fishery has the smallest proportion of non-commercial landings to its overall landings while the bottomfishing and spear/snorkel fisheries are mostly non-commercial landings. This is expected in the bottomfishing fishery as most commercial bottomfishing in Guam is deeper than coral reef habitat (Brent Tibbatts, personal communication, February 27, 2012). In recent years, commercial spear fishermen in Guam have been purposely avoiding the creel survey interviewers. Spearfishing is probably the most important gear type in commercial boat-based landings of coral reef species, but the data are not complete (Brent Tibbatts, personal communication, February 27, 2012). Thomas Flores, Jr. says that SCUBA and freediving spearing in the last two years has been mostly commercial. More teams of free diving spearfishers from the Federated States of Micronesia fish in Guam in the last few years compared to ten years ago. It is believed that most of these catches are sold because of the way the fish are packed upon return and “there appears to be an individual that’s ‘in charge,’ probably indicating that there’s a market these fishers are supplying fish to” (Thomas Flores, Jr., personal communication, February 28, 2012).

3.2.5. CNMI shore-based

The CNMI shore-based dataset has the shortest range of years. The shore-based time series is only six years, so trends may not be indicative of the overall fishery (Ray Roberto, personal communication, February 27, 2012). As in the other shore-based fisheries, most of the estimated landings are non-commercial. The commercial fishery has declined in the past two years. The spear/snorkel fishery accounts for most of the commercial landings while the cast net fishery accounts for the least. However, a creel technician had reported that some hook and line fishers who identify themselves as non-commercial have been selling their catch (Michael Tenorio, personal communication, March 1, 2012). Of the three expanded methods, spear estimates are the least reliable because the survey design is more effective at capturing participation of spear fishers than sampling their catch (Michael Tenorio, personal communication, March 1, 2012)

3.2.6. CNMI boat-based

Non-commercial landings exceed commercial landings in most years of the boat-based survey. There is also more variability in the commercial landings than in the non-commercial landings. The bottomfishing fishery accounts for the most landings, with the spear/snorkel and atulai method fisheries as the next most important fisheries, respectively. The bottomfishing non-commercial landings do not show as much variability as the commercial landings. Most of the spear/snorkel landings are non-commercial, with five of 11 years estimated as completely non-commercial. Boat-based commercial spearfishing is underrepresented in the creel survey data. The survey is scheduled until 2 a.m. and most serious commercial spear fishers work at night and do not return until after 2 a.m. (Ray Roberto, personal communication, February 27, 2012). It is unrealistic that there would be no sold catch of coral reef species by spearfishers in any given year (Michael Tenorio, personal communication, March 1, 2012). The atulai method fishery is estimated as entirely commercial in 2001 and 2002 and entirely recreational in 2006 and 2010. It is expected that the atulai fishery is variable in landings and in proportion of non-commercial landings, but not that some years would have no commercial landings. It is a pulse fishery, and atulai fishing can be a traditional social event in which some families share their catch with others and some sell a portion of their catch to cover fishing expenses (Ray Roberto, personal communication, February 27, 2012). Some fishermen do sell their atulai landings year after year, but it is likely a net restriction in 2004 contributed to variation in the results after this time (Michael Tenorio, personal communication, March 1, 2012).

3.3. Non-commercial landings reports

3.3.1. American Samoa shore-based

The top three gear types estimated at landing the most weight of coral reef species were rod and reel, gleaning, and throw net. The top four to six methods were spear/snorkel, handline, and passive gill nets. A spike in rod and reel in 1991 may overwhelm the importance of the gleaning fishery, responsible for the most landings in nine of the 12 years of the survey. Landings by handline and passive gill net are very low since 2005, but handline landings in 1990 and 1991 were comparable to throw net and gleaning landings. Atulai, mollusks, and surgeonfish were the top three CREMUS groups landed followed by jacks, invertebrates, and other finfish. The high landings of atulai in 1990 and 1991 overwhelm the other CREMUS groups, as in some years fewer atulai are caught. The effect of the expansion algorithm on catch estimates for seasonal fish is unknown. Because atulai are a pulse fishery, it is possible that some years have high landings and others hardly any (Domingo Ochavillo, personal communication, February 28, 2012). There were minimal landings of invertebrates from 2005 to 2010.

3.3.2. American Samoa boat-based

The top three methods in the American Samoa boat-based fishery were bottomfishing, mixed bottomfishing and trolling, and longlining. The top four to six methods were spearing, trolling, and atule-mixed. The boat-based fishery has relatively less coral reef landings than the shore-based fishery. Bottomfishing was double or more in 2001-2005 than in all other years. Landings by the top four to six methods are present in some years and absent in others. There is a spike in spearfishing in 2010. The landings of the top three and top four to six species groups are also present in some years and absent in others. Other finfish, jacks, and surgeonfish make up the top three landings categories while mollusks, crustaceans, and miscellaneous reef fish make up the next most important landings. Surgeonfish spiked in 2010. This spike is surprising because surgeonfish are usually caught consistently in high numbers; landings do not fluctuate much because they are always abundant (Domingo Ochavillo, personal communication, February 28, 2012). Non-commercial landings of the top overall four to six CREMUS groups are very low from 1990 to 1997. The spiny lobster fishery is an important commercial fishery, and most of the landings are reported as sold.

3.3.3. Guam shore-based

Methods accountable for the top three greatest landings overall in the Guam shore-based fishery since 2003 are hook and line, gill net, and spear/snorkel. The next four to six are cast net, hooks and gaffs, and surround net. The non-commercial spear/snorkel fishery trends downward. The gill net fishery spikes in 2010 while the hook and line fishery dives. Cast net landings are more comparable with the top three methods with a range of about seven thousand to 35 thousand pounds, while hooks and gaffs only exceeded five thousand pounds in 2005, 2007, and 2009. Surround net stays below 25 hundred pounds. Surgeonfish, jacks, mollusks, rabbitfish, atulai, and other are the CREMUS groups with the most overall landings, respectively. Atulai spike in 2009.

3.3.4. Guam boat-based

Bottomfishing, spear/snorkel, and gill net account for the most non-commercial coral reef landings overall in the Guam boat-based fishery, followed by spear/SCUBA, atulai night light, and surround net. The boat-based coral reef species landings are higher than the shore-based landings in Guam. Landings are highly variable. Gill net landings have the most variability of the top three methods. Surround net is not present in most years but spikes in 1999. The atulai night light method drops off in later years. The species groups with the most overall landings were atulai, emperors, surgeonfish, parrotfish, jacks, and miscellaneous reef fish. Atulai spike in 1999 and stay low following. Atulai catch was high in 1999, but the spike shows that the surveyors encountered netting activity of this seasonal species and should not lead to interpreting a decline in atulai landings in later years. Many fish are harvested in a short amount of time in an atulai run, but these events may be known as not captured by the creel survey, as was the case in 2010 and 2011 (Thomas Flores Jr., personal communication, February 28, 2012).

3.3.5. CNMI shore-based

Hook and line, spear/snorkel, and cast net are the only methods expanded in the CNMI shore-based survey. The apparent downward trend in the spear/snorkel fishery may be verifiable by looking at participation data, but this time series is also short (Ray Roberto, personal communication, February 27, 2012). Landings by hook and line are highest overall, but only highest annually in 2008 and 2009. The hook and line fishery is sometimes a pulse fishery, when juvenile jacks come close to shore (Ray Roberto, personal communication, February 27, 2012). Estimation for this fishery may have also been affected by changes in sampling effort in some years (Michael Tenorio, personal communication, March 1, 2012). Cast net has the lowest landings in every year except 2010, when the landings are highest. Juvenile jacks and juvenile goatfish are the usual targets of the cast net fishery, which is usually subsistence fishing and not enough is caught to sell (Ray Roberto, personal communication, February 27, 2012). The order of highest overall landings of CREMUS species groups is jacks, emperors, other, atulai, surgeonfish, and rabbitfish. Atulai spike in 2010 and rabbitfish spike in 2009. However, the atulai spike is not real; one interview had many fish and this led to an overestimation in the expansion procedure (Ray Roberto, personal communication, February 27, 2012).

3.3.6. CNMI boat-based

Bottomfishing, spear/snorkel, atulai, gill net, cast net, and trolling make up the top six non-commercial boat-based fisheries of coral reef species in CNMI. Bottomfishing trends downward from 2000 to 2003, and then jumps up to about 15 thousand pounds, where it remains relatively steady. Spear/snorkel trends downward until 2007 with a slight rise to 2008. The atulai method is not present in 2001, 2002, or 2006. Of the other methods, gill net landed about 20 thousand pounds in 2000 and about seven thousand pounds in 2002, but was low, if present, in the other years. A gill net restriction was imposed in 2002, which is why the landings drop off after this year (Ray Roberto, personal communication, February 27, 2012). Cast net and trolling are present in some years and absent in others. Emperors, atulai, surgeonfish, groupers, jacks, and parrotfish account for the most landings, respectively. Emperors and jacks spiked in 2000. Emperors are commonly landed in gill nets, so this matches the high gill net activity in 2000 (Ray Roberto, personal communication, February 27, 2012). The spike in jacks in 2000 could be a problem with the data, but jacks are usually a cultural/pulse fishery (Michael Tenorio, personal communication, March 1, 2012). Atulai were present in some years and absent in others. This could be partially due to net restrictions and partially because atulai are a pulse fishery (Michael Tenorio, personal communication, March 1, 2012).

3.3.7. Hawai‘i

3.3.7.1. Intercept harvest reports

A comparison between coral reef and non-coral reef species by year shows that the majority of species caught (by number of fish) are coral reef species. For all years combined, there were 36,734 fish of coral reef species intercept harvested and 21,471 fish of non-coral reef species harvest. For each individual year, except for 2008, there were more coral reef species caught than non-coral reef. In 2008, 3,181 non-coral reef species were landed and 2,161 coral reef species were landed. These results are shown in Figure 3.g.1.

Coral reef species groups are considered for all years combined. The top three groups are "other", akule, and jacks. Type 3 (verified) data made up 62% of the "other" harvest, 38% of the akule harvest, and 65% of the jacks harvest. With the exception of mullet, rudderfish, parrotfish, and reef sharks all other coral reef species groups have more than 50% of their harvest attributed to type 3 data. These results are shown in Figure 3.g.4.

There are 12 different gear types recorded in the intercept data: rod and reel, spear, hand pole, throw net, surround net, scoop net, gill net, hand line, hukilau net, crab net, hand, and cross net. The gear type responsible for the most harvest in the Hawaiʻi non-commercial fishery is overwhelmingly the rod and reel. From 2003 to 2010, there were 22,473 fish harvested from this gear type. The rod and reel fishery made up 62% of the total harvest. Following rod and reel is the spear fishery, with 3,953 fish harvested (11% of total), and the hand pole fishery with 3,214 fish harvested (9% of total). The majority of harvest for the rod and reel fishery is from type 3 data, but a large portion also comes from type 2; 13,172 and 9,301 respectively. These results are shown in Figure 3.g.2. The top three gear types are considered for each year from 2003 to 2010. When considering the total harvest for only these three gear types, rod and reel accounts for 76% of harvest, hand pole 11%, and spear 13% of the harvest. These results can be seen in Figure 3.g.3.

3.3.7.2. Estimated harvest reports

For the shore-based fishery, the top one to three coral reef species groups are other, goatfish, and surgeonfish. In 2003, there were 3,435,473 estimated fish harvested for the other group. The "other" group includes *Priacanthus meeki*. With the removal of 2003, the other group makes up 53% of total estimated landings when considering these three groups. These results can be seen in Figure 3.h.1. The top one to five species that make up the "other" group are *P. meeki*, *Herklotsichthys quadrimaculatus*, *Kuhlia sandvicensis*, *Encrasicholina purpurea*, and *Iso hawaiiensis*. In 2003, an estimated 2,644,519 *P. meeki* were harvested. This makes up 98% of this species' harvest for the combined years of 2003-2010. These results can be seen in Figure 3.h.2.

For the shore-based fishery, the top four to six coral reef species groups are akule, jacks, and rudderfish. When considering the total of these three groups, akule comprises 58% of the harvest. There was harvest in every year for each group (no data available for 2002). The year with the most akule harvest was 2005 with 473,609 estimated fish. The year with the least akule harvest was 2007 with 19,715 estimated fish. These results can be seen in Figure 3.h.3.

Species are also considered for the boat-based fishery. The top one to three coral reef species groups for the boat-based fishery are jacks, akule, and wrasse. Akule comprise 42% of harvest for these three groups, but harvest year-to-year is variable. In the 2007 estimate, 818,008 akule were harvested making up 53% of the harvest for all years. To compare, 4,661 akule were estimated for 2008. These results can be seen in Figure 3.h.4.

The top four to six groups for the boat-based fishery are surgeonfish, goatfish, and snappers. Surgeonfish make up 54% of harvest for these three groups. In 2006, the estimated harvest for surgeonfish was 186,792 which make up 27% of the harvest for the years 2003 through 2010. To compare, 2004 had an estimated harvest of 25,816 surgeonfish. These results can be seen in Figure 3.h.5.

For the combined boat- and shore-based fisheries, the top one to five groups are: other, akule, goatfish, surgeonfish, and jacks. The other group makes up 36% of all estimated harvest for all years combined and all groups (total of 13 groups). This group had estimated harvest of 9,558,895. The group with the second highest estimated landings, akule, had 3,865,771. These results can be seen in Figure 3.h.6. The ranks of the top five overall harvested species are graphed in Figure 3.h.7. *Priacanthus meeki* was ranked as the most caught fish in 2003, but doesn't make the top ten in following years. *Mulloidichthys flavolineatus* and *Acanthurus triostegus* are ranked in the top ten and *Selar crumenophthalmus* in the top twelve in every year. *Herklotsichthys quadrimaculatus* does not appear in 2003 or 2004 but ranks as the top caught species in 2008, 2009, and 2010.

3.3.7.3. 2010 harvest reports

For 2010 intercept harvest, the top three coral reef species groups are akule, other, and jacks. Akule makes up 33% of the harvest followed by other with 25% and jacks with 14%. These top 3 groups make up 73% of the 2010 intercept harvest. For the akule, 41% of the data are type 3 (verified). Other has 56% type 3 data and jacks has 59% type 3 data. These results can be seen in Figure 3.i.1.

The top three gear types for 2010 intercept data are rod and reel, throw net, and spear. Rod and reel accounts for 54% of intercept harvest followed by throw net with 23% and spear with 11%. These three gear types account for 88% of the 2010 intercept harvest. Sixty-two percent of the data for rod and reel harvest is type 3 (verified). For throw net, 18% of the data are type 3. Twenty-eight percent of the data are type 3 for the spear fishery. These results can be seen in Figure 3.i.2.

In the rod and reel fishery, the top one to five species for 2010 intercept harvest are *Decapterus macarellus, Herklotsichthys quadrimaculatus, Selar crumenophthalmus, Lutjanis kasmira*, and Clupeidae. *D. macarellus* makes up 18% of the intercept harvest for the 2010 rod and reel fishery. The top one to five species make up 65% of the harvest. Sixty-six percent of the data for *D. macarellus* is type 3 (verified). Sixty-nine percent is type 3 for *H. quadrimaculatus*, 88% for *S. crumenophthalmus*, and 65% *for L. kasmira*. Clupeidae is all type 2 data. These results can be seen in Figure 3.i.3. The rod and reel fishery is also considered by species group with the top one to three groups being other, jacks, and akule. Other makes up 33% of intercept harvest. The top three groups combined comprise 73% of the intercept harvest. The majority of data for these groups is type 3 (verified); 53% of other is verified, 64% of jacks, and 88% of akule. These results can be seen in Figure 3.i.4.

In the throw net fishery, the top one to five species for 2010 intercept harvest are *S. crumenophthalmus*, *Encrasicholina purpurea*, *Acanthurus triostegus*, *Mulloidichthys flavolineatus*, and *Kuhlia sandvicensis*. *S. crumenophthalmus* makes up 76% of the throw net intercept harvest. All of these data are type 2 (unverified). These results can be seen in Figure

3.i.5. These results are also displayed by coral reef species group. The top three groups are akule, other, and surgeonfish. These results can be seen in Figure 3.i.6.

The top one to five species in the spear fishery are *Ctenochaetus strigosus, A. triostegus, Abudefduf abdominalis, K. sandvicensis,* and *A. dussumieri*. *C. strigosus* makes up 24% of the harvest. The top five species combine account for 69% of the harvest. Twenty-five percent of *C. strigosus* data are type 3 (verified), 31% of *A. triostegus* data are type 3, *A. abdominalis* data are all type 2, 27% of *K. sandvicensis* is type 3, and 5% of *A. dussumieri* is type 3. These results can be seen in Figure 3.i.7. Considering the spear fishery by species group, the top one to three are surgeonfish, other, and squirrelfish. Sixty-six percent of the harvest is represented by surgeonfish, 18% by other, and 5% by squirrelfish. The data for surgeonfish is 25% type 3. It is 19% type 3 for other and 67% for squirrelfish. This can be seen in Figure 3.i.8.

For 2010 alone, the top one to five species for the shore-based estimated harvest are *H. quadrimaculatus, S. crumenophthalmus, A. triostegus, E. purpurea,* and *K. sandvicensis*. These first five species make up 68% of the estimated harvest for 2010. *H. quadrimaculatus* makes up 30% of the total harvest. These results can be seen if Figure 3.i.9. The top one to five species for the boat-based estimated harvest are *S. crumenophthalmus, D. macarellus, L. kasmira, C. strigosus,* and *Hemipteronotus pavoninus*. These first five species make up 78% of the estimated harvest for 2010. *S. crumenophthalmus* makes up 43% of the total harvest. These results can be seen in Figure 3.i.10.

3.4. Non-commercial algorithm percentage error

The non-commercial algorithm estimates the shore-based coral reef landings with 99% accuracy. The CNMI boat-based accuracy is 79% while the Guam boat-based accuracy is 88%. The directionality of the error is always downward; the algorithm underestimates the total coral reef landings. The error with the non-commercial estimation algorithm increases with increasing number of expanded strata that do not have interview data. In the boat-based surveys, some ports are sampled with participation runs but not with interviews. Therefore, the catch rate and proportion of non-commercial landings is not known for these ports, which leads to more pooling in the expansion algorithm and more error in the non-commercial algorithm.

4. Discussion

4.1. American Samoa, Guam, and CNMI

4.1.1 Characteristics of the fisheries

Our results show that shore-based fishing of coral reef species in American Samoa, Guam, and the CNMI is mostly non-commercial. In the shore-based fisheries, the top gear types in the overall fishery have the same rank as the top non-commercial gear types, with the exception of the CNMI shore-based fishery. Spear/snorkel is the top overall method, but switches with hook and line in the non-commercial sector. Hook and line, which includes rod and reel in the Guam and CNMI surveys, is always the most important gear type by landings in the non-commercial fishery. The only gear type in any shore-based survey that is not overwhelmingly non-commercial is surround net in the Guam shore-based survey. In every survey in which cast net landings occur, they are mostly, if not completely, non-commercial.

Boat-based fishing of coral reef species, to a lesser extent, is mostly non-commercial, with the exception of the American Samoa boat-based survey. All gear type landings in the American Samoa boat-based survey are overwhelmingly commercial. Bottomfishing is always the most important boat-based fishing method of coral reef species by landings in the overall fishery and non-commercial sector. In the Guam survey, in the years when spincasting and jigging occur, most landings are non-commercial.

Selar crumenophthalmus, making up its own CREMUS group, are always in the top six CREMUS groups landed overall, except in the case of the American Samoa boat-based survey. Year by year, however, landings of *S. crumenophthalmus* are highly variable. Jacks (excluding *S. crumenophthalmus*) and surgeonfish also always occur in the top six CREMUS groups landed. Other important non-commercial CREMUS groups are mollusks, rabbitfish, and parrotfish.

4.1.2 Considerations and Recommendations

In each region, the survey is not representative of all fishing activity, which may interfere with accurate estimation of non-commercial fishing activity. In American Samoa, only the southern shore of Tutuila is sampled, and the boat-based sport fishery is not sampled. The boat-based survey has had to respond to industrialization of the pelagic fishery, and does not sample long lining vessels unloading directly at the cannery (Graham 2011b). In Guam, commercial spearfishers have been avoiding interviewers in recent years (Brent Tibbatts, personal communication, February 27, 2012). In the CNMI, some commercial hook and line fishers have been identifying themselves as non-commercial fishers but have been selling their catch (Michael Tenorio, personal communication, March 1, 2012). Additionally, boat-based spearfishers usually return from fishing after creel surveying shifts are over (Ray Roberto, personal communication, February 27, 2012). In the CNMI, only the island of Saipan is sampled.

Year-to-year landings are highly variable in many of the reports generated. Low sample sizes of catch rates may introduce bias into the expansion process. Much of the variability in this report is associated with spearfishing or pulse fisheries. The option to exclude pulse fisheries exists in the Guam shore-based expansion and may be beneficial to include in the other expansions. Spearfishing is known to be a difficult method to encounter for an interview, so CPUE for this method may not be representative of the population. An analysis of the participation files may show if the variability in our assessment is consistent with the fishery or if it is a product of the expansion process.

Data quality also confounds the non-commercial results. Extensive pooling weakens the quality of the non-commercial algorithm, because non-commercial data do not transfer to the expanded file and pooled interviews are not traceable in the database. Landings in the CNMI boat-based creel survey are most dependent on the pooling algorithm, with about half of the weight concentrated in strata that are filled by the pooling algorithm. Additionally, estimation uncertainty propagates through all landings analysis, so more weight estimation translates to less certainty in the expanded data. The Guam boat-based survey has the highest rate of estimation in the field, with about one-third of intercept landings attributable to estimation. However, most of the weight in the boat-based surveys comes from pelagic fishes, so estimation uncertainty and heavy reliance on the pooling algorithm will have less of an effect on analysis of coral reef species than of pelagic species. The method of weight determination is unknown for 11% of landings in the Guam shore-based survey, and 29% of the weight is concentrated in strata with fewer than three interviews. Most of the shore-based landings in all regions are of coral reef species, and the effect of this uncertainty and pooling process on the estimations is unknown and potentially unverifiable.

By design, the Guam and CNMI expansion is not enabled to estimate landings in the non-commercial and commercial sectors. In the future, if these data could be captured in the expansion as it is done in the American Samoa expansion, it could lead to a better estimate of the non-commercial sector. Capturing the percent kept and sold data would prevent loss of pooled data that introduces estimation error into our non-commercial algorithm. However, the non-commercial algorithm is written in such a way that it can be used with minimal editing in any database that uses SQL containing the interview/catch, expanded species composition, and CREMUS files. Table names and column names in the non-commercial algorithm code must be changed to match the database, and then this analysis can be reproduced.

The data could further be improved if disposition of catch could be collected at the species level, like in the American Samoa boat-based survey, instead of at the interview/method level. The current forms only collect the percent kept/sold data at the interview level, so it is unknown which species are sold more than others. Collecting disposition at the species level would require modification of the forms and modification of the database, transferring the disposition from the interview files to the catch files. Ideally, data on non-commercial effort would be collected as well as catch. This may require more resources than are available, on the part of island agencies to collect the data and on the part of the WPacFIN program to expand the non-commercial data.

4.2. Hawai‘i

4.2.1 Characteristics of the fishery

Coral reef species account for the majority of harvest by number in the Hawai‘i recreational fishery. Of these species, the CREMUS group “other,” with a majority of harvest attributable to bait species, has the most harvest by numbers of fish. Akule, goatfish, jacks, and surgeonfish are important components of catch. *Selar crumenophthalmus* is the most caught species while *Mulloidichthys flavolineatus, Acanthurus triostegus, Herklotsichthys quadrimaculatus, Decapterus macarellus,* and *Kuhlia sandvicensis* are also important components of the catch by species. The rod and reel, like in the other regions, is the most important gear type by number of fish for harvesting coral reef species in the Hawai‘i non-commercial fishery.

4.2.2 Considerations and Recommendations

Data quality and completeness present several challenges to the data user. Our analysis was strictly based on abundance because weight data are not complete for most species. Species-level weight analysis would be feasible for species that do not have large standard deviations in mean weights, such as the smaller bait species. The collection of length and weight data are limited by restricting type 3 data to fish identified to a species level. For reef species that are difficult to distinguish in the field, allowing identification to the genus level in type 3 data would prevent loss of length and weight data (Tom Ogawa, personal communication, February 24, 2012). Another consideration for a species-level analysis is that there are taxonomic inconsistencies in the database. A data user should consider harvest of closely-related species and check for records stored under all species synonyms. The estimation error in 2003 of *Apogon kallopterus* and *Decapterus macarellus* also requires attention by the data user. Untraceable overlap with commercial data, absence of night sampling, incomplete sampling coverage in 2001, and incomplete coverage of party/charter boats are some additional considerations for users of this dataset.

There is a significant amount of variability between years in both intercept and estimated data. The variability is usually associated with pulse events. The large spike in 2003 for the “other” group can be partially attributed to the 2003 *Priacanthus meeki* pulse event. There is also high variation in year-to-year harvest of akule, a pulse fishery. The extent to which limitations in the sampling frame and the estimation procedure affect the temporal variability of harvest is unknown. Other spikes in the results were identified as potential errors by Tom Ogawa (personal communication, February 24, 2012), investigated, and corrected manually. Our analyses did not consider the telephone survey data and how it affects the expansion, but an analysis of the telephone participation data and intercept sampling effort may give a more complete picture of the sources of variability in the estimated data.

The downloadable data were used for this analysis in an effort to assess all data captured by the MRFSS survey. Because the downloadable data have been standardized for nationwide estimations, Hawai‘i-specific questions (see Appendix 4) are removed from the database. The MRIP query function is further limited to only the estimated data and selected species. Future analyses of landings by different types of non-commercial fishing or fishing method (differentiated from gear type) should request data from PIFSC or HDAR to receive Hawai‘i-specific data. The types of non-commercial fishing are not standardized among fishermen (Tom Ogawa, personal communication, October 17, 2011), so analysis of this sort will benefit from clear definitions of non-commercial fishing activity.

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A1. Glossary

Non-commercial: in the creel surveys, the ratio of the total catch which is reported to be kept, or not sold, or in the case of American Samoa's boat-based creel survey, with a disposition that will not be sold. In the MRFSS data, all data captured by the survey

Coral reef taxa: in the creel surveys, taxa that are included in the CREMUS lists for each archipelago, and those reef-associated taxa that are not included in the CREMUS, Bottomfish Management Unit Species (BMUS), or Pelagic Management Unit Species (PMUS) lists but are found in the creel survey interview or expanded data sets. In the MRFSS data, taxa included in the CREMUS list and those reef-associated taxa also on the HMRFS species list

Bycatch: in the creel surveys, fish that were caught, but thrown back

Landings: in the creel surveys, all fish that were kept

Harvest: in the MRFSS data, all fish except those that were released alive

Type 3, Verified: in the MRFSS intercept data, all fish that were inspected by a trained interviewer and identified to a species level

Type 2, Unverified: in the MRFSS intercept data, all fish that were not available to an interviewer for inspection or only identified to the family or genus level by an interviewer

Type 1: in the MRFSS intercept data, angler and trip data. Contains data such as location of the interview, fishing area and mode, hours fished, gear used, target species, and residence

Type A: in the estimated MRFSS data, fish that can be identified by trained interviewers. These data were estimated from type 3 verified intercept data.

Type B1: in the estimated MRFSS data, fish that are used for bait, released dead, or filleted. These data were estimated from type 2 unverified intercept data

Type B2: in the estimated MRFSS data, fish that are released alive. These data were estimated from type 2 unverified intercept data

CSV data: comma separated values, downloadable form of the MRFSS data that was used for this project.

SAS data: statistical analysis system file, alternative downloadable form of the MRFSS data.

SQL: structured query language, a programming language designed to manage data in relational database management systems.

Sampling strata vary by survey.

- American Samoa shore-based: expansion period (quarterly or annually), day type (weekday or weekend/holiday), day or night, gear type, route
- American Samoa boat-based: expansion period, day type, gear type
- Guam shore-based: expansion period, day type, day or night, gear type, and region
- Guam boat-based: expansion period, port, charter or non-charter, day type, and gear type
- CNMI shore-based: expansion period, day type, day or night, and gear type
- CNMI boat-based: expansion period, port, charter or non-charter, day type, and gear type
- MRFSS: expansion period (6 waves annually), state, fishing mode (shore, private rental boat, charter boat, party boat), and fishing area (>3 nmi from shore or <3 nmi from shore)

A2. Expansion Process Summaries

The most basic calculation producing expanded catch estimates is the same for each creel survey and MRFSS and MRIP. Catch data are collected in intercept interviews while effort data are collected through participation counts in the creel surveys and a telephone survey in MRFSS. The catch data are used to find an average CPUE per stratum, which can be multiplied by effort from participation data to give an estimate of landings.

A2.1. Equation

$$\frac{landings}{effort} \times expanded\ effort\ = expanded\ landings$$

A2.2. Shore-Based Creel Surveys

A2.2.1. Effort Data

The effort data are used to calculate an expanded unit of effort per stratum. Units of effort in the shore-based creel surveys are gear-hours and in the boat-based surveys are trips per day.

In the shore-based creel surveys, the gear-hour (unit of effort) is calculated differently in each of the islands. In general, an average gears per stratum is multiplied by the total number of days in an expansion period and the number of hours in a shift.

A2.2.1.1. Equation

$$\frac{gears}{stratum} \times expanded\ hours\ = expanded\ gear\text{-}hours$$

The calculations are most straightforward in the CNMI database. The average gear per sampling run is given by the total number of gears in a stratum divided by the total number of participation runs (about 2 hours in length) in the stratum. This is multiplied by the total number of days in the expansion period (weekdays or weekend/holidays) and the total number of hours in a shift during which the runs take place (six hours) to give the expanded number of gear-hours. All hours in a day are sampled (Brousseau et al., 2011b).

A2.2.1.2. Equation

$$\frac{\Sigma gears}{\Sigma runs} \times days\ in\ expansion\ period \times 6\ hours = expanded\ gear\text{-}hours$$

In the Guam database, the average gear per sampling day is given by the total number of gears in a stratum divided by the total numbers of days in a stratum on which a sampling run took place (Brousseau et al., 2010). This is slightly different than in CNMI because only one participation run takes place per shift (Oram et al., 2011d). This is then multiplied by the total number of days (weekend or weekend/holiday) in the expansion period and the total number of hours in a shift during which the runs take place (12 hours for day shifts and eight hours for night shifts) to give the expanded number of gear-hours (Brousseau et al., 2010).

A2.2.1.3. Equation

$$\frac{\Sigma gears}{\Sigma days\ of\ runs} \times days\ in\ expansion\ period \times shift\ hours = expanded\ gear\text{-}hours$$

Note that in Guam, the expansion process counts days shifts as 12 hours long and night shifts as eight hours long. This leaves four hours that are never sampled.

In the American Samoa database, the estimation of expanded gear-hours has more steps, because the gear-hours are first counted up only within an expansion period and day type, and then are stratified by gear type. First, the average gears are found by dividing up the interview data within the expansion period into six two-hour time blocks. The gears within each two-hour time block (including all fishing methods, but still stratified by day type) are counted up and divided by the total number of sampling runs per two-hour time block sampled to give the average gears per two-hour time block (Graham 2011a).

A2.2.1.4. Equation

$$\frac{\Sigma gears\ in\ two\text{-}hour\ blocks}{\Sigma runs\ in\ two\text{-}hour\ blocks} = average\ gears\ per\ two\text{-}hour\ block$$

This is then multiplied by the total days in the expansion period (weekday or weekend/holiday) and the total number of hours in the two-hour time block to give the expanded gear-hour by type of day, expansion period, and two-hour time block (Graham 2011a).

A2.2.1.5. Equation

$$average\ gear\ per\ two\text{-}hour\ block \times days\ in\ expansion\ period \times 2\ hours = expanded\ gear\text{-}hours\ per\ two\text{-}hour\ block$$

This gear-hour is then multiplied by the percentage of each method that accounted for all of the participation runs in the two-hour blocks to give the expanded gear-hour by method, type of day, expansion period, and two-hour time block. All of the two-hour time blocks with the same method are summed to give the expanded gear-hour per stratum (Graham 2011a).

A2.2.1.6. Equation

$$\sum \left(\frac{number\ interviews\ of\ particular\ method}{total\ number\ of\ interviews} \times expanded\ gear\text{-}hours\ per\ two\text{-}hour\ block \right) = expanded\ gear\text{-}hours\ per\ stratum$$

This is then divided by the ratio of sampled two-hour blocks to unsampled two-hour blocks to adjust the expanded gear hours for any two-hour time blocks in which no participation runs occurred (Graham 2011a).

A2.2.1.7. Equation

$$\frac{expanded\ gear\text{-}hours\ per\ stratum}{number\ of\ sampled\ two\text{-}hour\ blocks/6} = adjusted\ expanded\ gear\text{-}hours$$

In American Samoa, a temporal adjustment factor inflates the estimates to account for the time that is not sampled during participation runs. The adjustment assumes that effort during unsampled times is similar to effort during sampled times.

A2.2.2. Catch Data

There are also differences in how the catch data are used to calculate an average CPUE per stratum. In the CNMI and Guam databases, the average gear-hour CPUE is first calculated by calculating the gear-hours for each interview. This is the product of the number of gears used by the fishermen interviewed and the actual hours spent fishing (interview time – trip start time). Then the sum of the kilograms caught per stratum is divided by the sum of the gear-hours per stratum.

A2.2.2.1. Equation

$$\frac{\Sigma kilograms\ caught\ per\ stratum}{\Sigma(number\ of\ gears)(interview\ time - trip\ start\ time)} = average\ gear\text{-}hour\ CPUE$$

The calculations for the gear-hour CPUE end here in the CNMI database, but in the Guam database, some data that satisfies certain conditions is treated with an adjustment factor. The treated strata are those day shifts in Region 4 and Region 0 (Brousseau et al., 2010). Region 0 is all regions including the spatial adjustment, and hook and line is the only fishing method stratified by region (Penglong Tao, personal communication, December 28, 2011). Only Regions 1, 2, and 3 with the method of hook and line are not treated with a spatial adjustment factor.

In the American Samoa database, the average gear-hour CPUE is also the total pounds per stratum divided by the total gear-hours per stratum (Graham 2011a). How the gear-hours are calculated per stratum is not documented.

A2.3. Species Composition

Species composition estimates are fairly straightforward. The proportion of each species in a pooled stratum used for the catch estimate is multiplied by the expanded catch in that stratum to estimate the species composition.

A2.3.1. Equation

$$\frac{\Sigma kilograms\ of\ species\ caught}{\Sigma kilograms\ of\ all\ species\ caught} \times expanded\ landings = expanded\ species\ landings$$

In the American Samoa database, the percentages that were sold are applied at this time to the species composition data, easing a non-commercial analysis. The programmer for CNMI and Guam did not use these percentages because they were considered too unreliable to use, because they are the fisher's own estimate of what will be sold (Michael Quach, personal communication, October 27, 2011). Penglong Tao also explained that there is no data that can separate the recreational and commercial effort (Penglong Tao, personal communication, August 30, 2011).

A2.4. Boat-Based Creel Surveys

A2.4.1. Effort Data

The same general formula from the shore-based expansion applies to the boat-based expansion. An average catch per unit effort multiplied by expanded units of effort yields the estimated landings. The unit of effort in the boat-based expansion is the trip. The expanded trip number is the average estimated trips per day multiplied by the number of days in the expansion period. Estimations of an average trip per day are produced by dividing an estimated number of trips per stratum by the number of sampling days.

A2.4.1.1. Equation

$$\frac{estimated\ number\ of\ trips\ per\ day}{number\ of\ sampling\ days} \times number\ of\ days\ in\ expansion\ period = expanded\ trip\ number$$

The estimated number of trips per day is calculated differently in each region. In the Guam database, the number of trips per day from the boat log table is multiplied by an adjustment factor to give the total number of trips within a stratum. This adjustment factor is an adjusted sum of the trips (to account for boat trips that may not have been fishing trips and fishing trips using an unknown fishing method) divided by a temporal adjustment factor (Brousseau at al., 2010).

A2.4.1.2. Equation

$$number\ of\ trips\ per\ day \times \frac{adjusted\ number\ of\ trips}{temporal\ adjustment\ factor} = estimated\ number\ of\ trips\ per\ day$$

This sum of trips per day is then divided by the number of days sampled to give the average estimated trips per day (see Equation A2.4.1.1, first term). After this is multiplied by the number of days in the expansion period to give the expanded trip number, an additional adjustment is used for non-sampled ports. The expanded trip number is multiplied by a spatial adjustment factor, which is the trailer count in non-surveyed ports (those without boat log surveys) divided by the trailer count in surveyed ports, from the island-wide boat count (DAWR_Boat-Based_Survey_and_its_Expansion).

A2.4.1.3. Equation

$$expanded\ trip\ number \times \frac{trailor\ count\ in\ non\text{-}surveyed\ ports}{trailor\ count\ in\ surveyed\ ports} = expanded\ adjusted\ trips\ for\ non\text{-}surveyed\ ports$$

The process is the same in the CNMI boat-based database, except that the sum of trips in a day is selected differently by port and charter boat status, the two types of charter boat trips are treated with different adjustment factors than other trips, and there is no spatial adjustment factor (Brousseau et al., 2011b).

In the American Samoa database, Tutuila and Manu‘a surveys are expanded differently. In Tutuila, the actual number of trips per stratum is counted. An estimated number of additional trips is calculated by splitting up the number of trips with unknown fishing method proportionately by the percentage of each fishing method making up an expansion period and day type (Graham 2011b).

A2.4.1.4. Equation

$$\left(\frac{number\ of\ trips\ with\ a\ particular\ method\ per\ day}{total\ number\ of\ trips\ in\ stratum} \times number\ of\ trips\ with\ unknown\ method\ per\ day\right) = estimated\ number\ of\ additional\ trips\ with\ particular\ method\ per\ day$$

The actual and additional estimated number of trips are added together and then divided by the product of the spatial and temporal adjustment factors to give the estimated number of trips per stratum. The spatial adjustment factor is the percentage of the total fishing fleet surveyed and the temporal adjustment factor is the percentage of boats that are not covered because their activity occurs while samplers are not on duty (Graham 2011b).

A2.4.1.5. Equation

$$\frac{(number\ of\ trips\ per\ day) + (estimated\ number\ of\ additional\ trips\ per\ day)}{(percentage\ of\ total\ fishing\ fleet\ surveyed)(percentage\ of\ fleet\ not\ covered\ while\ surveyors\ are\ \text{ı}} = estimated\ number\ of\ trips\ per\ day$$

Like in the other creel survey expansions, the sum of the estimated number of trips per day within stratum is divided by the number of sampling days in the stratum to give the average trips per day within stratum. The Manu‘a survey usually has 100% coverage because there are so few boats. The estimated number of trips, which is the actual number of trips on Manu‘a, is divided by the monthly percent coverage factor when in it less than 100%. This is the only difference in the process (Graham 2011b).

A2.4.2. Catch data

The trip CPUE is standard in each region; it is the sum of the landings in a stratum divided by the number of interviews in the stratum.

A2.4.2.1. Equation

$$\frac{\Sigma kilograms\ landed}{number\ of\ interviews} = average\ trip\ CPUE$$

A2.5. Species Composition Estimates

The species composition files are produced in the same way in each island region as they are in the shore-based expansions.

A2.6. Pooling Algorithm

Another important part of the expansion process is the pooling algorithm. The CPUE calculation requires a sample size of three interviews (Graham 2011b; Penglong Tao, personal communication, December 13, 2011). When three interviews do not exist for a stratum, the algorithm looks for interviews from other strata dimensions, starting with the other day type then looking in other expansion periods. These interviews are kept to determine species composition estimates. Because some methods are hard to encounter, opportunistic interviews (non-random samples) can be used to calculate more reliable gear-hour CPUEs but are not used in estimating participation (Oram et al., 2011a-f). Strata in the expanded files are flagged when the pooling algorithm uses an interview from a different stratum. These flags indicate which strata dimension the interview was borrowed from, but not the actual interview.

While a pool flag field is defined in the Guam Fishery Dependent Data Systems and Databases document for the boat-based expansion, it was not received for this project (Brousseau et al., 2010). The "POOL_FLAG" field is described as: "Shows the quality of expanded data in the stratum (Nothing: standard stratum, D: combined TYP_DAY, M: combined METHOD 4-6 to 4, P: combined Port 1, 2, p: combined Port 1-3 for METHOD =1 or 3)" (Brousseau et al., 2010). In the shore-based section of the CNMI Fishery Dependent Data Systems and Databases document, the "POOL_FLAG" description reads: "Shows the quality of expanded data in the stratum (Nothing: standard stratum, D: Combine TYPE_DAY, Q: Combine quarters)" (Brousseau et al., 2011b). In the data, however, "M" and "Q" are the only codes. According to Penglong Tao, "M" stands for combining interviews with the same method and time of day (day or night), but over the whole year (personal communication, December 13, 2011). The database and the database metadata match for the boat-based survey. The reference table is used for pooling only when the algorithm cannot find interviews two years before and after the stratum it is trying to fill (Michael Quach, personal communication, February 2, 2012). Pool flag fields do not exist in the American Samoa datasets or the Guam shore-based dataset, according the database metadata (Brousseau et al., 2010 and 2011a). Interviews are pooled directly from a reference table in the Guam shore-based data at the time this report was written (Penglong Tao and David Hamm, personal communication, February 2, 2012). The expansion descriptions from the American Samoa databases, excerpted below from the *Shore Based Creel-Main* and *Offshore Creel-main* documents, lists the order of pooling and the code that can be found in the expansion reports, but not the file (Graham 2011a-b).

A2.6.1. American Samoa Shore-Based:

TD - Pooling interviews with the same route, expansion period, day or night survey, fishing method and but with the opposite type of day.

-1 - Pooling interviews with the same route, day or night survey, fishing method and type of day but from the next expansion period

1- - Pooling interviews with the same route, day or night survey, fishing method and type of day but from the previous expansion period

-2 - Pooling interviews with the same route, day or night survey, fishing method and type of day but from two expansion periods after the current one

2- - Pooling interviews with the same route, day or night survey, fishing method and type of day but from two expansion periods before the current one

YRTD - Pooling interviews with the same route, day or night survey, fishing method and type of day from the entire year.

YR - Pooling interviews with the same route, day or night survey, fishing method regardless of type of day from the entire year.

DF - Pooling default interviews for the appropriate route, day or night survey and fishing method

“All of the pooling methods listed above are used only for monthly and quarterly expansions. The YR and YRTD pooling methods are not done for Fiscal or Calendar year annual expansions and only the TD pooling method is used for expansions over an arbitrary range of months.”

A2.6.2. American Samoa Boat-Based:

BT - Pooling Bottom/Troll Mixed interviews with Bottom/Troll fishing trips on the same type of day and expansion period that are entered as separate interviews but with the same interview time

TB - Pooling Bottom/Troll Mixed interviews with Bottom/Troll fishing trips on the opposite type of day and same expansion period that are entered as separate interviews but with the same interview time

SP - Pooling interviews for all three types of spearfishing trips (spearfishing without tanks, spearfishing with tanks, and spearfishing with and without tanks) with the same type of day and expansion period.

TD - Pooling interviews with the same fishing method and expansion period but with the opposite type of day.

-1 - Pooling interviews with the same fishing method and type of day but from the next expansion period

1- - Pooling interviews with the same fishing method and type of day but from the previous expansion period

-2 - Pooling interviews with the same fishing method and type of day but from the next two expansion periods

2- - Pooling interviews with the same fishing method and type of day but from the previous two expansion periods

YR - Pooling interviews with the same fishing method and type of day but from the entire year.

A2.7. MRFSS and MRIP

A2.7.1. MRFSS

Under the MRFSS procedures, data derived from the telephone and intercept surveys are combined with U.S. Bureau of Census data to provide catch and effort estimates. The estimation procedure has three categories: effort estimation, catch estimation, and participation estimation (MRFSS Data User's Manual).

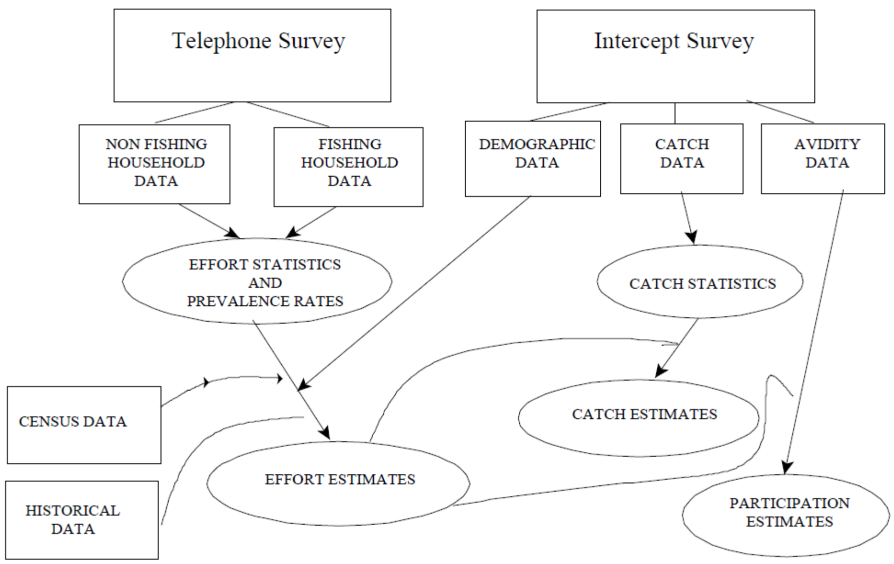


Figure 1: MRFSS information flow for data derived from the telephone and intercept surveys, and combined with U.S. Bureau of Census Data (from the MRFSS Data User's Manual).

The same basic equation as from the creel surveys applies.

A2.7.1.1. Equation

$$\frac{landings}{effort} \times expanded\ effort\ = expanded\ landings$$

A2.7.2. Effort Estimation

The unit of effort is the fishing trip, estimated per angler for each state, mode and wave. The sum of effort estimations for coastal county residents, non-coastal county residents, and out-of-state residents provides the total effort estimate. The data from the CHTS is used to calculate average numbers of trips per household for each fishing mode during each wave. This average is then multiplied by the number of permanent, full-time occupied households in the coastal zone. This then provides an estimate of the total number of fishing trips in each mode by coastal county residents.

A2.7.2.1. Equation

$$\frac{number\ of\ trips}{number\ of\ households\ surveyed} \times number\ of\ households = estimated\ number\ of\ fishing\ trips$$

To account for non-coastal residents, ratio estimators derived from the intercept survey are used. In Hawai‘i, however, all residents are considered coastal. A ratio estimator may also be used to account for those anglers without telephones (MRFSS Data User’s Manual, chapter 1).

To estimate the fishing effort by fishing area, “post-stratification is used to proportionally allocate the estimated number of fishing trips and the associated variance in a wave/state/mode stratum to fishing areas based on the ratio of the number of intercept interviews in the mode and area to the total number of intercept interviews conducted in the mode.” Data are post-stratified by inland coastal waters, state territorial seas, and offshore ocean water greater than 3 miles from shore (MRFSS Data User’s Manual, chapter 1). This is the same post-stratification method used to produce the species composition file in the island creel surveys.

A square root allocation strategy is used in order to provide for a more equitable sample allocation between counties with varying population sizes. The phone survey sample allocation “is proportionally allocated based on the square root of the number of full-time occupied households in each county.” This strategy is important when considering a county with a small number of full-time occupied households and a county with a larger number of households (relevant perhaps when comparing Honolulu county to Maui or Kaua‘i). When employing this strategy it is important to note that survey data must be re-weighted prior to calculation of county level statistics in order to avoid an overestimation of fishing effort (MRFSS Data User’s Manual, chapter 1).

When population estimates of total fishing effort are based on a small number of interviews, they are subject to wide variability. Several procedures have been put into place to adjust for outlying observations. First, telephone survey results from coastal households are compared with the statistical distribution of reported fishing effort for that year and the four years prior. If a household reports more fishing trips than the 95th percentile over the five-year distribution, it is then reduced to the value of the 95th percentile. Additionally, the estimation of fishing effort for party and charter boats is difficult due to the low incidence of reported activity in the telephone survey. “To reduce the effect of small sample sizes on effort estimates for the charter boat fishery, telephone survey data from the previous four years plus the current year are combined at the state and wave level and estimates are produced using a prevalence rate from the combined data base.” A problem with this approach is that it can possibly mask trends. The pooling of data across years, however, provides more reliable estimates for a small portion of the population. Further adjustment in this sector may be made to account for the fact that the majority of charter and party boat customers may be from out-of-state (MRFSS Data User's Manual, chapter 1). Charter boats were covered by HMRFS from 2003-2006 but were not estimated, so only intercept data exists (Hongguang Ma, personal communication, March 14, 2012).

A2.7.3. Catch Estimation

The catch estimation procedure considers the number and weight of finfish caught and whether or not they were landed or released alive. Catch is estimated for subregion, state, fishing mode, fishing area, wave, and species. "The total number of fish caught in a particular fishing mode and area is estimated from the estimated number of fishing trips taken in that mode, the average number of fish caught per trip in that particular mode, and the percent of intercepted trips in that mode and area" (MRFSS Data User's Manual, chapter 1). This is the general equation A2.7.1.1, with an adjustment factor based on the number of intercepted trips in the stratum.

Catch estimation procedures are performed separately for the different catch types: type A, type B1, and type B2. Catch is separated to distinguish between catch being identified from a trained interviewer and catch being reported by fishers (MRFSS Data User's Manual, chapter 1). The average weight of a species in the stratum is taken from the type A catch, and the sizes of the B1 fish are assumed to be the same.

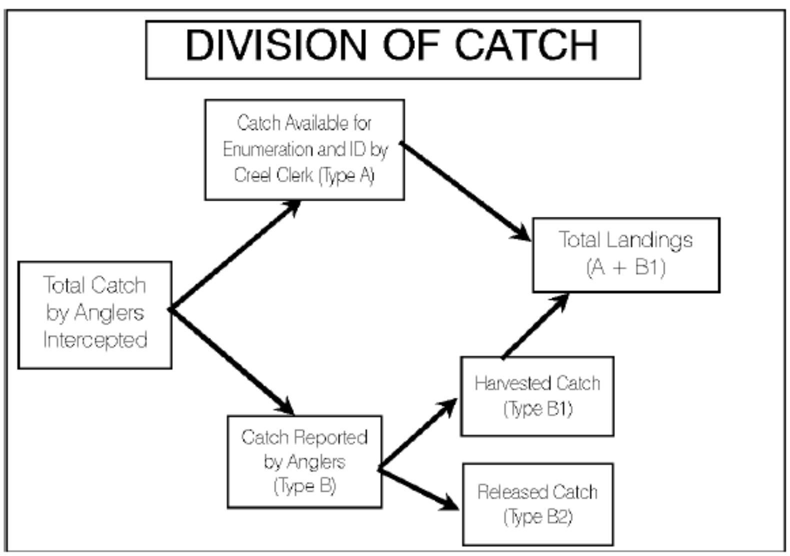


Figure 2: MRFSS estimated catch type distinctions (from the MRFSS Data User's Manual).

A2.7.4. Participation Estimation

The participation estimation determines the approximate number of participants in recreational fishing activities. Participation estimates are derived from intercept data and estimated total fishing effort. The estimation procedure accounts for varying levels of fishing activity as the probability of selection in the intercept survey will be higher for someone who frequently fishes. Participation estimates are made annually by state (MRFSS Data User's Manual, chapter 1).

A2.7.5. MRIP

The estimation procedure will be adjusted under MRIP. Historical MRFSS data will not be re-estimated using the MRIP algorithm (Joshua DeMello, personal communication, January 13, 2012). The revised estimation procedure should produce more accurate and less biased estimates (MRIP, 2010).

A3. Chronology Summaries

A3.1. American Samoa shore-based

The American Samoa shore-based creel survey has been run by different researchers using different methods since it began in 1978 (Michael Quach, personal communication, October 27, 2011; Graham 2011a). Data from before 1990 are not available, while data from 1990-1996 and 2002 onward are expanded. New routes were added by researchers in charge in 2002-2003 and again in 2004-2006, so the survey is stratified by consistent routes as much as possible (Graham 2011a).

The interview forms changed along with the methodologies. Five forms can be found on the NOAA NMFS PIFSC Web site. From 1990-1996, the disposition of the fisher's entire catch for the interview was marked as kept or sold. From 2002-2006, no field exists on the form for catch disposition or percent kept or sold. In 2006 and onward, the form has a field for percent kept or sold by gear type. Until 2006, the gear type was written in, but in 2006 the gear types of spear snorkel, hand line, gleaning, throw net, rod and reel, gill net, bamboo, sand mining, and other were available. Enu (trap) was added in 2009. Hours fished changes as well; from 1990-1996 the hours fished field exists, but in 2002 changes to a start and estimated end time by fish species caught, and returns to an hours fished field in 2004. In 2006 the fields for time are interview time, start and end times with logical fields for fishing beginning the day before or ending the day after, and down hours, similar to the current Guam and CNMI interview forms. Other changes in the forms include deleting the fisher party age fields and adding a logical bycatch field in 2004. In 2006, a separate space for detailed bycatch fields; logical complete, incomplete, and opportunistic fields; and space for remarks were added (from comparison of data collection forms).

A3.2. American Samoa boat-based

Standardized data collection for the American Samoa boat-based creel survey began in October 1985. Until 1995, the fishing method was marked as "unknown" for all boats that were counted in the participation survey but were not interviewed. The proportion of each method from boats interviewed was used to allocate trips by method. However, most of the boats that were not interviewed were bottomfishing and spear fishing vessels. These methods were rarely encountered by intercept surveyors, as they arrived back to port before the surveyors were on duty. Therefore, these methods are underrepresented before 1995. After 1995, the unknown method was changed to a known method, since some boats fish with the same method consistently. If the method cannot be determined or the boat uses multiple methods, the method is entered as unknown. In 1999 and 2000, more weights began to be calculated from fish landed in various conditions (Graham 2011b).

Sampling locations have evolved as changes in the fishery become apparent. In 2002 to July 2003, the sampling areas were five of six areas. The sixth area, Vatia, was assumed to have similar fishing activity and success rates as the sampled areas. Then, in July 2003, sampling efforts were refocused to have better coverage of the busier ports (between Fagotogo and Pago, based on the results of a one-month presence-absence study). The data collection methods are consistent from July 2003 to present, but the forms have changed.

Five forms can be found on the NOAA NMFS PIFSC Web site. The first form is from 2002-2003. From 2004-2006, the atule fishing method was deleted while the landed condition was added. From 2006-2008, the atule fishing method is added again, while free diving is the only remaining spearfishing method listed. Previous versions of the form included spearfishing with tanks, without tanks, and mixed. The space for fishing method of "other" was deleted. Species weight in pounds was added. Condition codes were reduced from eight options to six options. From 2008-2009, a field was added to describe if the interview was opportunistic or not. The 2009-present form has a field to describe if the interview was completed or not, as well as fields for the date and time the trip began and trip cost fields (from comparison of data collection forms).

A3.3. Guam shore-based

The Guam Department of Agriculture Division of Aquatic and Wildlife Resources (DAWR) has been collecting shore-based creel survey data since 1970 but data collection methods were not standardized until 1985. WPacFIN expands data from 1985 onward (Oram et al., 2011d). The previous version and the older version of the interview forms can be found on the NOAA NMFS PIFSC Web site. The current version adds the percent kept and sold fields, as well as the location and reef zone by method instead of a single location and reef zone for the form, and a bycatch section (from comparison of data collection forms).

A3.4. Guam boat-based

The Guam boat-based survey began in the late 1970s, but was not computerized until 1982. The data expansion process was standardized in 1998. Changes in the Access Point survey were in 1989 when Merizo Pier was added and in 1994 when the Agat Marina opened (Oram et al., 2011c). Four un-dated versions of the form can be found on the NOAA NMFS PIFSC Web site. The original version does not have percent kept or sold fields. The old version adds the percent kept or sold by method fields, as well as a buyer field, atulai night light fishing method, area fished by method instead of for the entire form, and vehicle license number. The previous version adds another space for the "other" fishing method, and adds a bycatch section to the form. The current version adds a price per pound field and trip cost fields (from comparison of data collection forms).

A3.5. CNMI shore-based

WPacFIN only expands data from May 2005 onward, when data collection methods were standardized. The expansion from the following year is used as a proxy to estimate landings from January 2005 until sampling began (David Hamm, personal communication, February 2, 2012). The CNMI Department of Land and Natural Resources Division of Fish & Wildlife (DFW) collected shore-based creel survey data in 1985 and from 1990-1994, but they are not used (Oram et al., 2011f). The NOAA NMFS PIFSC Web site only has one interview form available, dated from the mid-1990s, but the form included in the creel survey collection documentation resembles the current Guam shore-based form (Oram et al., 2011f).

A3.6. CNMI boat-based

CNMI's DFW collected boat-based creel survey data from 1988 to 1996, but WPacFIN only expands data from April 2000 onward, when data collection methods were standardized (Oram et al., 2011e). The estimated data from the following year were used to fill in from January 2000 until sampling began in April (David Hamm, personal communication, February 2, 2012). Changes in the survey include that in August 2005 the 20:00 and 22:00 time interval was added to the Participation Count and a night shift from 18:00 – 02:00 was added to the Access Point Survey (Oram et al, 2011e). The addition of the night shift is incorporated into the expansion process with an option for daytime only or full day expansions (Penglong Tao, personal communication, February 2, 2012). The forms found on the NOAA NMFS PIFSC Web site indicate that the current version of the form collects price per pound of landings by species as well as trip cost data. The previous form is otherwise identical, and no dates are given for the forms used from April 2000 and onward (from comparison of data collection forms).

A3.7. Hawai‘i

HMRFS started in Hawai‘i in July 2001. Data collection methods are fairly consistent after 2003. In 2001, there are only data available online for wave 6 and in 2002 there is no intercept data available online. Although recreational data began to be collected with consistency starting in 2001, phone survey data for 2001 and 2002 were not usable, so there are no expansion estimates for 2001 and 2002 (Tom Ogawa, personal communication, October 17, 2011). For the years 2003 and 2004, data are not available for island of return. The national standard is to consider county, which is probably why island specific data were lost for these years. Island specific data were, however, restored in 2005. When considering island specific data, it should be noted that Moloka‘i and Kaua‘i were not added to the field survey until 2004. As mentioned, the local contractor for the phone survey took over in wave 3 (May/June) of 2009 (Tom Ogawa, personal communication, December 2, 2011). Finally, in the past two years, more interview denials have occurred primarily due to the negative effects of the recession (Tom Ogawa, personal communication, October 27, 2011).

A4. Marine Recreational Fisheries in Hawai‘i

In order to understand the impact of marine recreational fishing on marine resources, the Marine Recreational Fisheries Statistics Survey (MRFSS) was established in 1979. Its stated purpose is to establish a reliable database for estimating these impacts. MRFSS may be the most complex national survey currently conducted. Since its inception, management goals and objectives have changed and the complexity of the recreational fisheries sector has increased. The data required for proper management are often different than the data delivered and there is concern that the data currently collected are not precise, robust, or timely enough. Additionally, data collected through MRFSS and other surveys are being used for management decisions that exceed its intended design and purpose (Committee on the Review of Recreational Fisheries Survey Methods, National Research Council, 2006). In Hawai‘i, NOAA National Marine Fisheries Service (NMFS) contracted with the Hawai‘i Department of Aquatic Resources (HDAR) to conduct the Hawai‘i Marine Recreational Fisheries Survey (HMRFS). HMRFS was developed to produce annual, statewide catch estimates of finfish by species, mode and area (Allen & Bartlett, 2008). This synthesis seeks to understand the similarities, differences, and limitations with the MRFSS national survey and the local HMRFS. Three primary information sources will be used to gain insight into the usefulness of Hawai‘i recreational data: the reviews conducted by Allen and Bartlett (2008) and the National Research Council (2006) and interviews with Tom Ogawa (Hawai‘i DLNR) and Hongguang Ma (PIFSC).

A4.1. Similarities & Differences between MRFSS and HMRFS

The MRFSS is comprised of three component surveys: (1) the coastal household telephone survey (CHTS) (effort), (2) the access-point intercept survey (CPUE), and (3) the for-hire survey (FHS) (Allen & Bartlett, 2008). The FHS has not been implemented in Hawai‘i (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006). The CHTS collects data on shore and private/rental boat fishing effort and the access-point (field) survey collects data from shore, private/rental boats, and charter boats. Telephone surveys in the MRFSS are coordinated at the national level by a single contractor. Due to language and cultural barriers, a local contractor conducts the phone survey in Hawai‘i (Allen & Bartlett, 2008). The local contractor took over in wave three (May/June) of 2009 (Tom Ogawa, personal communication, December 2, 2011). NOAA provides the target sample size desired for each island, fishing mode, and wave. To meet these targets, HDAR uses a stratified random sampling method to provide interviewers with assignments. “Docks, harbors, boat ramps and other areas where fishermen return from their trips are oversampled in order to yield a larger number of private boat trips.” The justification for this is to get an adequate representation of fishermen fishing in federal waters. Sites with little known use are included in the sample but interviewers that do not encounter any fishermen can move to an alternate but similar site. Data collected are sent to NMFS every month where the relevant data are then used to produce estimates (Allen & Bartlett, 2008)

In Hawai‘i, managers use different approaches but they do, however, produce data compatible with overall MRFSS goals (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006). The fisheries in Hawai‘i present unique challenges to recreational fishing data collection (Tom Ogawa, personal communication, October 17, 2011). Data on “fishing category” and target species (up to four recorded) are only collected in Hawai‘i (Allen & Bartlett, 2008). The definition of “recreational” is more complex in Hawai‘i than on the mainland. The HMRFS intercept survey asks several questions in order to determine fishermen type:

19. Do you ever sell any of the fish you catch?

1 ☐ Yes   2 ☐ No, ***Go to 20***

19a. When you sell your fish, do you consider yourself a commercial fisherman, trying to make some income or do you sell only to cover your fishing expenses?

1 ☐ For Income   2 ☐ Trip Costs Only, ***Go to 20***

19b. Do you consider yourself a full-time commercial fisherman?

1 ☐ Yes   2 ☐ No

If a fisher identifies himself as a full-time commercial fisher, the interview is filtered out of the estimation procedure (Hongguang Ma and Tom Ogawa, personal communication, March 14, 2012). If a fisher does not sell any of the fish they catch, they are considered purely recreational. If they sometimes sell fish to cover expenses, then they will be categorized as a recreational expense fisher. Fishers that sell fish for income will be categorized as either part-time commercial or full-time commercial (Hawai‘i Marine Recreational Fishery Survey Procedures Manual, n.d.). According to Tom Ogawa (personal communication, October 17, 2011), a part-time commercial fishermen is someone whose income from selling fish is less than 50% of their total income. From the fishermen’s perspective, this categorization can vary. For example, a fisher holding a commercial marine license (CML) may still consider himself as recreational.

Hawai‘i fishermen’s “unique” forms of economic activity further complicate the recreational definition. Subsistence fishing occurs on all of the main islands. Bartering occurs as well, especially on the outer islands. There are also cultural events such as baby luaus, family reunions, and funerals that can result in high fishing pressure in that area during the event. These behaviors are not differentiated in the HMRFS (Tom Ogawa, personal communication, October 17, 2011).

In Hawai‘i, each interviewer has his or her own unique approach to interviewing. The interviewer’s training manual for Hawai‘i was modified from an original manual geared toward mainland fishers and is used as a guideline for protocol. The characteristics of Hawai‘i’s fisheries are very different from those found on the mainland. One major difference is the possibility of intercepting the same angler more than once; many fishermen in Hawai′i are interviewed on a somewhat regular basis or regularly visit a site. Hawai‘i’s culture requires a modified protocol for interviews where interviews are often toned-down in order to match a particular fisher’s disposition. The majority of interviewers will “talk story” with a fisher before asking permission for an interview (Tom Ogawa, personal communication, October 27, 2011).

A4.2. Areas for Consideration

MRFSS methodology has several problems pertaining to bias. The nature of the survey itself does not allow for data to be collected from all anglers. To account for this, representative samples allowing for unbiased estimation of the catch by the total angler population should be collected. "However, resource limitations, survey design characteristics, sample frame errors, and restricted access to anglers in some modes may result in non-representative sampling of the angler population." Since data are not available for all anglers, adjustments are made in the estimation process. The expansion process requires assumptions about un-sampled anglers that are of unknown validity (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006).

The NRC (2006) identified three general areas of bias in the MRFSS design: sample frames for catch rate estimation (intercept data) and effort estimation (phone survey data) are either incomplete or have errors (or both); the fidelity to the sampling protocols used in phone and intercept surveys are not monitored adequately; and the MRFSS survey design makes assumptions of unknown validity used in the expansion of estimates over the non-sampled segments of the fishing population. Several other concerns have also been identified via personal communication and the review of the aforementioned documents. These include the voluntary nature of the survey, inefficiencies in the effort estimation, issues with CPUE, overlap with the commercial sector, a lack of human dimensions data, difficulty in identifying target species, missing segments of the populations, issues determining hooking mortality, and the determination of recreational data.

A4.2.1. Sampling frame issues

As mentioned, the sample frames for catch rate estimation (intercept data) and effort estimation (phone survey data) are either incomplete or have errors. The sample frame only includes a subset of the true population and estimates are derived by expanding the frame. In the expansion process, the intercept frame is used to correct for the incompleteness of the effort frame. However, the intercept frame is incomplete itself, in part because no sampling takes place at night (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006).

A4.2.2. Sampling protocols

Surveyors in Hawai‘i each have their own unique approach to interviewing, so trying to measure fidelity to protocol may be challenging. They also have some flexibility when it comes to choosing a sampling time in addition to being able to choose alternate sites. Intercept surveys are currently assumed to be a random sample, however interviewers are allowed to make judgments about where, when, and which units to sample. In a probability sample, interviewers should exercise no judgment in choosing who to interview. Therefore, samples may not be truly random and this deviation from probability sampling protocol has unknown impacts on CPUE and effort estimates (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006). Allowing the sampling time to be chosen by surveyors weakens the statistical integrity because it is supposed to be a random survey, not a quota survey. Weather problems may be unavoidable but surveyors should not choose to go to the docks at times when the most people are returning; times should be randomized (Hongguang Ma, personal communication, October 19, 2011).

A4.2.3. Assumptions

Current methodology makes unverified or unverifiable assumptions about angler behavior in non-sampled segments of the population in order to cope with budgetary constraints. Data do not exist to test the validity of these assumptions in order to determine whether or not they result in large biases. It is unknown whether or not the adjustments made in the expansion process introduce bias and not being able to test for said bias results in uncertainty about the quality of estimates (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006).

A4.2.4. Inefficiencies in effort estimation

Random digit dialing (RDD) is used to gather angler effort data. This is not an efficient way to gather data as less than 1/20 of telephone calls reach an angler (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006). The problems with RDD were also identified by Tom Ogawa (personal communication, October 17, 2011). He mentioned that an increasing number of fishermen are without landlines and surveyors are not allowed to dial cell phones. Alternatives to phone surveys, such as web-based surveys, should be considered (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006).

A4.2.5. Catch per unit effort

Ogawa suggested a real-time estimate of fishing participation may reduce potential bias in the expansion estimates. There have been challenges with night fishing estimations in Hawaiʻi and elsewhere. Catch rates at private sites and for night fishing are assumed to be similar to catch rates in sampled areas and at sampled times. The instance of illegal fishing is also of concern; it is well known that this activity takes place in Hawaiʻi at night or on weekends when enforcement is not on duty (Tom Ogawa, personal communication, October 17, 2011). Spear fishermen are difficult to encounter due to the fact that they spend most of their time fishing underwater. It is possible that their catch is underrepresented. Additionally, cultural behaviors (baby luaus, reunions) are not accounted for in HMRFS (Tom Ogawa, personal communication, October 17, 2011).

A4.2.6. Voluntary nature of survey

The MRFSS and HMRFS are voluntary surveys; voluntary surveys limit the represented population to those who will submit data. Most of the time, fishermen will refuse HMRFS surveyors (Tom Ogawa, personal communication, October 17, 2011). It is important to note that in the report by Allen and Bartlett (2008), they state that “very few fishermen, estimated to be no more than 5-10%, refuse to be interviewed.” The data focused on for this report was from 2003 and since then, certain conditions have changed in Hawaiʻi. In the past two years, more interview denials have occurred due primarily to the negative effects of the recession. In general, less people have been fishing which is likely due to the rising costs of oil. Rising costs coupled with job layoffs across the state have likely kept people from finding time to fish and relax. Surveyors found that fishers were sometimes disgruntled after having spent hours and hundreds of dollars to come back with no catch. It was found that fishermen, even those who were regularly interviewed in the past, would refuse to talk to familiar surveyors (Tom Ogawa, personal communication, October 27, 2011). Refusal may also be due to the fact that fishermen are in a rush or that they fear the surveyors are enforcement.

Often times, fishermen that do allow the interview will allow only enough time for a few of their fish to be measured and weighed (Tom Ogawa, personal communication, October 17, 2011). This can lead to mean species lengths and weights that may not be representative. Sometimes, the sample size is simply not large enough to produce a representative mean weight (Hongguang Ma, personal communication, October 19, 2011). This is reflected in the missing weight data (Tom Ogawa, personal communication, October 17, 2011). Comparing mean species weights and lengths from HMRFSS to CML reports can provide insights into bias. For example, commercial fishermen are generally more experienced than recreational fishermen so they probably catch more and bigger fish. Also, commercial fishermen usually sell the biggest fish in their catch, so a mean species weight from HMRFS that exceeds its complementary commercial mean weight is likely not representative (Hongguang Ma, personal communication, October 19, 2011).

A4.2.7. Commercial overlap

Many fishermen in Hawai‘i may purchase a CML in order to sell fish to cover fishing expenses or to avoid bag limits set for recreational fishermen (Tom Ogawa, personal communication, October 17, 2011). Fishermen holding a CML are required to report all fish caught on their monthly CML report. However, some fishermen only report fish they sell (Tom Ogawa and Hongguang Ma, personal communication, October 17-19, 2011). This lack of reporting creates a gap in the commercial data (Tom Ogawa, personal communication, October 17, 2011). Conversely, when fishermen do correctly include fish caught but not sold on their CML report, data overlaps with HMRFS data (Hongguang Ma, October 19, 2011). If a fishermen reports that they are full-time commercial fishermen, the interview is not used to estimate catch in the HMRFS expansion. HMRFS does however keep the part-time and full-time commercial and expense fishermen data, which is the source of overlap with the CML reports (Tom Ogawa, personal communication, October 17, 2011).

A4.2.8. Human dimensions

A limitation to the HMRFS is that data collection effort is not designed to develop estimates that can be used for managing fisheries by island or region, or for seasonal adjustments. Also, many useful types of data about anglers are not explored. This includes demographic data as well as subsistence uses and cultural values of fishing. Currently, the HMRFS does not collect demographic data such as gender, ethnicity, age, education, income, or years lived in Hawai‘i. The only useable location data are the zip codes, which can allow for spatial analysis of the residences. Also, it may be important to consider the harvest of non-finfish species as these species are important when considering any type of ecosystem based management approach (Allen & Bartlett, 2008).

A4.2.9. Target species & Hooking mortality

Data on target species are only collected in Hawai'i and is not part of the MRFSS. Responses regarding target species do not always yield a species-level response but rather a general target (e.g. tuna). Target species data are thus difficult to analyze. To more easily observe the frequency of common targets, general species "groups" could be created (Allen & Bartlett, 2008). There are also issues with mortality estimates of catch released alive; the estimation of released catch and hooking mortality needs more attention. There is a percentage of fish released alive that will die from the stress of being caught. This estimation would be important in understanding total removals (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006).

A4.2.10. Other concerns

There are also fishermen recall problems. Interviewers ask fishermen how often they fished in the previous two months, which a fishermen may not recall (Tom Ogawa, personal communication, October 17, 2011). Some of the questions asked during the field survey may be in need of modification as some are regularly misinterpreted by fishermen (Allen & Bartlett, 2008).

Another source of problems is variation in an estimate among years, especially when fluctuations in estimates result in fluctuations in regulations for subsequent years. While fluctuations could be real, they may also be artificial due to problems with bias (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006).

A4.3. Future Improvements

Since the inception of MRFSS, data needs have changed: (1) "management decisions require data on finer temporal and spatial scales", (2) "recreational fishing data are now required for use in stock assessments, sometimes as the sole data concerning stock status" and (3) "managing recreational catch and retention has become a primary activity for fisheries management as recreational removals have supplanted commercial removals for many species and areas" (Committee on the Review of Recreational Fisheries Survey Methods, NRC, 2006). MRIP will replace the MRFSS and is designed to meet two needs: (1) "provide the detailed, timely, scientifically sound estimates that fisheries managers, stock assessors and marine scientists need to ensure the sustainability of ocean resources" and (2) "address head-on stakeholder concerns about the reliability and credibility of recreational fishing catch and effort estimates (Marine Recreational Information Program, n.d.). Under MRIP, there will be a new estimation methodology which will produce more accurate results by eliminating many sources of potential bias. Revised estimations will date back to 2004 and may be available in early 2012.

Some sampling design problems will be addressed by new MRIP expansion methods or by new sampling methods. Under MRFSS, each interview was treated as independent and CPUE calculations were based on an average of all interviews in the state. MRIP will estimate a state-level CPUE using sites as the sampling unit as opposed to interviews. MRIP will also incorporate fishing pressure estimates into the expansion algorithm. HMFRS determines sampling sites through a sample draw program that uses fishing pressure estimates but MRFSS did not use this in the expansion process (Hongguang Ma, personal communication, October 19, 2011). The pressure estimates are based on historical data (Hongguang Ma, personal communication, October 19, 2011) and are surveyor's estimations of current pressure (for the current wave) and projected pressure (for the next wave) collected in the field (Tom Ogawa, personal communication, October 17, 2011).

Ma et al. (2011) explored post-stratification by county using 2008 HMRFS data. MRIP stratifies by state and fishing mode. If the samples were random and representative, estimations without stratification by method would be accurate enough, but the limitations of the survey make it unlikely that stratification by mode is enough. HMRFS takes data on fishing methods within a fishing mode, so the data can also be post-stratified by fishing method. Ma et al. (2011) showed that the sample size was small to estimate (fishing) method specific catch rate at county level in historic HMRFS data for most fishing methods.

As mentioned, there is overlap between data collected via HMRFS and CML reports. Disposition codes on the interview forms allow for tracking the fate of a particular fish. Disposition codes include:

- Eaten/plan to eat (3)
- Used for bait/plan to use for bait (4)
- Sold/plan to sell (5)
- Thrown back dead/plan to throw away (6)
- Some other purpose (7)
- Don’t know/didn’t ask (8)
- Refused (9)
- Exchange, Trade (0)

Surveyors are instructed to separate the sold and kept catch as much as possible (Tom Ogawa, personal communication, October 17, 2011). Currently, Hongguang Ma (personal communication, October 19, 2011) is working to separate the types of recreational catch in Hawai‘i between expense fishermen and purely recreational fishermen as the disposition codes and fishermen type questions allow.

Some additional suggestions from the Committee on the Review of Recreational Fisheries Survey Methods (2006) include: (1) the establishment of a comprehensive, universal sampling frame with national coverage, (2) use of dual-frame procedures when possible (to reduce sample bias), (3) consideration of panel and internet surveys, (4) use of log books by for-hire boats to keep track of fish landed and kept as well as those caught and released, (5) enhance national database to support social, economic, and other human dimensions analyses, (6) development of a national statistical program and independent research group for marine recreational fisheries data, (7) significant investment in intellectual and technical expertise to handle large number of complex technical issues associated with surveys, (8) greater coordination between federal, state, and other survey programs to achieve a national perspective, and (10) focus on stakeholder involvement (workshops, outreach activities, establishment of stakeholder advisory group, etc.). Allen and Bartlett (2008) suggest regular monitoring of the field survey effort. This would “include documentation and analysis of refusals, tracking of the number and type of substitute days and sites, and regular visits with field interviewers to ensure systematic treatment of issues as they arise.”

A5. Code

A5.1. Diagnostics

A5.1.1. Coral Reef Taxa Identification

This code selects distinct species names found in the intercept files when they are not contained in the CREMUS, BMUS, or PMUS lists.

```
SELECT DISTINCT SPEC_NAME
FROM GIn_Cat1_N AS t1
WHERE
  (t1.SPECIES not in (select SPECIES from G_Spec_BP) and
  t1.SPECIES not in (select SPECIES from [Guam CREMUS Species]));
```

The Gin_Cat1_N table is the Guam shore-based interview data and the G_Spec_BP is a table compiled by Penglong Tao containing bottomfish and pelagic management unit species. The code was reproduced for each creel survey with appropriate table and field names.

A5.1.2. Distinct strata represented in expanded and intercept tables

The following code creates a list of all the distinct strata represented in the expanded species composition files or the intercept files.

**The Guam shore-based intercept files only contains data from YEAR >= 2003, so omission of the expanded species composition data before 2003 is necessary to preserve ratio integrity. Also the expanded species composition file combines the REGIONs for all METHODs that are not 1 and replaces the REGION code with 0, so REGIONs are not perfectly representative of the original intercept file. The intercept file's REGION column was renamed to ORIG_REGION, and then a new column called REGION was created so diagnostics that compare the two files can easily be made using the usual REGION column name.*

Column Name	Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.

```
SELECT DISTINCT
  YEAR, METHOD, TYP_DAY, DN
FROM CIN_SC
ORDER BY
  YEAR, METHOD, TYP_DAY, DN
UNION
SELECT DISTINCT
  YEAR, METHOD, TYP_DAY, DN
FROM CIN_CAT_X_INT
ORDER BY
```

```
  YEAR, METHOD, TYP_DAY, DN;
```

Below is a table comparing the different strata definitions for each of the creel surveys:

Creel Survey	Column Names
CNMI shore-based	YEAR, METHOD, TYP_DAY, DN
CNMI boat-based	YEAR, PORT, METHOD, TYP_DAY, CHARTER
Guam shore-based	YEAR, METHOD, REGION, TYP_DAY, DN
Guam boat-based	YEAR, PORT, METHOD, TYP_DAY, CHARTER

A5.1.3. Number of interviews and landings per stratum

This following code counts all of the distinct interviews and sums the total pounds that represent each stratum. A zero in the NUM_INTERVIEWS column signifies the absence of data in the intercept files for that stratum.

Column Name	Basic Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.
NUM_INTERVIEWS	COUNT(KEY1)	This field counts all of the unique interview keys, grouped by each unique stratum.
TOT_SUM_CAT_KGS	SUM(SUM(CAT_KGS))	This field sums all of the CAT_KGS from each unique interview in each unique stratum.
TOT_SUM_CAT_LBS	TOT_SUM_CAT_KGS * 2.20462	This field converts the TOT_SUM_CAT_KGS column from kilograms into pounds using the conversion factor 2.20462.
POOL_FLAG	Pooling Flag	This field is brought over from the expanded species composition file, but is only available in the CNMI data set, and not for Guam.

```
SELECT DISTINCT
  A.YEAR, A.METHOD, A.TYP_DAY, A.DN,
  A.NUM_INTERVIEWS,
  A.TOT_SUM_CAT_KGS,
  (A.TOT_SUM_CAT_KGS * 2.20642) AS TOT_SUM_CAT_LBS,
  X.POOL_FLAG
FROM
```

```
  (SELECT
    S.YEAR, S.METHOD, S.TYP_DAY, S.DN,
    COUNT(I.KEY1) AS NUM_INTERVIEWS,
    IIF(ISNULL(SUM(I.SUM_CAT_KGS)),
      0,
      SUM(I.SUM_CAT_KGS)
    ) AS TOT_SUM_CAT_KGS
  FROM
    CIN_STRATA_REP AS S
  LEFT JOIN
    (SELECT
      YEAR, METHOD, TYP_DAY, DN,
      KEY1,
      IIF(ISNULL(SUM(CAT_KGS)),
        0,
        SUM(CAT_KGS)
      ) AS SUM_CAT_KGS
    FROM CIN_CAT_X_INT
    GROUP BY
      YEAR, METHOD, TYP_DAY, DN,
      KEY1) AS I
  ON
    I.YEAR = S.YEAR AND
    I.METHOD = S.METHOD AND
    I.TYP_DAY = S.TYP_DAY AND
    I.DN = S.DN
  GROUP BY S.YEAR, S.METHOD, S.TYP_DAY, S.DN) AS A
LEFT JOIN CIN_SC AS X
ON
  X.YEAR = A.YEAR AND
  X.METHOD = A.METHOD AND
  X.TYP_DAY = A.TYP_DAY AND
  X.DN = A.DN
ORDER BY A.YEAR, A.METHOD, A.TYP_DAY, A.DN;
```

A5.1.4. Comparison of number of species in expanded and intercept strata

The following code calculates the difference between the number of unique species recorded per strata in the intercept files and the number of unique species recorded per strata in the expanded species composition files.

Column Name	Basic Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.
SC_NUM_SP	COUNT(SPECIES)	This counts all the species records found in the

		expanded species composition files.
CAT_NUM_SP	COUNT(SPECIES)	This counts all the species records found in the intercept files.
DIFF	SC_NUM_SP - CAT_NUM_SP	This calculates the difference between the expanded species composition species count and the intercept species count.
TOT_EX_KGS	SUM(EX_KGS)	This sums up the weight of the strata to provide an idea of how significant the DIFF is.

```
SELECT
  SC.YEAR, SC.METHOD, SC.TYP_DAY, SC.DN,
  IIF(ISNULL(SC_CNT_SP), 0, SC_CNT_SP) AS SC_NUM_SP,
  IIF(ISNULL(CAT_CNT_SP), 0, CAT_CNT_SP) AS CAT_NUM_SP,
  (SC_NUM_SP - CAT_NUM_SP) AS DIFF,
  IIF(ISNULL(SUM_EX_KGS), 0, SUM_EX_KGS) AS TOT_EX_KGS
FROM
  (SELECT
    YEAR, METHOD, TYP_DAY, DN,
    COUNT(SPECIES) AS SC_CNT_SP,
    SUM(EX_KGS) AS SUM_EX_KGS
  FROM CIN_SC
  GROUP BY YEAR, METHOD, TYP_DAY, DN
  ) AS SC
LEFT JOIN
  (SELECT
    YEAR, METHOD, TYP_DAY, DN,
    COUNT(SPECIES) AS CAT_CNT_SP
  FROM
    (SELECT DISTINCT
      YEAR, METHOD, TYP_DAY, DN,
      SPECIES
    FROM CIN_CAT_X_INT)
  GROUP BY YEAR, METHOD, TYP_DAY, DN
  ) AS CAT
ON
  SC.YEAR = CAT.YEAR AND
  SC.METHOD = CAT.METHOD AND
  SC.TYP_DAY = CAT.TYP_DAY AND
  SC.DN = CAT.DN
```

```
UNION SELECT
  CAT.YEAR, CAT.METHOD, CAT.TYP_DAY, CAT.DN,
  IIF(ISNULL(SC_CNT_SP), 0, SC_CNT_SP) AS SC_NUM_SP,
  IIF(ISNULL(CAT_CNT_SP), 0, CAT_CNT_SP) AS CAT_NUM_SP,
  (SC_NUM_SP - CAT_NUM_SP) AS DIFF,
  IIF(ISNULL(SUM_EX_KGS), 0, SUM_EX_KGS) AS TOT_EX_KGS
FROM
  (SELECT
    YEAR, METHOD, TYP_DAY, DN,
    COUNT(SPECIES) AS SC_CNT_SP,
    SUM(EX_KGS) AS SUM_EX_KGS
  FROM CIN_SC
  GROUP BY YEAR, METHOD, TYP_DAY, DN
  ) AS SC
RIGHT JOIN
  (SELECT
    YEAR, METHOD, TYP_DAY, DN,
    COUNT(SPECIES) AS CAT_CNT_SP
  FROM
    (SELECT DISTINCT
      YEAR, METHOD, TYP_DAY, DN,
      SPECIES
    FROM CIN_CAT_X_INT)
  GROUP BY YEAR, METHOD, TYP_DAY, DN
  ) AS CAT
ON
  SC.YEAR = CAT.YEAR AND
  SC.METHOD = CAT.METHOD AND
  SC.TYP_DAY = CAT.TYP_DAY AND
  SC.DN = CAT.DN;
```

A5.1.5. Taxa found in intercept files but not expanded files

This code selects distinct species found in one table and not the other.

```
SELECT DISTINCT SPEC_NAME
FROM CIN_CAT_X_INT AS t1
WHERE (t1.SPECIES not in (select SPECIES from CIN_SC));
```

A5.1.6. Methods found in intercept files but not expanded files

This code selects distinct methods found in one table and not the other.

```
SELECT DISTINCT METH_NAME
FROM CIN_CAT_X_INT AS t1
```

```
WHERE (t1.METHOD not in (select METHOD from CIN_SC));
```

A5.2. Non-commercial and commercial fishery summaries

The following procedure is a 10 step process. The following steps were used to calculate the summary for the CNMI shore based summary, but similar steps were used to create the summaries for CNMI boat-based, and Guam shore-based and boat-based records.

A5.2.1. Percentage of CREMUS landings to total landings per interview

The following code calculates the percentage of CREMUS landings to total landings for each interview as PC_CRE by selecting all records that are found on the CREMUS table, then summing over each record's PC_KGS. Row count will be smaller than the count of all distinct interviews in the event that an interview only has records of non-CREMUS species.

** The list of Guam's CREMUS groups is appended with G_ instead of C_ like is found in the following CNMI code example.*

Column Name	Basic Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.
KEY1	Interview Identifier	This unique key is used by functions to identify each individual interview.
PC_CRE	SUM(PC_KGS)	In each interview, this sums together the weight of each species of fish that appears on the CREMUS list to calculate the percent of the total weight that is from coral reef species.

```
SELECT
  I.YEAR, I.METHOD, I.TYP_DAY, I.DN,
  I.KEY1,
  SUM(I.PC_KGS) AS PC_CRE
FROM
  CIN_CAT_X_INT AS I,
  C_CREMUS_SP AS CRE
WHERE
  I.SPECIES = CRE.SPECIES
GROUP BY
  I.YEAR, I.METHOD, I.TYP_DAY, I.DN,
  I.KEY1
ORDER BY I.YEAR, I.METHOD, I.TYP_DAY, I.DN;
```

A5.2.2. Percentage of non-commercial, CREMUS landings to total landings per interview

The following code calculates the percentage of non-commercial, CREMUS landings per interview to total landings per interview as PC_NCOM_CRE by calculating the product of the percentages PC_UNSOLD and PC_CRE (divided by 100 to change PC_UNSOLD from percent to a ratio). This will have the same record count as the PC_CRE table.

Column Name	Basic Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.
KEY1	Interview Identifier	This unique key is used by functions to identify each individual interview.
PC_NCOM_CRE	PC_UNSOLD * PC_CRE	In each interview, this reduces the percent of the weight that is from coral reef species by the percent of the weight that is not sold to calculate the percent of the weight of each interview that is from non-commercial coral reef species.

```
SELECT DISTINCT
  I.YEAR, I.METHOD, I.TYP_DAY, I.DN,
  I.KEY1,
  (I.PC_UNSOLD / 100 * A.PC_CRE) AS PC_NCOM_CRE
FROM
  CIN_CAT_X_INT AS I,
  CIN_PC_CRE AS A
WHERE
  I.KEY1 = A.KEY1
ORDER BY I.YEAR, I.METHOD, I.TYP_DAY, I.DN;
```

A5.2.3. Total percentage of CREMUS landings for each stratum

The following code calculates the total percentage of CREMUS species for each stratum by first summing up the products of each interview's CAT_KGS and PC_CRE in a stratum to find the TOT_CRE_KGS, then dividing that sum by the TOT_CAT_KGS. A NULL value in TOT_CAT_KGS column signifies the absence of data in the intercept files for that stratum. If TOT_CAT_KGS is 0, the sum of all the intercept records for that stratum sum to 0. In order to avoid the Div/0 error when calculating the TOT_PC_CRE, the percentage was automatically set to 0%.

Column Name	Basic Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.
TOT_CAT_KGS	SUM(CAT_KGS)	In each stratum, this sums together the weight of all fish recorded in the interviews.
TOT_CRE_KGS	SUM(PC_CRE * CAT_KGS)	In each stratum, this sums together the weight of all fish recorded in the interviews reduced by the percentage of each interview that is CREMUS to calculate the total weight of coral reef landings.
TOT_PC_CRE	TOT_CRE_KGS / TOT_CAT_KGS	In each stratum, this calculates the total percentage of a stratum's weight that is comprised of coral reef landings by dividing the CREMUS weight by the catch weight.

```
SELECT
  S.YEAR, S.METHOD, S.TYP_DAY, S.DN,
  SUM(I.CAT_KGS) AS TOT_CAT_KGS,
  SUM(A.PC_CRE * I.CAT_KGS) AS TOT_CRE_KGS,
  IIF(ISNULL(TOT_CAT_KGS),
     NULL,
     IIF(TOT_CAT_KGS = 0,
        0,
        (TOT_CRE_KGS / TOT_CAT_KGS)))
  AS TOT_PC_CRE
FROM
  (CIN_STRATA_REP AS S
LEFT JOIN
  CIN_PC_CRE AS A
ON
  A.YEAR = S.YEAR AND
  A.METHOD = S.METHOD AND
  A.TYP_DAY = S.TYP_DAY AND
  A.DN = S.DN)
LEFT JOIN
  CIN_CAT_X_INT AS I
ON
  I.KEY1 = A.KEY1
GROUP BY S.YEAR, S.METHOD, S.TYP_DAY, S.DN
ORDER BY S.YEAR, S.METHOD, S.TYP_DAY, S.DN;
```

A5.2.4. Total percentage of non-commercial CREMUS landings for each stratum

The following code calculates the total percentage of non-commercial CREMUS species for each stratum by first summing up the products of each interview's CAT_KGS and PC_NCOM_CRE in a stratum to find the TOT_NCOM_CRE_KGS, then dividing that sum by the TOT_CAT_KGS. A NULL value in TOT_CAT_KGS column signifies the absence of data in the intercept files for that stratum. If TOT_CAT_KGS is 0, the sum of all the intercept records for that stratum sum to 0. In order to avoid the Div/0 error when calculating the TOT_PC_NCOM_CRE, the percentage was automatically set to 0%.

Column Name	Basic Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.
TOT_CAT_KGS	SUM(CAT_KGS)	In each stratum, this sums together the weight of all fish recorded in the interviews.
TOT_NCOM_CRE_KGS	SUM(PC_NCOM_CRE * CAT_KGS)	In each stratum, this sums together the weight of all fish recorded in the interviews reduced by the percentage of each interview that is non-commercial coral reef to calculate the total weight of the non-commercial coral reef landings.
TOT_PC_NCOM_CRE	TOT_NCOM_CRE_KGS / TOT_CAT_KGS	In each stratum, this calculates the total percentage of a stratum's weight that is comprised of non-commercial coral reef landings by dividing the total NCOM_CRE weight by the total catch weight.

```
SELECT
  S.YEAR, S.METHOD, S.TYP_DAY, S.DN,
  SUM(I.CAT_KGS) AS TOT_CAT_KGS,
  SUM(A.PC_NCOM_CRE * I.CAT_KGS) AS TOT_NCOM_CRE_KGS,
  IIF(ISNULL(TOT_CAT_KGS),
     NULL,
     IIF(TOT_CAT_KGS = 0,
        0,
        (TOT_NCOM_CRE_KGS / TOT_CAT_KGS)))
  AS TOT_PC_NCOM_CRE
FROM
  (CIN_STRATA_REP AS S
```

```
LEFT JOIN
  CIN_PC_NCOM_CRE AS A
ON
  A.YEAR = S.YEAR AND
  A.METHOD = S.METHOD AND
  A.TYP_DAY = S.TYP_DAY AND
  A.DN = S.DN)
LEFT JOIN
  CIN_CAT_X_INT AS I
ON
  I.KEY1 = A.KEY1
GROUP BY S.YEAR, S.METHOD, S.TYP_DAY, S.DN
ORDER BY S.YEAR, S.METHOD, S.TYP_DAY, S.DN;
```

A5.2.5. Total expanded weight of each species per stratum

The following code calculates the sum of the total expanded weight for each species per stratum.

Column Name	Basic Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.
TOT_EX_KGS	SUM(EX_KGS)	In each stratum, this sums together the expanded weight of each species of fish.

```
SELECT
  S.YEAR, S.METHOD, S.TYP_DAY, S.DN,
  SUM(EX_KGS) AS TOT_EX_KGS
FROM
  CIN_STRATA_REP AS S
LEFT JOIN
  CIN_SC AS C
ON
  S.DN = C.DN AND
  S.YEAR = C.YEAR AND
  S.METHOD = C.METHOD AND
  S.TYP_DAY = C.TYP_DAY
GROUP BY S.YEAR, S.METHOD, S.TYP_DAY, S.DN
ORDER BY S.YEAR, S.METHOD, S.TYP_DAY, S.DN;
```

A5.2.6. Weighted average percentage of CREMUS landings for each YEAR/METHOD pairing

To calculate an estimated total percentage of CREMUS landings for each stratum that was expanded but was not represented in the intercept files, the following code calculates the weighted average of the total percentages of CREMUS species for the same YEAR and METHOD using the stratum's TOT_EX_KGS as the weight. Strata where the TOT_EX_KGS sums to 0 kgs are ignored because that means that is has no weight at all in the average.

Column Name	Basic Algorithm	Description
YEAR, METHOD	Strata Definition	Together, these fields create a unique key that identify all year method pairs within the data.
YM_TOT_EX_KGS	SUM(TOT_EX_KGS)	In each pairing, this sums together the weight of all fish recorded in the expanded SC table in order to establish the weight of a pairing for averaging.
WAVG_YM_PC_CRE	SUM(TOT_EX_KGS * TOT_PC_CRE) / YM_TOT_EX_KGS	In each pairing, this sums together the expanded weights for all fish species reduced by the percentage of each stratum that is coral reef then divides by the total pairing's expanded weight to calculate the weighted average percentage of the weight that is from coral reef landings.

```
SELECT
  A.YEAR, A.METHOD,
  SUM(B.TOT_EX_KGS) AS YM_TOT_EX_KGS,
  IIF(ISNULL(YM_TOT_EX_KGS),
    NULL,
    IIF(YM_TOT_EX_KGS = 0,
      NULL,
      (SUM(B.TOT_EX_KGS * A.TOT_PC_CRE) / YM_TOT_EX_KGS)))
  AS WAVG_YM_PC_CRE
FROM
  CIN_TOT_PC_CRE AS A
LEFT JOIN
  CIN_TOT_EX_KGS AS B
ON
  B.YEAR = A.YEAR AND
  B.METHOD = A.METHOD AND
  B.TYP_DAY = A.TYP_DAY AND
  B.DN = A.DN
WHERE
  B.TOT_EX_KGS > 0 AND
  A.TOT_PC_CRE IS NOT NULL
GROUP BY A.YEAR, A.METHOD;
```

A5.2.7. Weighted average percentage of non-commercial CREMUS landings for each YEAR/METHOD paring

To calculate an estimated total percentage of non-commercial CREMUS landings for each stratum that was expanded but was not represented in the intercept files, the following code calculates the weighted average of the total percentages of non-commercial CREMUS landings for the same YEAR and METHOD using the stratum's TOT_EX_KGS as the weight. Strata where the TOT_EX_KGS sums to 0 Kgs are ignored because that means that is has no weight at all in the average.

Column Name	Basic Algorithm	Description
YEAR, METHOD	Strata Definition	Together, these fields create a unique key that identify all year method pairs within the data.
YM_TOT_EX_KGS	SUM(TOT_EX_KGS)	In each pairing, this sums together the weight of all fish recorded in the expanded SC table in order to establish the weight of a pairing for averaging.
WAVG_YM_PC_NCOM_CRE	SUM(TOT_EX_KGS * TOT_PC_NCOM_CRE) / YM_TOT_EX_KGS	In each pairing, this sums together the expanded weights for all fish species reduced by the percentage of each stratum that is non-commercial coral reef then divides by the total pairing's expanded weight to calculate the weighted average percentage of the weight that is from non-commercial coral reef landings.

```
SELECT
  A.YEAR, A.METHOD,
  SUM(B.TOT_EX_KGS) AS YM_TOT_EX_KGS,
  IIF(ISNULL(YM_TOT_EX_KGS),
    NULL,
    IIF(YM_TOT_EX_KGS = 0,
      NULL,
      (SUM(B.TOT_EX_KGS * A.TOT_PC_NCOM_CRE) / YM_TOT_EX_KGS)))
  AS WAVG_YM_PC_NCOM_CRE
FROM
  CIN_TOT_PC_NCOM_CRE AS A
LEFT JOIN
  CIN_TOT_EX_KGS AS B
ON
  B.YEAR = A.YEAR AND
  B.METHOD = A.METHOD AND
```

```
  B.TYP_DAY = A.TYP_DAY AND
  B.DN = A.DN
WHERE
  B.TOT_EX_KGS > 0 AND
  A.TOT_PC_NCOM_CRE IS NOT NULL
GROUP BY A.YEAR, A.METHOD;
```

A5.2.8. Weighted average percentage of CREMUS landings by METHOD

In the event that there exists a stratum that is expanded and yet does not contain sibling YEAR/METHOD strata from which a weighted average percentage of CREMUS landings for each YEAR/METHOD pairing can be calculated, the following code calculates the weighted average grouped by all years for that METHOD and the weight is equivalent to the TOT_SUM_CAT_KGS (i.e. the weighted average percentage of CREMUS landings by CNMI shore-based octopus hooking in 2008 is 0.32601).

Column Name	Basic Algorithm	Description
METHOD	Strata Definition	This field is used as a unique key that identifies all the expanded methods within the data.
M_TOT_CAT_KGS	SUM(TOT_CAT_KGS)	For each method, this sums together the weight of all fish recorded in the catch table to establish a weight for averaging.
WAVG_M_PC_CRE	SUM(TOT_CAT_KGS * TOT_PC_CRE) / M_TOT_CAT_KGS	For each method, this sums together the recorded weights for all fish species reduced by the percentage of each stratum that is coral reef then divides by the total method’s recorded weight to calculate the weighted average percentage of the weight that is from coral reef landings.

```
SELECT
  A.METHOD,
  SUM(A.TOT_CAT_KGS) AS M_TOT_CAT_KGS,
  IIF(ISNULL(M_TOT_CAT_KGS),
    NULL,
    IIF(M_TOT_CAT_KGS = 0,
      NULL,
      (SUM(A.TOT_CAT_KGS * A.TOT_PC_CRE) / M_TOT_CAT_KGS)))
  AS WAVG_M_PC_CRE
FROM
  CIN_TOT_PC_CRE AS A
WHERE
  A.TOT_PC_CRE IS NOT NULL
GROUP BY A.METHOD;
```

A5.2.9. Weighted average percentage of non-commercial CREMUS landings by METHOD

In the event that there exists a stratum that is expanded and yet does not contain sibling YEAR/METHOD strata from which a weighted average percentage of non-commercial CREMUS landings for each YEAR/METHOD paring can be calculated, the following code calculates the weighted average grouped by all years for that METHOD and the weight is equivalent to the TOT_SUM_CAT_KGS (i.e. the weighted average percentage of CREMUS landings by CNMI shore-based octopus hooking in 2008 is 0.32601).

Column Name	Basic Algorithm	Description
METHOD	Strata Definition	This field is used as a unique key that identifies all the expanded methods within the data.
M_TOT_CAT_KGS	SUM(TOT_CAT_KGS)	For each method, this sums together the weight of all fish recorded in the catch table to establish a weight for averaging.
WAVG_M_PC_NCOM_CRE	SUM(TOT_CAT_KGS * TOT_PC_NCOM_CRE) / M_TOT_CAT_KGS	For each method, this sums together the recorded weights for all fish species reduced by the percentage of each stratum that is non-commercial coral reef then divides by the total method's recorded weight to calculate the weighted average percentage of the weight that is from non-commercial coral reef landings.

```
SELECT
  A.METHOD,
  SUM(A.TOT_CAT_KGS) AS M_TOT_CAT_KGS,
  IIF(ISNULL(M_TOT_CAT_KGS),
    NULL,
    IIF(M_TOT_CAT_KGS = 0,
      NULL,
      (SUM(A.TOT_CAT_KGS * A.TOT_PC_NCOM_CRE) / M_TOT_CAT_KGS)))
  AS WAVG_M_PC_NCOM_CRE
FROM
  CIN_TOT_PC_NCOM_CRE AS A
WHERE
  A.TOT_PC_NCOM_CRE IS NOT NULL
GROUP BY A.METHOD;
```

A5.2.10. Summary

The following code compares the expanded species composition files with the estimated total percentage of CREMUS landings and the estimated total percentage of non-commercial CREMUS landings for each stratum, filters out all non-CREMUS landing records, then for each species in each expanded stratum, calculates the total non-commercial CREMUS and commercial CREMUS landings in pounds.

**METHOD = "Ika Shibi" in Guam boat-based had two records that even when aggregated by method over all recorded years, contained no catch data with which to calculate the weighted average percentage of non-commercial CREMUS landings. Because there are only two records of this method in the intercept file, both records are for* Thunnus albacares *(which are non-CREMUS), and 100% of these landings were sold, the estimated total percentage of non-commercial CREMUS landings for the two expanded strata (YEAR=1982, PORT=1, METHOD=8, TYP_DAY=1, CHARTER=0 AND YEAR=1993, PORT=1, METHOD=8, TYP_DAY=2, CHARTER=0) were manually set to 0.*

Column Name	Basic Algorithm	Description
YEAR, METHOD, TYP_DAY, DN	Strata Definition	Together, these fields create a unique key that defines the strata.
SPECIES	Species Identifier	This unique key is used to identify each distinct fish species.
METH_NAME, SPEC_NAME	Method name, Species name	These columns translate the METHOD and SPECIES numbers into words on a 1:1 basis.
CRE_NAME	CREMUS group identifier	This identifies to which CREMUS group the fish species belongs.
EX_KGS	Expanded weight in kilograms	This field is copied directly from the Species Composition table (SC) and represents the estimated weight of total landings for a fish species in the given strata.
EX_LBS	Expanded weight in pounds	This field converts the EX_KGS column from kilograms into pounds using the conversion factor 2.20462.
EST_TOT_PC_CRE	TOT_PC_CRE or WAVG_YM_PC_CRE or WAVG_M_PC_CRE	For each stratum, this is the total percentage of a stratum's weight that is

		comprised of coral reef landings, and estimates using weighted averages when there is insufficient data to calculate the actual percentage regularly.
WAVG_YM_PC_CRE	SUM(TOT_EX_KGS * TOT_PC_CRE) / YM_TOT_EX_KGS	This is the weighted average percentage of the weight that is from coral reef landings for each YEAR-METHOD pairing.
WAVG_M_PC_CRE	SUM(TOT_CAT_KGS * TOT_PC_CRE) / M_TOT_CAT_KGS	This is the weighted average percentage of the weight that is from coral reef landings for each METHOD.
EST_EX_CRE_KGS	EX_KGS * EST_TOT_PC_CRE	For this species in this stratum, this is the expanded weight of landings reduced by the by percent of the weight in the stratum that is only coral reef.
EST_EX_CRE_LBS	EST_EX_CRE_KGS * 2.20462	This field converts the EST_EX_CRE_KGS column from kilograms into pounds using the conversion factor 2.20462.
EST_TOT_PC_NCOM_CRE	TOT_PC_NCOM_CRE or WAVG_YM_PC_NCOM_CRE or WAVG_M_PC_NCOM_CRE	For each stratum, this is the total percentage of a stratum's weight that is comprised of non-commercial coral reef landings, and estimates using weighted averages when there is insufficient data to calculate the actual percentage regularly.
WAVG_YM_PC_NCOM_CRE	SUM(TOT_EX_KGS * TOT_PC_NCOM_CRE) / YM_TOT_EX_KGS	This is the weighted average percentage of the weight that is from non-commercial coral reef landings for each YEAR-METHOD pairing.
WAVG_M_PC_NCOM_CRE	SUM(TOT_CAT_KGS * TOT_PC_NCOM_CRE) / M_TOT_CAT_KGS	This is the weighted average percentage of the weight that is from non-commercial coral reef landings for each METHOD.

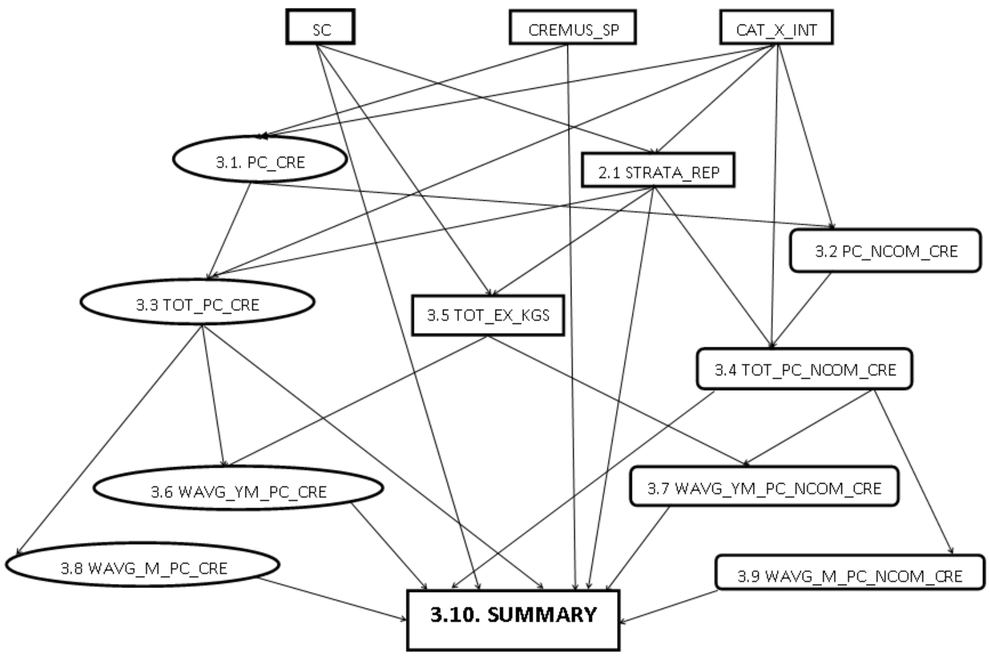
EST_EX_NCOM_CRE_KGS	EX_KGS * EST_TOT_PC_NCOM_CRE	For this species in this stratum, this is the expanded weight of landings reduced by the by percent of the weight in the stratum that is only non-commercial and coral reef.
EST_EX_NCOM_CRE_LBS	EST_EX_NCOM_CRE_KGS * 2.20462	This field converts the EST_EX_NCOM_CRE_KGS column from kilograms into pounds using the conversion factor 2.20462.
EST_EX_COM_CRE_LBS	EST_EX_CRE_LBS - EST_EX_NCOM_CRE_LBS	For this species in this stratum, this is the expanded weight of commercial coral reef landings calculated as the difference of total expanded coral reef weight minus the expanded non-commercial coral reef weight.

```
SELECT
  S.YEAR,
  S.METHOD,
  X.METH_NAME,
  S.TYP_DAY,
  S.DN,
  X.SPECIES,
  X.SPEC_NAME,
  CRE.CRE_NAME,
  X.EX_KGS,
  (X.EX_KGS * 2.20462) AS EX_LBS,
  IIF(ISNULL(PC.TOT_CAT_KGS),
    IIF(ISNULL(YC.WAVG_YM_PC_CRE),
      MC.WAVG_M_PC_CRE,
      YC.WAVG_YM_PC_CRE),
    IIF(PC.TOT_CAT_KGS = 0,
      0,
      (PC.TOT_CRE_KGS / PC.TOT_CAT_KGS)))
    AS EST_TOT_PC_CRE,
  YC.WAVG_YM_PC_CRE,
  MC.WAVG_M_PC_CRE,
  (X.EX_KGS * EST_TOT_PC_CRE) AS EST_EX_CRE_KGS,
  (EST_EX_CRE_KGS * 2.20462) AS EST_EX_CRE_LBS,
  IIF(ISNULL(PN.TOT_CAT_KGS),
```

```
    IIF(ISNULL(YN.WAVG_YM_PC_NCOM_CRE),
      MN.WAVG_M_PC_NCOM_CRE,
      YN.WAVG_YM_PC_NCOM_CRE),
    IIF(PN.TOT_CAT_KGS = 0,
      0,
      (PN.TOT_NCOM_CRE_KGS / PN.TOT_CAT_KGS)))
    AS EST_TOT_PC_NCOM_CRE,
  YN.WAVG_YM_PC_NCOM_CRE,
  MN.WAVG_M_PC_NCOM_CRE,
  (X.EX_KGS * EST_TOT_PC_NCOM_CRE) AS EST_EX_NCOM_CRE_KGS,
  (EST_EX_NCOM_CRE_KGS * 2.20462) AS EST_EX_NCOM_CRE_LBS,
  IIF(EST_EX_CRE_LBS <= EST_EX_NCOM_CRE_LBS, 0, (EST_EX_CRE_LBS -
EST_EX_NCOM_CRE_LBS)) AS EST_EX_COM_CRE_LBS
FROM
  ((((((((CIN_STRATA_REP AS S
LEFT JOIN CIN_SC AS X
ON
  S.DN = X.DN AND
  S.TYP_DAY = X.TYP_DAY AND
  S.METHOD = X.METHOD AND
  S.YEAR = X.YEAR)
LEFT JOIN CIN_TOT_PC_NCOM_CRE AS PN
ON
  PN.DN = S.DN AND
  PN.TYP_DAY = S.TYP_DAY AND
  PN.METHOD = S.METHOD AND
  PN.YEAR = S.YEAR)
LEFT JOIN CIN_WAVG_YM_PC_NCOM_CRE AS YN
ON
  YN.METHOD = S.METHOD AND
  YN.YEAR = S.YEAR)
LEFT JOIN CIN_WAVG_M_PC_NCOM_CRE AS MN
ON
  MN.METHOD = S.METHOD)
LEFT JOIN CIN_TOT_PC_CRE AS PC
ON
  PC.DN = S.DN AND
  PC.TYP_DAY = S.TYP_DAY AND
  PC.METHOD = S.METHOD AND
  PC.YEAR = S.YEAR)
LEFT JOIN CIN_WAVG_YM_PC_CRE AS YC
ON
  YC.METHOD = S.METHOD AND
  YC.YEAR = S.YEAR)
LEFT JOIN CIN_WAVG_M_PC_CRE AS MC
ON
```

```
  MC.METHOD = S.METHOD)
LEFT JOIN C_CREMUS_SP AS CRE
ON
  CRE.SPECIES = X.SPECIES)
WHERE
  CRE.CRE_NAME IS NOT NULL;
```

A5.2.11. Table / Query Relational Diagram



A5.3. Hawai‘i Code

A5.3.1. Diagnostics

A5.3.1.1. Number and frequency of type 3 intercept records by species complete for length and weight

This following code counts all of the records for each distinct SP_CODE and then also counts the number of those records that are complete, which is defined as when a record has both a WGT (weight) and LNGTH (length) measurement. Finally, the ratio of how many records are complete over total records is calculated.

Column Name	Basic Algorithm	Description
SP_CODE	DISTINCT SP_CODE	A unique value given to every distinct species of fish
SCINAME	SCINAME	The scientific name of a given species of fish
NUM_REC	COUNT(SP_CODE)	The total number of records of a given species of fish
NUM_CMPLT_REC	COUNT(SP_CODE) WHERE LNGTH IS NOT NULL AND WGT IS NOT NULL	The number of records of a given species of fish where the length and weight measurements both exist
PC_CMPLT	NUM_CMPLT_REC / NUM_REC	The ratio of complete records compared to the total number of records for a given species of fish

```
SELECT
  C.SP_CODE, C.SCINAME,
  C.NUM_REC,
  E.NUM_CMPLT_REC,
  (E.NUM_CMPLT_REC / C.NUM_REC) AS PC_CMPLT
FROM
  (SELECT
    A.SP_CODE, B.SCINAME,
    COUNT(A.SP_CODE) AS NUM_REC
  FROM ALL_HAWAII_I3 AS A
  LEFT JOIN HI_CRE AS B
  ON B.SP_CODE = A.SP_CODE
  GROUP BY A.SP_CODE, B.SCINAME
  )  AS C
LEFT JOIN
  (SELECT
    D.SP_CODE,
    IIF(COUNT(D.SP_CODE) > 0, COUNT(D.SP_CODE), 0) AS NUM_CMPLT_REC
  FROM
    (SELECT
      SP_CODE,
      LNGTH,
      WGT
    FROM ALL_HAWAII_I3
    WHERE
      (LNGTH <> 0 AND WGT <> 0) OR
      (LNGTH IS NOT NULL AND WGT IS NOT NULL)
    ) AS D
```

```
   GROUP BY D.SP_CODE
   ) AS E
ON C.SP_CODE = E.SP_CODE;
```

A5.3.1.2. Completeness of estimated catch data

The following code counts all of records of each unique species of fish, then counts all of those records where only a length measurement was recorded and then all the records where neither length nor weight are calculated. Then the frequencies of those occurrences are calculated.

** A record does not exist that has a VAR_LBS calculation but not a LBS_AB1 calculation.*

Column Name	Algorithm	Description
SP_CODE	DISTINCT SP_CODE	A unique value given to every distinct species of fish
SCINAME	SCINAME	The scientific name of a given species of fish
NUM_RECORDS	COUNT(SP_CODE)	The total number of records of a given species of fish
RECORD_FREQ	NUM_RECORDS / COUNT(DISTINCT STRATA) WHEN STRATA = DISTINCT YEAR, WAVE, ST, MODE, AREA	The ratio of the count of all records for a given species of fish over the count of all the distinct strata.
NUM_LBS_AB1	COUNT(LBS_AB1)	The number of records of a given species of fish that have an estimated A and B1 weight calculated.
NUM_VAR_LBS	COUNT(VAR_LBS)	The number of records of a given species of fish that have an estimated variance calculated.
LBS_VAR_DIFF	NUM_LBS_AB1 - NUM_VAR_LBS	The difference between the number of records that have an estimated A and B1 weight calculated and the records that have an estimated variance calculated for a given species of fish
LBS_VAR_DIFF_FREQ	LBS_VAR_DIFF / NUM_RECORDS	The ratio of number of records that only have an estimated weight but no variance over the total number of records for a given species of fish

NUM_INCMPLT	NUM_RECORDS - NUM_LBS_AB1	The number of records that do not have weight or variance calculated for a given species of fish
INCMPLT_FREQ	NUM_INCMPLT / NUM_RECORDS	The frequency of incomplete records as calculated by the number of incomplete records divided by the total number of records for a given species of fish

```
SELECT
  X.SP_CODE,
  C.SCINAME,
  COUNT(X.SP_CODE) AS NUM_RECORDS,
  (NUM_RECORDS / (SELECT COUNT(*) FROM (SELECT DISTINCT YEAR, WAVE, ST,
MODE, AREA FROM ALL_HAWAII_EST_CAT))) AS RECORD_FREQ,
  COUNT(X.LBS_AB1) AS NUM_LBS_AB1,
  COUNT(X.VAR_LBS) AS NUM_VAR_LBS,
  (NUM_LBS_AB1 - NUM_VAR_LBS) AS LBS_VAR_DIFF,
  (LBS_VAR_DIFF / NUM_RECORDS) AS LBS_VAR_DIFF_FREQ,
  (NUM_RECORDS - NUM_LBS_AB1) AS NUM_INCMPLT,
  (NUM_INCMPLT / NUM_RECORDS) AS INCMPLT_FREQ
FROM ALL_HAWAII_EST_CAT AS X
LEFT JOIN HI_CRE AS C
ON X.SP_CODE = C.SP_CODE
GROUP BY X.SP_CODE, C.SCINAME
ORDER BY C.SCINAME;
```

A6. Tables and Figures

A6. Tables and Figures

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        7. *Other* intercept harvest of type 2 (unverified) and type 3 (verified) by year
        8. *Jacks* intercept harvest of type 2 (unverified) and type 3 (verified) by year
        9. *Akule* intercept harvest of type 2 (unverified) and type 3 (verified) by year
        10. Completeness of estimated catch data
        11. Completeness of estimated weight data by species
        12. Frequency of occurrence in strata and frequency of incompleteness for weight and variance by species

2. **Total non-commercial and commercial coral reef species landings for top 3 gears/methods**
    a. **American Samoa** Shore-Based
        1. *Overall* by year
        2. *Rod and reel* by year
        3. *Gleaning* by year
        4. *Throw net* by year

    b. **American Samoa** Boat-Based
        1. *Overall* by year
        2. *Bottomfishing* by year
        3. *Spearfishing* by year
        4. *Bottomfishing/trolling mixed* by year

    c. **Guam** Shore-Based
        1. *Overall* by year
        2. *Hook and line* by year
        3. *Gill net* by year
        4. *Spear/snorkel* by year

    d. **Guam** Boat-Based
        1. *Overall* by year

2. *Bottomfishing* by year
3. *Spear/SCUBA* by year
4. *Spear/snorkel* by year

e. **CNMI** Shore-Based
1. *Overall* by year
2. *Spear/snorkel* by year
3. *Hook and line* by year
4. *Cast net* by year

f. **CNMI** Boat-Based
1. *Overall* by year
2. *Bottomfishing* by year
3. *Spear/snorkel* by year
4. *Atulai method* by year

3. Overall non-commercial coral reef species landings

a. **American Samoa** Shore-Based
1. Top 1 to 3 methods
2. Top 4 to 6 methods
3. Top 1 to 3 coral reef taxa
4. Top 4 to 6 coral reef taxa

b. **American Samoa** Boat-Based
1. Top 1 to 3 methods
2. Top 4 to 6 methods
3. Top 1 to 3 coral reef taxa
4. Top 4 to 6 coral reef taxa

c. **Guam** Shore-Based
1. Top 1 to 3 methods
2. Top 4 to 6 methods
3. Top 1 to 3 coral reef taxa
4. Top 4 to 6 coral reef taxa

d. **Guam** Boat -Based
1. Top 1 to 3 methods
2. Top 4 to 6 methods
3. Top 1 to 3 coral reef taxa
4. Top 4 to 6 coral reef taxa

e. **CNMI** Shore-Based
1. Top 1 to 3 methods
2. Top 4 to 6 methods
3. Top 1 to 3 coral reef taxa
4. Top 4 to 6 coral reef taxa

f. **CNMI** Boat -Based
1. Top 1 to 3 methods
2. Top 4 to 6 methods
3. Top 1 to 3 coral reef taxa
4. Top 4 to 6 coral reef taxa

g. **Hawai‘i intercept data**

1. Relative contribution by coral reef species to total intercept harvest (# of fish)
2. Overall type 2 (unverified) and type 3 (verified) intercept harvest (# of fish) of coral reef species by gear type
3. Top 1 to 3 methods
4. Overall harvest by coral reef species group

h. **Hawai‘i estimated/expanded harvest**

1. Annual shore-based harvest (# of fish) of top 1 to 3 coral reef species groups
2. Annual shore-based harvest (# of fish) of top 1 to 5 coral reef species in CREMUS group “other”
3. Annual shore-based harvest (# of fish) of top 4 to 6 coral reef species groups
4. Annual boat-based harvest (# of fish) of top 1 to 3 coral reef species groups
5. Annual boat-based harvest (# of fish) of top 4 to 6 coral reef species groups
6. Overall harvest by coral reef species group
7. Ranking of coral reef species by number of fish harvested

i. **2010 Hawai‘i harvest summaries**

1. Overall intercept harvest by coral reef species group
2. Overall type 2 (unverified) and type 3 (verified) intercept harvest (# of fish) of coral reef species by gear type
3. Overall type 2 (unverified) and type 3 (verified) intercept harvest (# of fish) of coral reef species in the *rod and reel* fishery
4. Overall type 2 (unverified) and type 3 (verified) intercept harvest (# of fish) of coral reef species groups in the *rod and reel* fishery
5. Overall type 2 (unverified) and type 3 (verified) intercept harvest (# of fish) of coral reef species in the *throw net* fishery
6. Overall type 2 (unverified) and type 3 (verified) intercept harvest (# of fish) of coral reef species groups in the *throw net* fishery
7. Overall type 2 (unverified) and type 3 (verified) intercept harvest (# of fish) of coral reef species in the *spear* fishery
8. Overall type 2 (unverified) and type 3 (verified) intercept harvest (# of fish) of coral reef species groups in the *spear* fishery
9. Estimated shore-based harvest of the top 20 coral reef species
10. Estimated boat-based harvest of the top 20 coral reef species

4. Algorithm Percentage Error

Table 1.a.1: Taxa found in the American Samoa, Guam, or CNMI interview files but not found in the coral reef, bottomfish, or pelagic management unit species lists with proposed categories and overall occurrence as percentage of total intercept landings. The year ranges of the intercept files are as follows: CNMI shore-based, 2005-2010; CNMI boat-based, 2000-2010; Guam shore-based, 2003-2010; Guam boat-based, 1982-January 2011; American Samoa shore-based, 1988-2000, 2002-3, 2005-April 2011; and American Samoa boat-based, 1986-March 2011.

Creel Survey		Taxon	Proposed Management Unit	Proposed CREMUS Group	Taxa Record Count	Percent of Total Taxa Record Count	Intercept Landings (lbs)	Percent of Overall Intercept Landings
Dataset: American Samoa Shore-Based		Black sea urchin insides	Coral Reef	Invertebrates	3	0.02%	10	0.01%
Total Taxa Records:	18,210	Blue triggerfish	Coral Reef	Other Finfish	2	0.01%	1	0.00%
Total Intercept Landings (lbs):	87,594	Catfishes	Coral Reef	Other Finfish	5	0.03%	1	0.00%
		Flounders	Coral Reef	Other Finfish	6	0.03%	7	0.01%
		Heart sea urchin	Coral Reef	Invertebrates	2	0.01%	8	0.01%
		Masina	Coral Reef		1	0.01%	2	0.00%
		Opii	Coral Reef	Mollusks	6	0.03%	44	0.05%
		Papatu	Coral Reef		3	0.02%	11	0.01%
		Pufferfishes	Coral Reef	Other Finfish	4	0.02%	5	0.01%
		Sea anemone	Coral Reef	Invertebrates	9	0.05%	50	0.06%
		Sisi	Coral Reef		2	0.01%	7	0.01%
		Trunkfishes	Coral Reef	Other Finfish	2	0.01%	1	0.00%
		Wedged picassofish	Coral Reef	Other Finfish	1	0.01%	0	0.00%
Dataset: American Samoa Boat-Based		Eels	Coral Reef	Other Finfish	30	0.03%	430	0.02%
Total Taxa Records:	98,094	Fishes (unknown)	Coral Reef	Other Finfish	87	0.09%	1,862	0.07%
Total Intercept Landings (lbs):	2,650,592	Pinktail triggerfish	Coral Reef	Other Finfish	1	0.00%	4	0.00%
		Salmon			2	0.00%	2	0.00%
		Spiny pufferfish	Coral Reef	Other Finfish	17	0.02%	216	0.01%
		White tip reef shark	Coral Reef	Reef sharks	5	0.01%	62	0.00%
Dataset: Guam Shore-Based		Coenobitidae	Coral Reef	Crustaceans	1	0.03%	1	0.01%
Total Taxa Records:	2,964	*Macrobrachium lar*	Coral Reef	Crustaceans	1	0.03%	0	0.00%
Total Intercept Landings (lbs):	4,499	Sargassaceae	Coral Reef	Algae	1	0.03%	1	0.02%
		Unidentified bait fishes	Coral Reef	Other	1	0.03%	0	0.00%
Dataset: Guam Boat-Based		*Polymixia berndti*	Coral Reef	Other	1	0.00%	5	0.00%
Total Taxa Records:	56,623	*Tetrapterus angustirostris*	Pelagic		30	0.05%	653	0.05%
Total Intercept Landings (lbs):	1,201,668	Tridacnidae	Coral Reef	Mollusks	1	0.00%	60	0.01%
Dataset: CNMI Shore-Based		Cigar Wrasse	Coral Reef	Wrasse	107	2.83%	84	2.17%
Total Taxa Records:	3,778	Eel (freshwater)	Coral Reef	Other	1	0.03%	0	0.01%
Total Intercept Landings (lbs):	3,862	Goby	Coral Reef	Other	2	0.05%	1	0.02%
		Sharks	Coral Reef	Sharks	2	0.05%	6	0.15%
Dataset: CNMI Boat-Based		Cigar Wrasse	Coral Reef	Wrasse	4	0.05%	-	0.00%
Total Taxa Records:	7,337	Eel (freshwater)	Coral Reef	Other	1	0.01%	-	0.00%
Total Intercept Landings (lbs):	275,955	Goby	Coral Reef	Other	28	0.38%	216	0.08%
		Sharks	Coral Reef	Sharks	1	0.01%	-	0.00%

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Table 1.a.2: Methods used to determine taxa weights in interview data with counts and percents of total records and landings in the CNMI, Guam, and American Samoa shore-based datasets. The year ranges of the intercept files are as follows: CNMI shore-based, 2005-2010; CNMI boat-based, 2000-2010; Guam shore-based, 2003-2010; Guam boat-based, 1982-January 2011; American Samoa shore-based, 1988-2000, 2002-3, 2005-April 2011; and American Samoa boat-based, 1986-April 2011.

Creel Survey		Method of Weight Determination	Taxa Record Count	Percent of Total Taxa Count	Intercept Landings (lbs)	Percent of Total Intercept Landings
Dataset: CNMI Shore-Based		Actual	1,621	43%	1,231	32%
Total Taxa Records:	3,778	Calculated	2,104	56%	2,297	59%
Total Intercept Landings (lbs):	3,862	Estimated	35	1%	331	9%
		Zero	18	0%	3	0%
Dataset: CNMI Boat-Based		Actual	2,212	30%	14,506	5%
Total Taxa Records:	7,337	Calculated	4,843	66%	242,334	88%
Total Intercept Landings (lbs):	275,955	Estimated	215	3%	19,115	7%
		Zero	67	1%	1	0%
Dataset: Guam Shore-Based		Actual	16	1%	16	0%
Total Taxa Records:	2,964	Calculated	2,710	91%	3,303	73%
Total Intercept Landings (lbs):	4,499	Estimated	208	7%	666	15%
		Zero	30	1%	514	11%
Dataset: Guam Boat-Based		Actual	3,721	7%	170,962	14%
Total Taxa Records:	56,623	Calculated	42,649	75%	661,061	55%
Total Intercept Landings (lbs):	1,201,668	Estimated	10,252	18%	369,542	31%
		Zero	1	0%	103	0%
Dataset: American Samoa Shore-Based		Actual	17,760	96%	86,740	99%
Total Taxa Records:	18,435	Calculated from Length	408	2%	241	0%
Total Intercept Landings (lbs):	87,594	Calculated from Interview Average	72	0%	553	1%
		Calculated from Database Average	22	0%	59	0%
		Blank	173	1%	0	0%

Table 1.a.3: Condition of fish landed in the American Samoa boat-based creel survey intercept file shown as total count and percentage of total taxa records and landings from 1986-April 2011. Weights of fish landed in conditions other than whole are calculated.

Condition	Taxa Record Count	Percent of Total Taxa Count	Intercept Landings (lbs)	Percent of Total Intercept Landings
Whole	95,349	87%	2,116,319	80%
Gutted and gilled	13,776	13%	524,315	20%
Headed and gutted	37	0%	3,052	0%
Headed, gutted, and gilled	38	0%	3,465	0%
Gutted	62	0%	1,908	0%
Headed	2	0%	123	0%
Shark bit	29	0%	826	0%
Headed, gutted, gilled, and shark bit	7	0%	109	0%
Chucks/loins	13	0%	475	0%
Total Taxa Records:	109,313			
Total Intercept Landings (lbs):	2,650,592			

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Table 1.a.4: Count of interviews per stratum and pounds landed per stratum summarized by percent of total strata count and pounds landed per stratum in different ranges of number of interviews per stratum. Strata with zero interviews are strata existing in the expanded files that were derived from participation data, but have no intercept data. Strata with 1 to 2 interviews have been subjected to the pooling algorithm. The year ranges of the analysis are as follows: CNMI shore-based, 2005-2010; CNMI boat-based, 2000-2010; Guam shore-based, 2003-2010; and Guam boat-based, 1982-2010.

		Classification of Strata by Interview Count	Strata Count	Percent of Total Strata Count	Intercept Landings (lbs)	Percent of Total Intercept Landings	Estimated Landings (lbs)	Percent of Total Estimated Landings
Dataset:	CNMI Shore-Based	0	8	10%	-	0%	7,767	3%
Total Strata:	82	1 to 2	24	29%	370	10%	35,834	12%
Total Intercept Landings (lbs):	3,852	3 to 10	18	22%	872	23%	80,765	28%
Total Estimated Landings (lbs):	288,429	11 to 50	20	24%	916	24%	69,254	24%
		>50	12	15%	1,693	44%	94,808	33%
Dataset:	CNMI Boat-Based	0	268	50%	-	0%	2,026,811	26%
Total Strata:	540	1 to 2	89	16%	3,328	1%	2,314,069	29%
Total Intercept Landings (lbs):	270,221	3 to 10	109	20%	24,292	9%	1,281,538	16%
Total Estimated Landings (lbs):	7,892,392	11 to 50	64	12%	145,554	54%	1,544,857	20%
		>50	10	2%	97,047	36%	44,335	1%
Dataset:	Guam Shore-Based	0	75	25%	-	0%	70,780	11%
Total Strata:	303	1 to 2	83	27%	887	20%	113,564	18%
Total Intercept Landings (lbs):	4,445	3 to 10	96	32%	1,729	39%	328,135	52%
Total Estimated Landings (lbs):	627,391	11 to 50	49	16%	1,829	41%	114,683	18%
		>50	0	0%	-	0%	-	0%
Dataset:	Guam Boat-Based	0	463	30%	-	0%	5,104,620	23%
Total Strata:	1,549	1 to 2	419	27%	26,947	2%	1,239,933	5%
Total Intercept Landings (lbs):	1,197,956	3 to 10	358	23%	84,245	7%	2,943,098	13%
Total Estimated Landings (lbs):	22,660,803	11 to 50	194	13%	205,505	17%	3,911,473	17%
		>50	115	7%	881,259	73%	9,461,678	42%

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Table 1.a.5: Pooling flags and actual and expected untouched strata determined by interview count in the CNMI shore-based and boat-based creel surveys. Strata with 3 or more interviews are not expected to have a pooling flag, marking that the catch rate for the stratum was calculated using interviews selected by the pooling algorithm. The year ranges of the analysis are as follows: CNMI shore-based, 2005-2010 and CNMI boat-based, 2000-2010.

		Flag	Meaning	Strata Count	Percent of Total Strata	Estimated Landings (lbs)	Percent of Estimated Landings
Dataset:	CNMI Shore-Based	Expected Blank	Strata with 3 or more interviews	50	61%	244,828	85%
Total Strata:	82	Blank	Strata that are not flagged	63	77%	257,888	89%
Total Estimated Landings (lbs):	288,429	M	Pooled by combining all records in a year with the same method and type of day	7	9%	1,848	1%
		Q	Pooled by combining all records in previous and following quarters	12	15%	28,693	10%
Dataset:	CNMI Boat-Based	Expected Blank	Strata with 3 or more interviews	183	34%	2,870,730	40%
Total Strata:	540	Blank	Strata that are not flagged	399	74%	4,897,043	68%
Total Estimated Landings (lbs):	7,211,610	D	Pooled by combining day types	70	13%	1,098,316	15%
		U	Data from a reference table	71	13%	1,216,251	17%

Table 1.a.6: Count and percentage of unique taxa summarized in ranges of difference between taxa totals in interview and expanded species composition strata. No difference in the count of unique taxa signifies that the expanded stratum and intercept stratum have the same number of taxa present. The percent strata deviation is the sum of the percent of total counts when there is a difference in the count of unique taxa. The year ranges of the analysis are as follows: CNMI shore-based, 2005-2010; CNMI boat-based, 2000-2010; Guam shore-based, 2003-2010; and Guam boat-based, 1982-2010.

	Creel Survey	Classification of Strata by Differences in Count of Unique Taxa	Strata Count	Percent of Total Count	Estimated Landings (lbs)	Percent of Total Estimated Landings
Dataset:	CNMI Shore-Based	0	34	41%	160,735	56%
Total Strata:	82	1 to 2	14	17%	34,306	12%
Percent Strata Deviation:	59%	3 to 10	24	29%	72,637	25%
Total Estimated Landings (lbs):	288,429	> 10	10	12%	20,751	7%
Dataset:	CNMI Boat-Based	0	158	29%	6,089,872	77%
Total Strata:	540	1 to 2	63	12%	807,648	10%
Percent Strata Deviation:	71%	3 to 10	176	33%	659,186	8%
Total Estimated Landings (lbs):	7,892,392	> 10	143	26%	335,686	4%
Dataset:	Guam Shore-Based	0	75	25%	328,681	52%
Total Strata:	303	1 to 2	107	35%	256,886	41%
Percent Strata Deviation:	75%	3 to 10	32	11%	6,705	1%
Total Estimated Landings (lbs):	627,391	> 10	89	29%	35,119	6%
Dataset:	Guam Boat-Based	0	785	51%	17,101,391	75%
Total Strata:	1549	1 to 2	143	9%	379,659	2%
Percent Strata Deviation:	49%	3 to 10	247	16%	1,234,453	5%
Total Estimated Landings (lbs):	22,660,803	> 10	374	24%	3,945,300	17%

Table 1.a.7: Taxa found in the intercept files but not in the estimated species composition files of each creel survey. The year ranges of the intercept files are as follows: CNMI shore-based, 2005-2010; CNMI boat-based, 2000-2010; Guam shore-based, 2003-2010; Guam boat-based, 1982-January 2011; American Samoa shore-based, 1988-2000, 2002-3, 2005-April 2011; and American Samoa boat-based, 1986-April 2011. Year ranges of the species composition files, when different, are as follows: Guam boat-based, 1982-2010; American Samoa shore-based, 1990-1996, 2005-2010; American Samoa boat-based, 1986-2010.

Creel Survey		Taxon	Taxon Record Count	Percent of Total Record Count	Intercept Landings (lbs)	Percent of Total Intercept Landings
Dataset:	American Samoa Shore-Based	Banded goatfishes	7	0.04%	29	0%
Total Taxa Records:	18,210	Black jack	1	0.01%	4	0%
Total Intercept Landings (lbs):	87,594	Black sea urchin insides	3	0.02%	10	0%
		Blue triggerfish	2	0.01%	1	0%
		Bluelined surgeonfish	1	0.01%	0	0%
		Flame hawkfish	1	0.01%	0	0%
		Harlequin tuskfish	1	0.01%	2	0%
		Kawakawa	1	0.01%	2	0%
		Large red crab	1	0.01%	9	0%
		Masina	1	0.01%	2	0%
		One-bloch grouper	1	0.01%	1	0%
		Opii	6	0.03%	44	0%
		Paeony bulleye	6	0.03%	3	0%
		Rainbow runner	9	0.05%	236	0%
		Rockmover wrasse	1	0.01%	1	0%
		Ruby snapper (ehu)	1	0.01%	3	0%
		Sand and coral rubble	5	0.03%	2,980	3%
		Snubnose pompano	2	0.01%	1	0%
		Sunset wrasse	1	0.01%	1	0%
		Tilefishes	3	0.02%	13	0%
		Trumpetfish	1	0.01%	0	0%
		Tunas (unknown)	1	0.01%	0	0%
		Wahoo	2	0.01%	121	0%
		Wedged picassofish	1	0.01%	0	0%

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		White-edged lyretail	2	0.01%	3	0%
Dataset: American Samoa Boat-Based		Blue shark	1	0.00%	150	0%
Total Taxa Records:	98,094					
Total Intercept Landings (lbs):	2,650,592					
Dataset: Guam Shore-Based		*Actinopyga* spp.	1	0.03%	-	-
Total Taxa Records:	2,964	*Aeoliscus strigatus*	1	0.03%	-	-
Total Intercept Landings (lbs):	4,499	*Aetobatis narinari*	1	0.03%	-	-
		Caranx i'e'	430	14.51%	314	7%
		Caranx lugubris	1	0.03%	1	0%
		Halichoeres spp.	1	0.03%	0	0%
		Limnichthys donaldsoni	1	0.03%	-	-
		Manahak ha'tang	6	0.20%	550	12%
		Mulloidichthys ti'ao	172	5.80%	92	2%
		Serranidae	1	0.03%	0	0%
Dataset: Guam Boat-Based		*Caulerpa racemosa*	1	0.00%	5	0%
Total Taxa Records:	56,623	*Charonia tritonis*	1	0.00%	8	0%
Total Intercept Landings (lbs):	1,201,668	*Gymnothorax meleagris*	1	0.00%	1	0%
		Heterocarpus spp.	4	0.01%	127	0%
		Lambis chiragra	2	0.00%	3	0%
		Manahak spp.	11	0.02%	203	0%
		Plectorhinchus albovittatus	1	0.00%	42	0%
		Strombus taurus	1	0.00%	2	0%
Dataset: CNMI Shore-Based		Clam/bivalve	1	0.03%	1	0%
Total Taxa Records:	3,778	Eel (freshwater)	1	0.03%	0	0%
Total Intercept Landings (lbs):	3,862	Sea Cucumber	1	0.03%	17	0%
Dataset: CNMI Boat-Based		Clam/bivalve	1	0.01%	-	-
Total Taxa Records:	7,337	Eel (freshwater)	1	0.01%	-	-
Total Intercept Landings (lbs):	275,955	Sharks	1	0.01%	-	-
		Shrimp (saltwater)	1	0.01%	-	-
		Spiny lobster	1	0.01%	-	-

Table 1.a.8: Taxa that are found in the Guam shore-based expansion file but not in the intercept file and make up greater than 1% of the overall shore-based estimated landings between 2003 and 2010.

Taxa	Count of Taxa Records	Percent of Total Taxa Records	Estimated Landings (lbs)	Percent of Total Estimated Landings
Lambis spp.	14	0%	244	5%
Assorted Reef Fish	24	0%	145	3%
Stichopus horrens	21	0%	98	2%
Spratelloides delicatulus	13	0%	61	1%
Dussumieria sp B	13	0%	58	1%
Echinothrix diadema	21	0%	57	1%
Holothuria leucospilota	13	0%	47	1%
Total Record Count:	7,774			
Total Estimated Landings (lbs):	4,499			

Table 1.a.9: Fishing methods found in the intercept files but not the estimated species composition files of each creel survey. The year ranges of the intercept files are as follows: CNMI shore-based, 2005-2010; CNMI boat-based, 2000-2010; Guam shore-based, 2003-2010; Guam boat-based, 1982-January 2011; American Samoa shore-based, 1988-2000, 2002-3, 2005-April 2011; and American Samoa boat-based, 1986-April 2011. Year ranges of the species composition files, when different, are as follows: Guam boat-based, 1982-2010; American Samoa shore-based, 1990-1996, 2005-2010; American Samoa boat-based, 1986-2010.

Creel Survey		Gear Type	Interview Count	Percent of Total Interview Count	Intercept Landings (lbs)	Percent of Total Intercept Landings
Dataset:	American Samoa Shore-Based	NULL	4	0%	95	0%
Total Interview Count:	3,883	Diving-boat	24	1%	2,472	3%
Total Intercept Landings (lbs):	87,594	Enu (traps)	50	1%	2,701	3%
		Gill net-boat	6	0%	505	1%
		Harpoon	5	0%	216	0%
		Harpoon-boat	2	0%	72	0%
		Mixed inshore	7	0%	457	1%
		Other shore-based	27	1%	413	0%
		Sand mining	3	0%	2,980	3%
		Siening-boat	9	0%	955	1%
		Troll-boat	26	1%	1,273	1%
		Weir fishing	2	0%	98	0%
Dataset:	American Samoa Boat-Based	NULL	2,076	9%	583	0%
Total Interview Count:	23,428	Spear (boat, no tanks)	868	4%	113,659	4%
Total Intercept Landings (lbs):	2,650,592	Spear (boat, tanks)	454	2%	13,667	1%
		Spear (boat, w/wo tanks)	5	0%	-	0%
		Unknown-boat based	251	1%	317	0%
Dataset:	Guam Shore-Based	NULL	3	0%	4	0%
Total Interview Count:	1,451					
Total Intercept Landings (lbs):	4,499					
Dataset:	Guam Boat-Based	Atulai net	1	0%	400	0%
Total Interview Count:	20,114	Manahak	21	0%	2,832	0%
Total Intercept Landings (lbs):	1198318.81	Octopus snagging	2	0%	78	0%

		Pelagic gill driftnet	1	0%	87	0%
		SCUBA w/handline	1	0%	12	0%
		Shrimp trap	5	0%	224	0%
		Snorkel w/handline	1	0%	2	0%
Dataset:	CNMI Shore-Based	Gill Net	2	0%	168	4%
Total Interview Count:	2,134	Gleaning	5	0%	25	1%
Total Intercept Landings (lbs):	3,862	Traps	1	0%	2	0%
Dataset:	CNMI Boat-Based	Hook and line	5	0%	23	0%
Total Interview Count:	2,906	Shallow bottomfishing	1	0%	-	0%
Total Intercept Landings (lbs):	275,955					

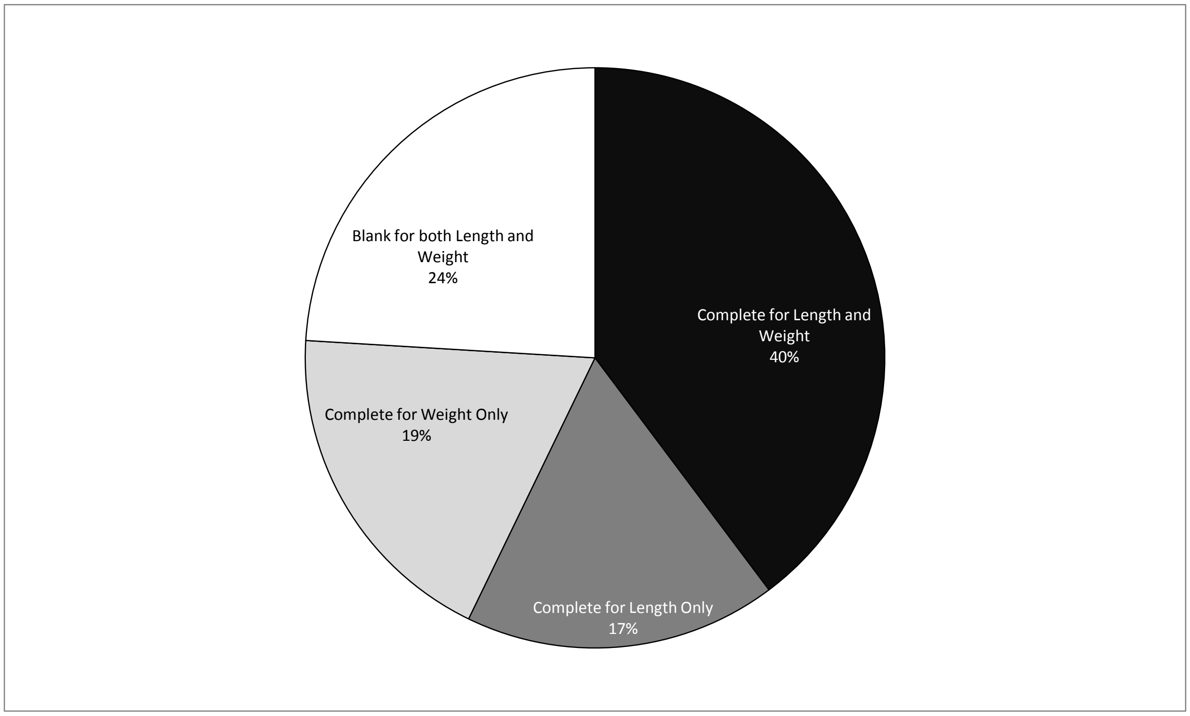

Figure 1.b.1: Relative completeness of type 3 (verified) data by number of records in the Hawaiʻi non-commercial fishery for 2001-2010. No data available for 2002.

Table 1.b.2. Count of type 3 (verified) intercept records complete for length and weight in the Hawai‘i non-commercial fishery, 2001-2010.

Species	Number of Complete Records	Complete Records as a Percent of Total
Total	3361	40%
Coryphaena hippurus	498	48%
Katsuwonus pelamis	358	40%
Thunnus albacares	300	28%
Acanthocybium solandri	227	35%
Hemipteronotus pavoninus	178	65%
Caranx melampygus	144	38%
Caranx ignobilis	85	52%
Pristipomoides filamentosus	85	69%
Aprion virescens	77	55%
Parupeneus multifasciatus	76	50%
Kuhlia sandvicensis	69	45%
Carangoides orthogrammus	67	60%
Mulloidichthys vanicolensis	62	70%
Selar crumenophthalmus	59	33%
Hemipteronotus baldwini	58	84%
Lutjanis kasmira	58	41%
Acanthurus triostegus	56	34%
Mulloidichthys flavolineatus	56	29%
Albula glossodonta	54	48%
Abudefduf abdominalis	49	62%
Makaira nigricans	44	19%
Thunnus obesus	42	52%
Chorinemus sanctipetri	35	48%
Decapterus macarellus	35	35%
Thalassoma duperreyi	34	79%
Etelis caruscans	28	54%
Tetrapturus angustirostris	27	39%
Euthynnus affinis	24	33%
Parupeneus porphyreus	23	41%
Mugil cephalus	21	35%
Sphyraena barracuda	20	37%
Parupeneus cyclostomus	18	47%
Scorpaenopsis cacopsis	18	95%
Tetrapturus audax	18	53%

Bodianus bilunulatus	17	40%
Etelis carbunculus	17	30%
Herklotsichthys quadrimaculatus	16	23%
Abudefduf sordidus	15	21%
Acanthurus dussumieri	15	25%
Cirrhitus pinnulatus	14	45%
Priacanthus meeki	12	33%
Uraspis secunda	12	100%
Myripristis berndti	11	34%
Elagatis bipinnulata	10	40%
Lutjanis fulvus	10	15%
Carangoides ferdau	9	82%
Mulloidichthys pflugeri	9	43%
Platybelone argalus	9	64%
Pristipomoides sieboldii	9	56%
Cephalopholis argus	8	38%
Epinephelus quernus	8	62%
Ctenochaetus strigosus	7	10%
Polydactylus sexfilis	7	47%
Bothus mancus	6	100%
Caranx lugubris	6	86%
Kyphosus cinerascens	6	13%
Naso annulatus	6	86%
Scarus perspicillatus	6	35%
Sphyraena helleri	6	43%
Hemipteronotus umbrilatus	5	71%
Kyphosus bigibbus	5	17%
Myripristis vittata	5	31%
Acanthurus olivaceus	4	57%
Caranx sexfasciatus	4	40%
Cheilio inermis	4	100%
Gnathanodon speciosus	4	80%
Pristipomoides zonatus	4	25%
Scarus psittacus	4	36%
Thunnus alalunga	4	67%
Acanthurus xanthopterus	3	33%
Aphareus rutilans	3	100%
Ctenochaetus hawaiiensis	3	50%
Iso hawaiiensis	3	10%

Kyphosus vaigiensis	3	23%
Myripristis kuntee	3	100%
Naso unicornis	3	8%
Seriola dumerili	3	18%
Upeneus arge	3	25%
Acanthurus nigroris	2	29%
Alectis ciliaris	2	50%
Aphareus furcatus	2	40%
Aulostomus chinensis	2	40%
Auxis thazard	2	40%
Encrasicholina purpurea	2	9%
Halichoeres ornatissimus	2	50%
Monotaxis grandoculis	2	22%
Scarus sordidus	2	15%
Thalassoma trilobatum	2	20%
Acanthurus blochii	1	14%
Acanthurus nigrofuscus	1	50%
Anampses chrysocephalus	1	33%
Anampses cuvieri	1	100%
Arothron meleagris	1	50%
Calotomus carolinus	1	25%
Cheilinus unifasciatus	1	11%
Elops hawaiensis	1	13%
Fistularia commersoni	1	100%
Gomphosus varius	1	10%
Hyporhamphus acutus	1	100%
Myripristis amaena	1	50%
Naso lituratus	1	20%
Neomyxus leuciscus	1	25%
Parupeneus bifasciatus	1	13%
Pseudocaranx dentex	1	33%
Rhinecanthus rectangulus	1	33%
Acanthurus achilles	0	0%
Acanthurus leucopareius	0	0%
Aluterus scriptus	0	0%
Apogon kallopterus	0	0%
Apogon menesemus	0	0%
Arothron hispidus	0	0%
Atherinomorus insularum	0	0%

Canthigaster amboinensis	0	0%
Chaetodon lunula	0	0%
Chanos chanos	0	0%
Conger cinereus	0	0%
Coris flavovittata	0	0%
Coryphaena equiselis	0	0%
Dendrochirus barberi	0	0%
Diodon holocanthus	0	0%
Forcipiger flavissimus	0	0%
Gymnothorax flavimarginatus	0	0%
Gymnothorax rueppelliae	0	0%
Hemiramphidae	0	0%
Holocentrus xantherythrum	0	0%
Istiophorus platypterus	0	0%
Melichthys niger	0	0%
Melichthys vidua	0	0%
Muraena pardalis	0	0%
Myripristis chryseres	0	0%
Naso hexacanthus	0	0%
Novaculichthys taeniourus	0	0%
Paracirrhites forsteri	0	0%
Parupeneus pleurostigma	0	0%
Plectroglyphidodon sindonis	0	0%
Plectrypops lima	0	0%
Priacanthus cruentatus	0	0%
Rhinecanthus aculeatus	0	0%
Sargocentron spiniferum	0	0%
Sarotherodon melanotheron	0	0%
Scarus dubius	0	0%
Scarus rubroviolaceus	0	0%
Scarus taeniurus	0	0%
Scorpaenopsis diabolus	0	0%
Sufflamen bursa	0	0%
Tylosurus crocodilus	0	0%
Uropterygius macrocephalus	0	0%
Valamugil engeli	0	0%
Zebrasoma flavescens	0	0%

Table 1.b.3: Hawai'i intercept fish found only within type 2 (unverified) data. Harvest of taxa ID found only in type 2 data refers to the number of fish that are identified only by the name in the first column. The harvest of actual taxa refers to the number of fish that were categorized taxonomically under the name found in the first column. Fish not identified by an interviewer to the species level are placed in type 2 data at the genus or family level.

Taxa ID found only in type 2 data	Harvest of Taxa ID found only in type 2 data (number of fish)	Intercept Harvest of actual taxa (number of fish)	Contribution of taxa ID found only in type 2 data to actual taxa harvest (frequency)	Contribution of actual taxa to total intercept harvest (frequency)
Apogonidae	6	62	10%	0%
Balistidae	92	206	45%	0%
Belonidae	34	160	21%	0%
Bothidae	2	9	22%	0%
Bramidae	1	1	100%	0%
Carangidae	274	13,240	2%	15%
Carcharhinidae	3	36	8%	0%
Carcharhinus amblyrhynchos	8	8	100%	0%
Carcharhinus galapagensis	14	14	100%	0%
Carcharhinus melanopterus	3	3	100%	0%
Carcharhinus plumbeus	1	1	100%	0%
Triaenodon obesus	7	7	100%	0%
Chaetodontidae	2	6	33%	0%
Chaetodon unimaculatus	1	2	50%	0%
Chromis verater	1	1	100%	0%
Cirrhitidae	1	166	1%	0%
Clupeidae	129	2,603	5%	3%
Engraulidae	20	691	3%	1%
Congridae	2	9	22%	0%
Coris gaimardi	2	2	100%	0%
Diodontidae	3	12	25%	0%
Diodon hystrix	1	1	100%	0%

Gobiidae	19	19	100%	0%
Holocentridae	9	488	2%	1%
Istiophoridae	4	527	1%	1%
Makaira indica	1	1	100%	0%
Kyphosidae	32	442	7%	1%
Labridae	80	3,088	3%	4%
Hemipteronotus	586	2,559	23%	3%
Thalassoma ballieui	9	9	100%	0%
Thalassoma purpureum	2	2	100%	0%
Mugilidae	31	452	7%	1%
Mullidae	29	3,949	1%	5%
Muraenidae	48	67	72%	0%
Gymnomuraena zebra	1	1	100%	0%
Gymnothorax eurostus	5	5	100%	0%
Naso	8	176	5%	0%
Ophichthidae	1	1	100%	0%
Pomacentridae	13	732	2%	1%
Priacanthidae	37	1,666	2%	2%
Ruvettus pretiosus	3	3	100%	0%
Sargocentron tiere	2	2	100%	0%
Saurida gracilis	1	1	100%	0%
Scaridae	106	254	42%	0%
Scombridae	15	6,834	0%	8%
Thunnus thynnus	3	3	100%	0%
Scorpaenidae	8	34	24%	0%
Pontinus macrocephalus	5	5	100%	0%
Sphyrna lewini	4	4	100%	0%
Spratelloides delicatulus	9	9	100%	0%
Synodontidae	42	42	100%	0%
Tetradontidae	39	62	63%	0%

Table 1.b.4. Comparison between the MRFSS and MRIP online query species present in the "snapshot" tool. A "y" indicates presence. The species "other sharks" is present twice in this table. This occurs because there are different species groups under MRIP and MRFSS.

Species Group	Species	Query MRFSS	Query MRIP
Anchovies	Other Anchovies	y	-
Barracudas	Other Barracudas	y	y
Billfishes	Blue Marlin	y	-
Billfishes	Other Billfishes	y	-
Bonefishes	Smallmouth Bonefish	y	-
Bonefishes	Other Bonefishes	y	-
Butterflyfishes	Other Butterflyfishes	y	-
Cartilaginous Fishes	Other Sharks	-	y
Damselfishes	Blackspot Seargeant	y	-
Damselfishes	Other Damselfishes	y	-
Dolphins	Other Dolphins	y	y
Eels	Eels	-	y
Eels	Conger Eels	y	-
Eels	Moray Eels	y	-
Eels	Snake Eels	y	-
Flagtails	Hawaiian Flagtail	y	-
Flounders	Other Flounders	-	y
Goatfish	Bandtail Goatfish	y	-
Goatfish	Manybar Goatfish	y	-
Goatfish	Whitesaddle Goatfish	y	-
Goatfish	Yellowstripe Goatfish	y	-
Goatfish	Other Goatfish	y	-
Hawkfishes	Other Hawkfishes	y	-
Herrings	Other Herrings	-	y
Jacks (Trevally)	Bigeye Scad	y	-
Jacks (Trevally)	Bigeye Trevally	y	-
Jacks (Trevally)	Blufin Trevally	y	-
Jacks (Trevally)	Giant Trevally	y	-
Jacks (Trevally)	Greater Amberjack	y	y
Jacks (Trevally)	Island Jack	y	-
Jacks (Trevally)	Mackerel Scad	y	-
Jacks (Trevally)	Whitemouth Trevally	y	-
Jacks (Trevally)	Other Jacks	y	y
Mackerels & Tunas	Albacore	y	-
Mackerels & Tunas	Kawakawa	y	-
Mackerels & Tunas	Skipjack Tuna	y	-
Mackerels & Tunas	Wahoo	y	-
Mackerels & Tunas	Yellowfin Tuna	y	-
Mackerels & Tunas	Other Mackerels & Tuna	y	y
Mullets	Striped Mullets	y	-
Mullets	Other Mullets	y	y
Other Fish	Other Fish	y	y
Puffers	Puffers	-	y

Scorpionfish	Other Scorpionfish	y	-
Sea Bass	Groupers	y	-
Sea Chubs	Highfin Rudderfish	y	-
Sea Chubs	Other Sea Chubs	y	y
Sharks	Hammerhead	y	-
Sharks	Requiem	y	-
Sharks	Other Sharks	y	y
Snappers	Blacktail Snapper	y	-
Snappers	Bluestripe Snapper	y	-
Snappers	Green Jobfish	y	-
Snappers	Pink Snapper	y	-
Snappers	Von Siebolds Snapper	y	-
Snappers	Other Snappers	y	-
Squirrel/Soldierfishes	Bigscale Soldierfish	y	-
Squirrel/Soldierfishes	Whitetip Soldierfish	y	-
Squirrel/Soldierfishes	Squirrel Fishes	y	-
Squirrel/Soldierfishes	Other Squirrel/Soldierfishes	y	-
Surgeonfishes	Convict Tang	y	-
Surgeonfishes	Goldring Surgeonfish	y	-
Surgeonfishes	Unicornfishes	y	-
Surgeonfishes	Other Surgeonfishes	y	-
Tarpon	Hawaiian Tenpounder	y	-
Triggerfishes/Filefishes	Triggerfishes/Filefishes	-	y
Wrasse	Hawaiian Hogfish	y	-
Wrasse	Razorfishes	y	-
Wrasse	Dragon Wrasse	y	-
Wrasse	Other Wrasse	y	y

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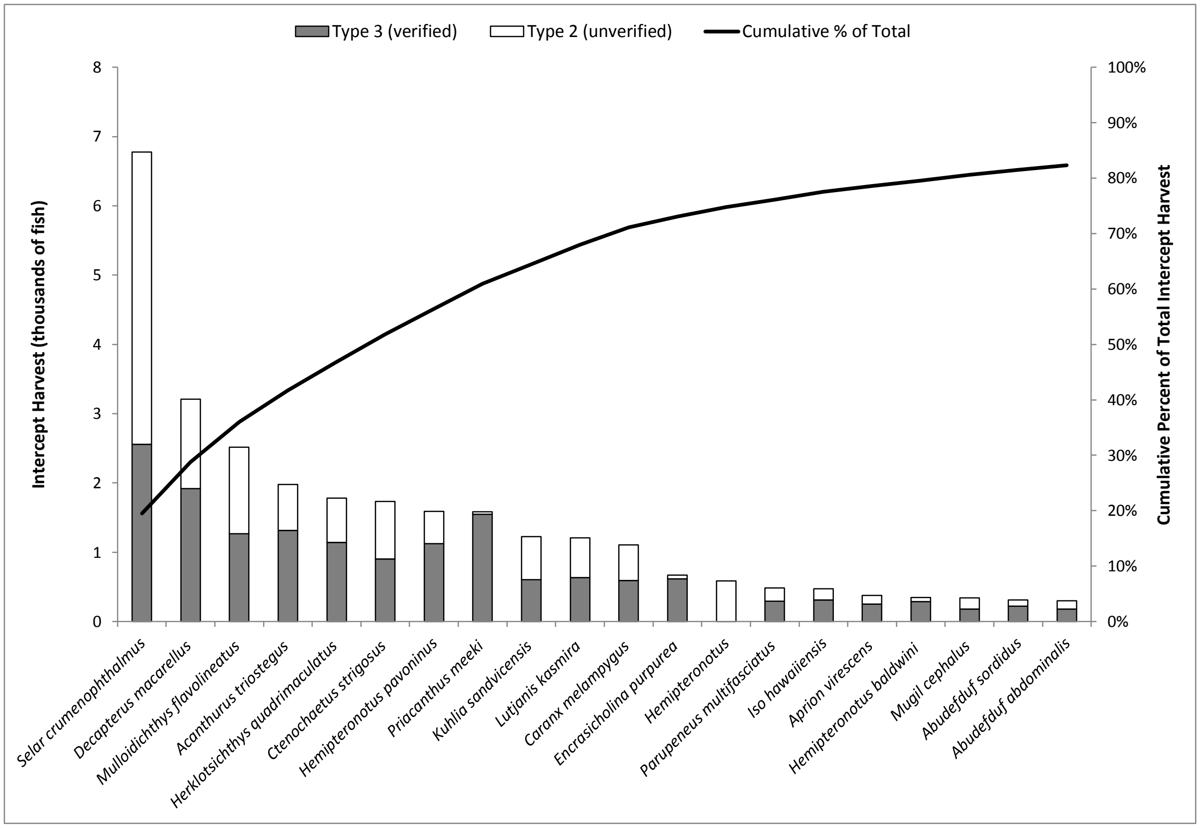

Figure 1.b.5: Overall Hawai'i intercept harvest (number of fish) of the top 20 coral reef species in the non-commercial fishery from 2003-2010.

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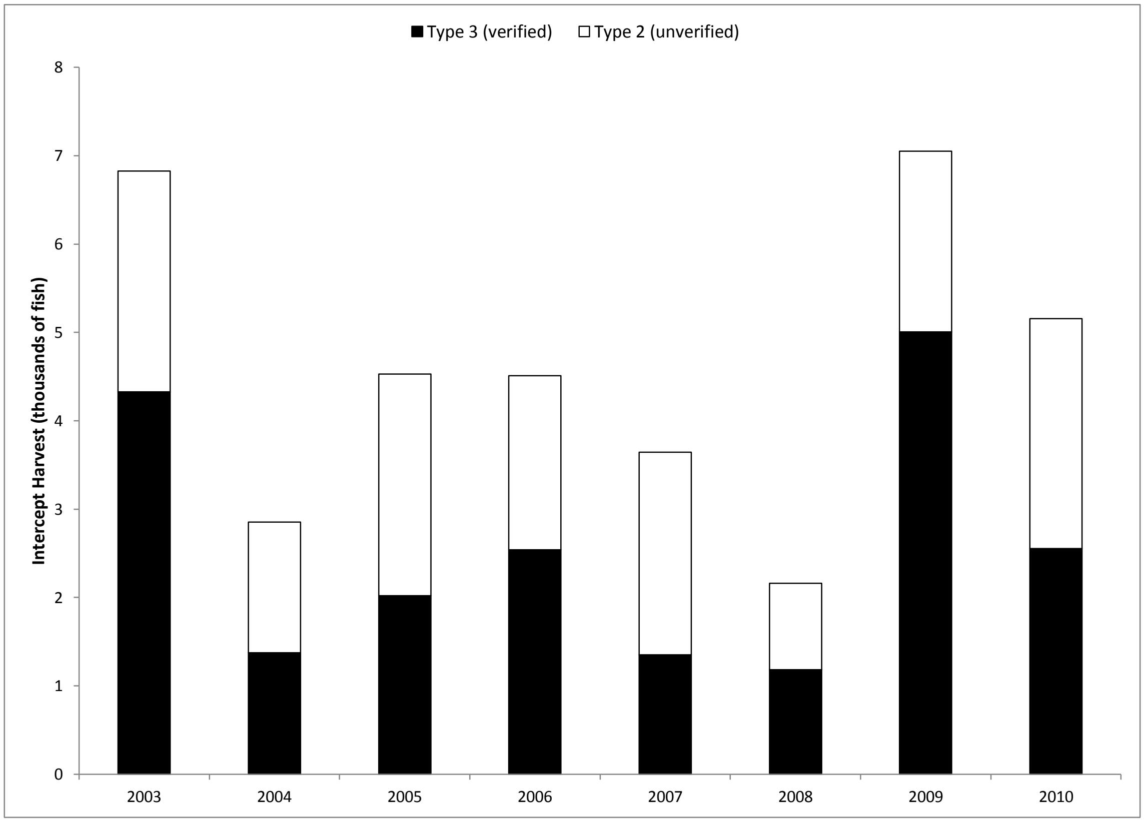

Figure 1.b.6: Annual Hawai'i intercept harvest (number of fish) of all coral reef species in the non-commercial fishery.

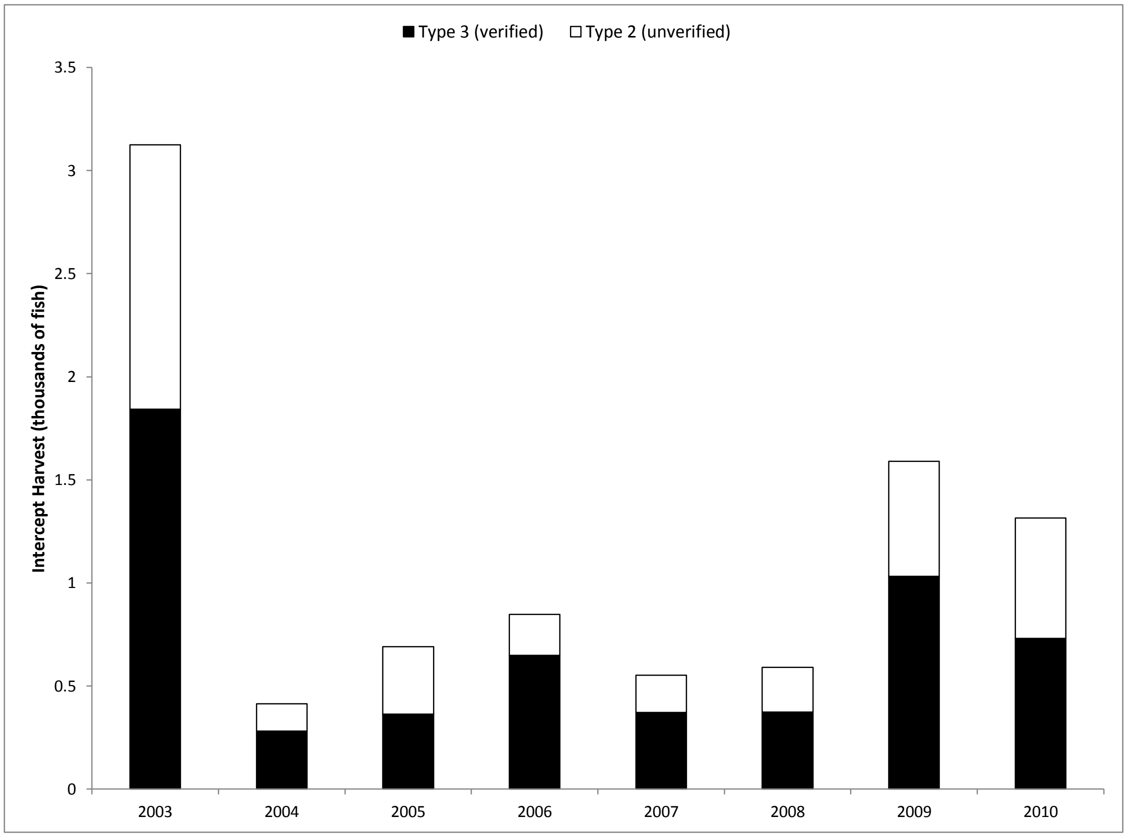

Figure 1.b.7: "Other" intercept harvest (number of fish). Shown annually for the Hawai'i non-commercial fishery. "Other" is the coral reef species group with the most harvest.

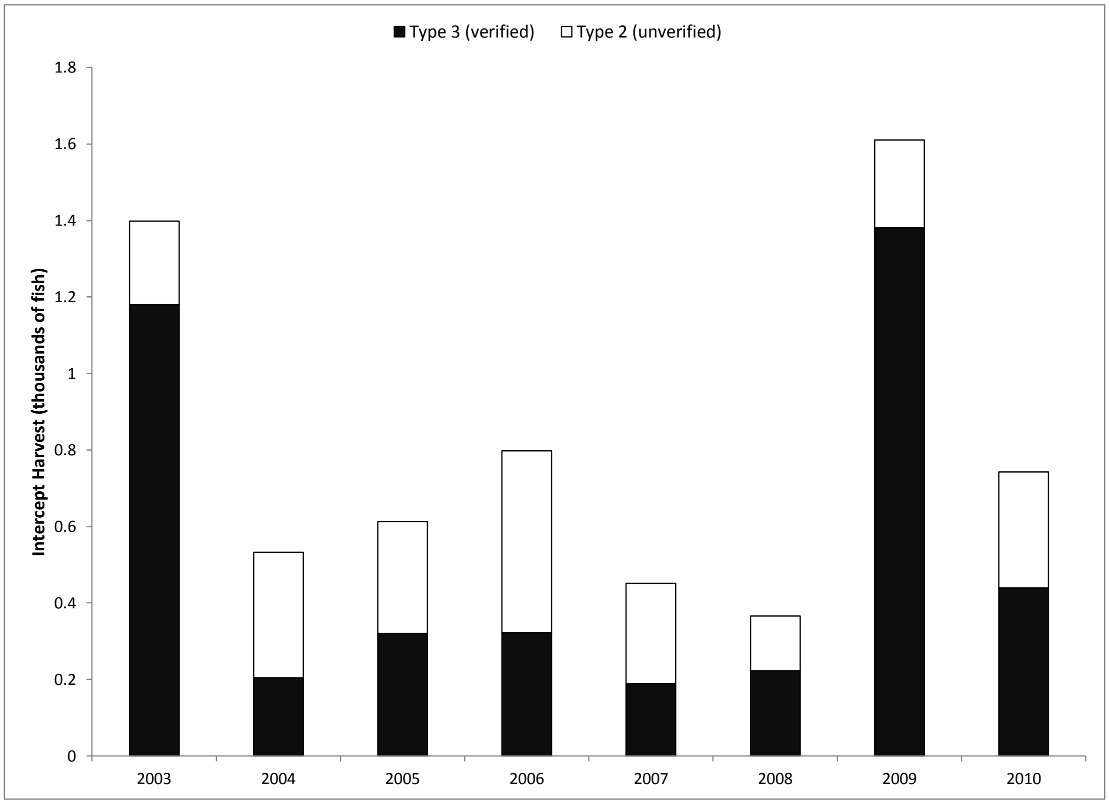

Figure 1.b.8: "Jacks" intercept harvest (number of fish). Shown annually for the Hawai'i non-commercial fishery. "Jacks" is the coral reef species group with the second most harvest.

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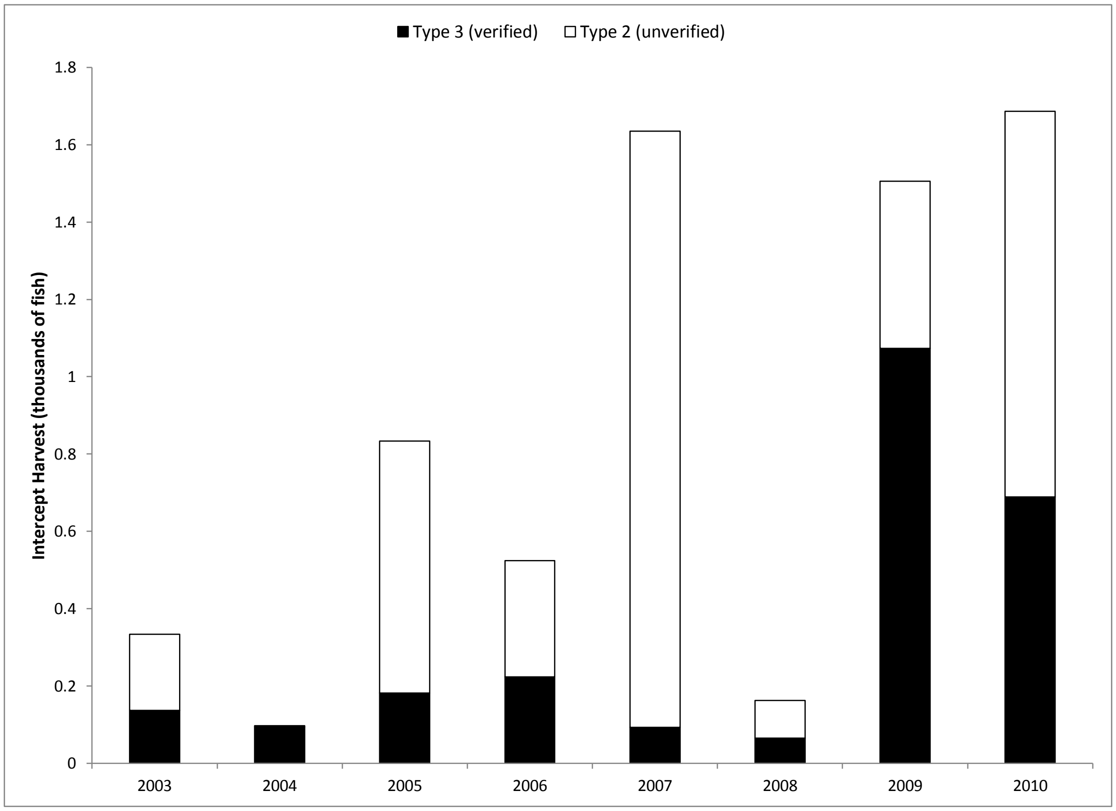

Figure 1.b.9: "Akule" intercept harvest (number of fish). Shown annually for the Hawaiʻi non-commercial fishery. "Akule" is the coral reef species group with the third most harvest.

Table 1.b.10: Percentage of cells complete for abundance and weight columns of Hawai‘i estimated catch data. Incomplete cells have a value of zero or are blank.

Column Name	Meaning	Incomplete	Complete
ESTCLAIM	Estimated number of type A fish	43%	57%
ESTWGT	Estimated weight of type A fish	65%	35%
ESTHARV	Estimated number of type B1 fish harvested	54%	46%
ESTREL	Estimated number of type B2 fish released	79%	21%
LANDING	Estimated total harvest (types A + B1)	18%	82%
WGT_AB1	Estimated weight of types A and B1	62%	38%
TOT_CAT	Estimated total catch (types A + B1 + B2)	6%	94%

Table 1.b.11: Completeness of MRFSS Hawai'i estimated data shown by taxon. Data users must substitute an average weight for species in strata with incomplete weight to produce an additive harvest by weight without underestimation. All records incomplete for weight are also incomplete for variance, while some records are complete for weight but incomplete for variance.

Taxa	Occurrence in Strata (Count)	**Occurrence in Strata (Frequency)**	Records Complete for Harvest Weight (Count)	Records Complete for Variance (Count)	Records Incomplete for Variance (Count)	Records Incomplete for Variance within species (Frequency)	Records Incomplete for Weight and Variance within species (Count)	**Records Incomplete for Weight and Variance within species (Frequency)**
Total	284	**100%**	1673	1189	484	11%	2736	**62%**
Caranx melampygus	173	**61%**	124	116	8	5%	49	**28%**
Coryphaena hippurus	147	**52%**	105	104	1	1%	42	**29%**
Acanthocybium solandri	135	**48%**	89	86	3	2%	46	**34%**
Katsuwonus pelamis	125	**44%**	92	90	2	2%	33	**26%**
Thunnus albacares	121	**43%**	85	84	1	1%	36	**30%**
Caranx ignobilis	118	**42%**	66	51	15	13%	52	**44%**
Lutjanis kasmira	113	**40%**	36	24	12	11%	77	**68%**
Parupeneus multifasciatus	105	**37%**	63	50	13	12%	42	**40%**
Selar crumenophthalmus	101	**36%**	36	29	7	7%	65	**64%**
Carangoides orthogrammus	94	**33%**	50	39	11	12%	44	**47%**
Kuhlia sandvicensis	89	**31%**	46	31	15	17%	43	**48%**
Lutjanis fulvus	88	**31%**	10	4	6	7%	78	**89%**
Albula glossodonta	87	**31%**	44	31	13	15%	43	**49%**
Sphyraena barracuda	84	**30%**	22	11	11	13%	62	**74%**
Aprion virescens	83	**29%**	49	45	4	5%	34	**41%**
Acanthurus triostegus	79	**28%**	33	24	9	11%	46	**58%**
Mulloidichthys flavolineatus	77	**27%**	31	16	15	19%	46	**60%**
Decapterus macarellus	69	**24%**	20	13	7	10%	49	**71%**
Euthynnus affinis	68	**24%**	24	13	11	16%	44	**65%**
Makaira nigricans	66	**23%**	27	19	8	12%	39	**59%**
Mulloidichthys vanicolensis	65	**23%**	39	27	12	18%	26	**40%**
Acanthurus dussumieri	64	**23%**	15	10	5	8%	49	**77%**
Carangidae	63	**22%**	0	0	0	0%	63	**100%**
Abudefduf abdominalis	62	**22%**	28	17	11	18%	34	**55%**
Chorinemus sanctipetri	59	**21%**	28	15	13	22%	31	**53%**
Mugil cephalus	53	**19%**	13	6	7	13%	40	**75%**
Abudefduf sordidus	51	**18%**	9	4	5	10%	42	**82%**
Ctenochaetus strigosus	50	**18%**	6	3	3	6%	44	**88%**
Hemipteronotus pavoninus	50	**18%**	31	27	4	8%	19	**38%**

Pristipomoides filamentosus	50	**18%**	32	26	6	12%	18	**36%**
Seriola dumerili	49	**17%**	8	0	8	16%	41	**84%**
Parupeneus porphyreus	48	**17%**	17	11	6	13%	31	**65%**
Thalassoma duperreyi	47	**17%**	22	10	12	26%	25	**53%**
Tetrapturus angustirostris	45	**16%**	14	7	7	16%	31	**69%**
Cirrhitus pinnulatus	44	**15%**	13	2	11	25%	31	**70%**
Bodianus bilunulatus	42	**15%**	15	4	11	26%	27	**64%**
Herklotsichthys quadrimaculatus	41	**14%**	12	9	3	7%	29	**71%**
Scaridae	40	**14%**	0	0	0	0%	40	**100%**
Etelis caruscans	39	**14%**	22	14	8	21%	17	**44%**
Kyphosus cinerascens	39	**14%**	4	1	3	8%	35	**90%**
Parupeneus cyclostomus	36	**13%**	13	6	7	19%	23	**64%**
Thunnus obesus	36	**13%**	18	16	2	6%	18	**50%**
Kyphosus bigibbus	34	**12%**	6	4	2	6%	28	**82%**
Naso unicornis	34	**12%**	2	1	1	3%	32	**94%**
Tetrapturus audax	34	**12%**	8	5	3	9%	26	**76%**
Hemipteronotus	32	**11%**	0	0	0	0%	32	**100%**
Etelis carbunculus	31	**11%**	14	12	2	6%	17	**55%**
Muraenidae	30	**11%**	0	0	0	0%	30	**100%**
Elagatis bipinnulata	29	**10%**	5	4	1	3%	24	**83%**
Hemipteronotus baldwini	29	**10%**	20	11	9	31%	9	**31%**
Labridae	27	**10%**	0	0	0	0%	27	**100%**
Myripristis berndti	27	**10%**	12	3	9	33%	15	**56%**
Polydactylus sexfilis	27	**10%**	7	3	4	15%	20	**74%**
Priacanthus meeki	27	**10%**	10	2	8	30%	17	**63%**
Aulostomus chinensis	25	**9%**	1	1	0	0%	24	**96%**
Cephalopholis argus	25	**9%**	7	1	6	24%	18	**72%**
Mulloidichthys pflugeri	25	**9%**	7	2	5	20%	18	**72%**
Myripristis vittata	25	**9%**	5	2	3	12%	20	**80%**
Platybelone argalus	24	**8%**	7	2	5	21%	17	**71%**
Tetradontidae	21	**7%**	0	0	0	0%	21	**100%**
Balistidae	19	**7%**	0	0	0	0%	19	**100%**
Sphyraena helleri	19	**7%**	4	2	2	11%	15	**79%**
Belonidae	17	**6%**	0	0	0	0%	17	**100%**
Melichthys niger	17	**6%**	0	0	0	0%	17	**100%**
Scarus perspicillatus	17	**6%**	6	2	4	24%	11	**65%**
Scarus taeniurus	17	**6%**	0	0	0	0%	17	**100%**
Scorpaenopsis cacopsis	17	**6%**	16	4	12	71%	1	**6%**
Anampses chrysocephalus	16	**6%**	2	0	2	13%	14	**88%**

Kyphosus vaigiensis	16	**6%**	3	0	3	19%	13	**81%**
Naso annulatus	16	**6%**	6	2	4	25%	10	**63%**
Pristipomoides sieboldii	16	**6%**	6	3	3	19%	10	**63%**
Synodontidae	15	**5%**	0	0	0	0%	15	**100%**
Thalassoma trilobatum	15	**5%**	2	0	2	13%	13	**87%**
Iso hawaiiensis	14	**5%**	2	1	1	7%	12	**86%**
Scarus sordidus	14	**5%**	4	3	1	7%	10	**71%**
Upeneus arge	14	**5%**	4	0	4	29%	10	**71%**
Canthigaster amboinensis	13	**5%**	0	0	0	0%	13	**100%**
Carangoides ferdau	13	**5%**	7	5	2	15%	6	**46%**
Encrasicholina purpurea	12	**4%**	2	0	2	17%	10	**83%**
Epinephelus quernus	12	**4%**	7	1	6	50%	5	**42%**
Parupeneus bifasciatus	12	**4%**	1	0	1	8%	11	**92%**
Elops hawaiensis	11	**4%**	1	0	1	9%	10	**91%**
Gomphosus varius	11	**4%**	2	0	2	18%	9	**82%**
Monotaxis grandoculis	11	**4%**	4	0	4	36%	7	**64%**
Priacanthidae	11	**4%**	0	0	0	0%	11	**100%**
Chanos chanos	10	**4%**	1	1	0	0%	9	**90%**
Scarus rubroviolaceus	10	**4%**	0	0	0	0%	10	**100%**
Thunnus alalunga	10	**4%**	3	2	1	10%	7	**70%**
Acanthurus xanthopterus	9	**3%**	3	0	3	33%	6	**67%**
Ctenochaetus hawaiiensis	9	**3%**	2	1	1	11%	7	**78%**
Gnathanodon speciosus	9	**3%**	3	1	2	22%	6	**67%**
Holocentrus xantherythrum	9	**3%**	0	0	0	0%	9	**100%**
Kyphosidae	9	**3%**	0	0	0	0%	9	**100%**
Pristipomoides zonatus	9	**3%**	4	2	2	22%	5	**56%**
Caranx sexfasciatus	8	**3%**	4	1	3	38%	4	**50%**
Cheilinus unifasciatus	8	**3%**	1	0	1	13%	7	**88%**
Gymnothorax flavimarginatus	8	**3%**	0	0	0	0%	8	**100%**
Neomyxus leuciscus	8	**3%**	1	0	1	13%	7	**88%**
Plectroglyphidodon sindonis	8	**3%**	0	0	0	0%	8	**100%**
Scarus psittacus	8	**3%**	2	1	1	13%	6	**75%**
Acanthurus olivaceus	7	**2%**	4	0	4	57%	3	**43%**
Aphareus rutilans	7	**2%**	3	0	3	43%	4	**57%**
Auxis thazard	7	**2%**	2	0	2	29%	5	**71%**
Bothus mancus	7	**2%**	6	2	4	57%	1	**14%**
Caranx lugubris	7	**2%**	3	1	2	29%	4	**57%**
Conger cinereus	7	**2%**	0	0	0	0%	7	**100%**
Fistularia commersoni	7	**2%**	1	0	1	14%	6	**86%**

Naso lituratus	7	**2%**	1	0	1	14%	6	**86%**
Pseudocaranx dentex	7	**2%**	1	0	1	14%	6	**86%**
Acanthurus achilles	6	**2%**	0	0	0	0%	6	**100%**
Alectis ciliaris	6	**2%**	2	0	2	33%	4	**67%**
Aphareus furcatus	6	**2%**	1	1	0	0%	5	**83%**
Arothron meleagris	6	**2%**	1	0	1	17%	5	**83%**
Mullidae	6	**2%**	0	0	0	0%	6	**100%**
Scorpaenidae	6	**2%**	0	0	0	0%	6	**100%**
Thalassoma ballieui	6	**2%**	0	0	0	0%	6	**100%**
Tylosurus crocodilus	6	**2%**	1	0	1	17%	5	**83%**
Acanthurus blochii	5	**2%**	1	0	1	20%	4	**80%**
Acanthurus nigroris	5	**2%**	2	0	2	40%	3	**60%**
Gobiidae	5	**2%**	0	0	0	0%	5	**100%**
Gymnothorax eurostus	5	**2%**	0	0	0	0%	5	**100%**
Hemipteronotus umbrilatus	5	**2%**	3	1	2	40%	2	**40%**
Pomacentridae	5	**2%**	0	0	0	0%	5	**100%**
Priacanthus cruentatus	5	**2%**	0	0	0	0%	5	**100%**
Rhinecanthus rectangulus	5	**2%**	1	0	1	20%	4	**80%**
Sarotherodon melanotheron	5	**2%**	1	0	1	20%	4	**80%**
Atherinomorus insularum	4	**1%**	0	0	0	0%	4	**100%**
Calotomus carolinus	4	**1%**	1	0	1	25%	3	**75%**
Carcharhinus amblyrhynchos	4	**1%**	0	0	0	0%	4	**100%**
Diodon holocanthus	4	**1%**	0	0	0	0%	4	**100%**
Istiophoridae	4	**1%**	0	0	0	0%	4	**100%**
Mugilidae	4	**1%**	0	0	0	0%	4	**100%**
Naso	4	**1%**	0	0	0	0%	4	**100%**
Rhinecanthus aculeatus	4	**1%**	0	0	0	0%	4	**100%**
Sphyrna lewini	4	**1%**	0	0	0	0%	4	**100%**
Zebrasoma flavescens	4	**1%**	0	0	0	0%	4	**100%**
Apogon kallopterus	3	**1%**	0	0	0	0%	3	**100%**
Apogonidae	3	**1%**	0	0	0	0%	3	**100%**
Carcharhinidae	3	**1%**	0	0	0	0%	3	**100%**
Carcharhinus galapagensis	3	**1%**	0	0	0	0%	3	**100%**
Carcharhinus melanopterus	3	**1%**	0	0	0	0%	3	**100%**
Diodontidae	3	**1%**	0	0	0	0%	3	**100%**
Halichoeres ornatissimus	3	**1%**	2	0	2	67%	1	**33%**
Melichthys vidua	3	**1%**	0	0	0	0%	3	**100%**
Myripristis amaena	3	**1%**	1	0	1	33%	2	**67%**
Naso hexacanthus	3	**1%**	0	0	0	0%	3	**100%**

Parupeneus pleurostigma	3	**1%**	1	1	0	0%	2	**67%**
Plectrypops lima	3	**1%**	0	0	0	0%	3	**100%**
Pontinus macrocephalus	3	**1%**	0	0	0	0%	3	**100%**
Ruvettus pretiosus	3	**1%**	0	0	0	0%	3	**100%**
Scarus dubius	3	**1%**	0	0	0	0%	3	**100%**
Triaenodon obesus	3	**1%**	0	0	0	0%	3	**100%**
Acanthurus nigrofuscus	2	**1%**	1	0	1	50%	1	**50%**
Aluterus scriptus	2	**1%**	0	0	0	0%	2	**100%**
Bothidae	2	**1%**	0	0	0	0%	2	**100%**
Chaetodon lunula	2	**1%**	0	0	0	0%	2	**100%**
Clupeidae	2	**1%**	0	0	0	0%	2	**100%**
Congridae	2	**1%**	0	0	0	0%	2	**100%**
Coris gaimardi	2	**1%**	0	0	0	0%	2	**100%**
Engraulidae	2	**1%**	0	0	0	0%	2	**100%**
Gymnothorax rueppelliae	2	**1%**	0	0	0	0%	2	**100%**
Holocentridae	2	**1%**	0	0	0	0%	2	**100%**
Myripristis chryseres	2	**1%**	0	0	0	0%	2	**100%**
Sargocentron spiniferum	2	**1%**	0	0	0	0%	2	**100%**
Spratelloides delicatulus	2	**1%**	0	0	0	0%	2	**100%**
Sufflamen bursa	2	**1%**	1	0	1	50%	1	**50%**
Uraspis secunda	2	**1%**	2	1	1	50%	0	**0%**
Uropterygius macrocephalus	2	**1%**	0	0	0	0%	2	**100%**
Valamugil engeli	2	**1%**	0	0	0	0%	2	**100%**
Acanthurus leucopareius	1	**0%**	0	0	0	0%	1	**100%**
Anampses cuvieri	1	**0%**	1	0	1	100%	0	**0%**
Apogon menesemus	1	**0%**	0	0	0	0%	1	**100%**
Arothron hispidus	1	**0%**	0	0	0	0%	1	**100%**
Bramidae	1	**0%**	0	0	0	0%	1	**100%**
Carcharhinus plumbeus	1	**0%**	0	0	0	0%	1	**100%**
Chaetodon unimaculatus	1	**0%**	0	0	0	0%	1	**100%**
Chaetodontidae	1	**0%**	0	0	0	0%	1	**100%**
Cheilio inermis	1	**0%**	1	1	0	0%	0	**0%**
Chromis verater	1	**0%**	0	0	0	0%	1	**100%**
Cirrhitidae	1	**0%**	0	0	0	0%	1	**100%**
Coris flavovittata	1	**0%**	0	0	0	0%	1	**100%**
Coryphaena equiselis	1	**0%**	1	0	1	100%	0	**0%**
Dendrochirus barberi	1	**0%**	0	0	0	0%	1	**100%**
Diodon hystrix	1	**0%**	0	0	0	0%	1	**100%**
Forcipiger flavissimus	1	**0%**	0	0	0	0%	1	**100%**

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Gymnomuraena zebra	1	**0%**	0	0	0	0%	1	**100%**
Hemiramphidae	1	**0%**	0	0	0	0%	1	**100%**
Hyporhamphus acutus	1	**0%**	1	0	1	100%	0	**0%**
Istiophorus platypterus	1	**0%**	0	0	0	0%	1	**100%**
Makaira indica	1	**0%**	0	0	0	0%	1	**100%**
Muraena pardalis	1	**0%**	0	0	0	0%	1	**100%**
Myripristis kuntee	1	**0%**	1	1	0	0%	0	**0%**
Novaculichthys taeniourus	1	**0%**	0	0	0	0%	1	**100%**
Ophichthidae	1	**0%**	0	0	0	0%	1	**100%**
Paracirrhites forsteri	1	**0%**	0	0	0	0%	1	**100%**
Sargocentron tiere	1	**0%**	0	0	0	0%	1	**100%**
Saurida gracilis	1	**0%**	0	0	0	0%	1	**100%**
Scombridae	1	**0%**	0	0	0	0%	1	**100%**
Scorpaenopsis diabolus	1	**0%**	0	0	0	0%	1	**100%**
Thalassoma purpureum	1	**0%**	0	0	0	0%	1	**100%**
Thunnus thynnus	1	**0%**	0	0	0	0%	1	**100%**
Unidentified sharks	1	**0%**	0	0	0	0%	1	**100%**

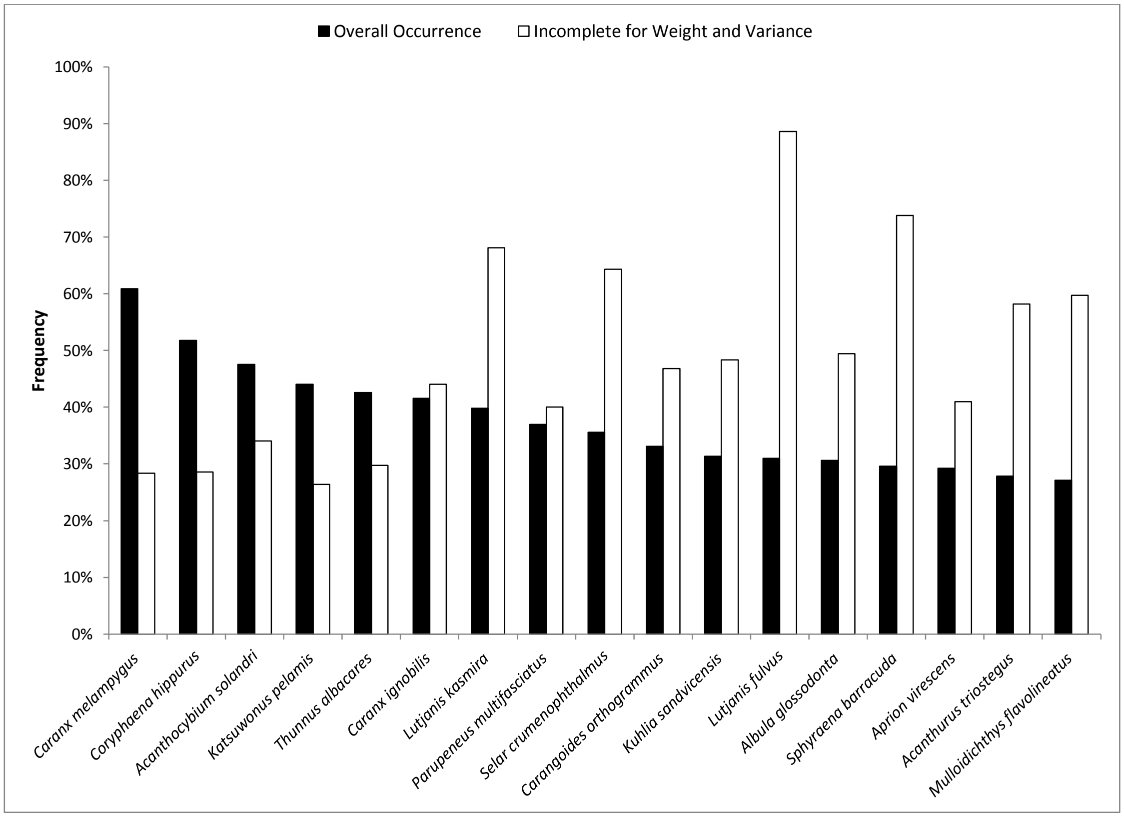

Figure 1.b.12: Frequency of occurrence in state/wave/mode/area strata for all species occurring in greater than 25% of strata and frequency of weight and variance incompleteness within strata in the Hawai'i non-commercial fishery. Estimated data, 2001-2010. No data available for 2002.

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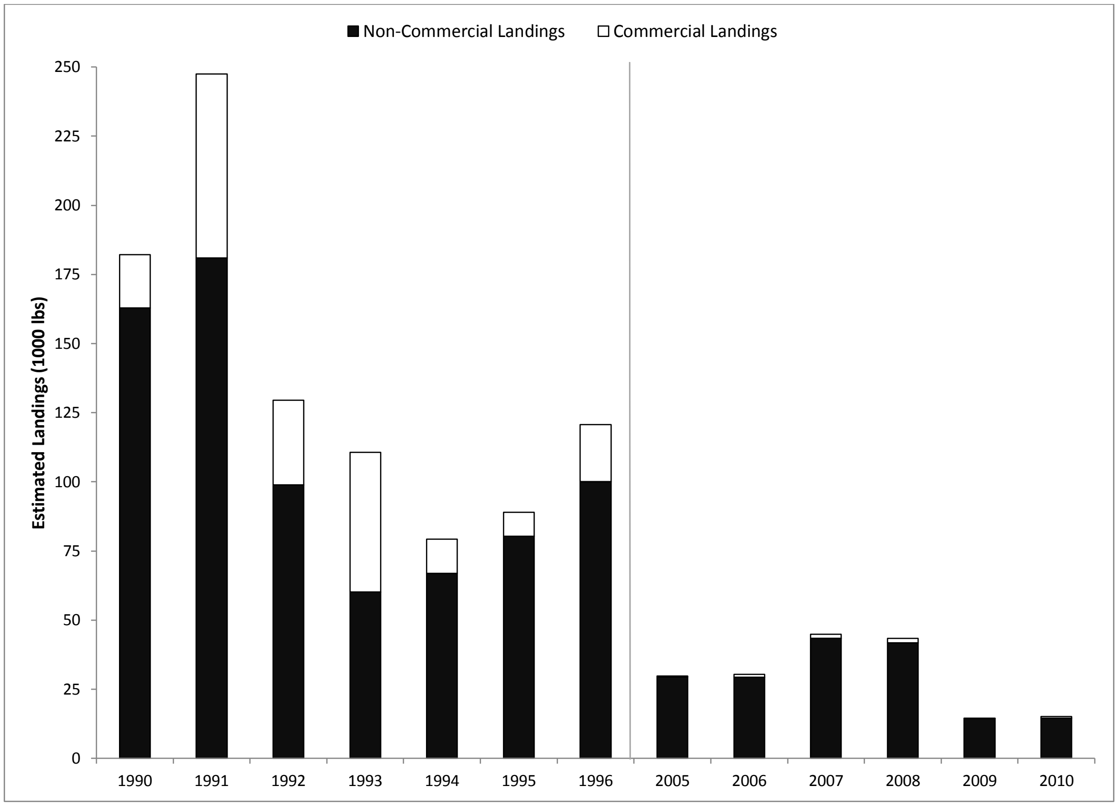

Figure 2.a.1: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the American Samoa shore-based fishery

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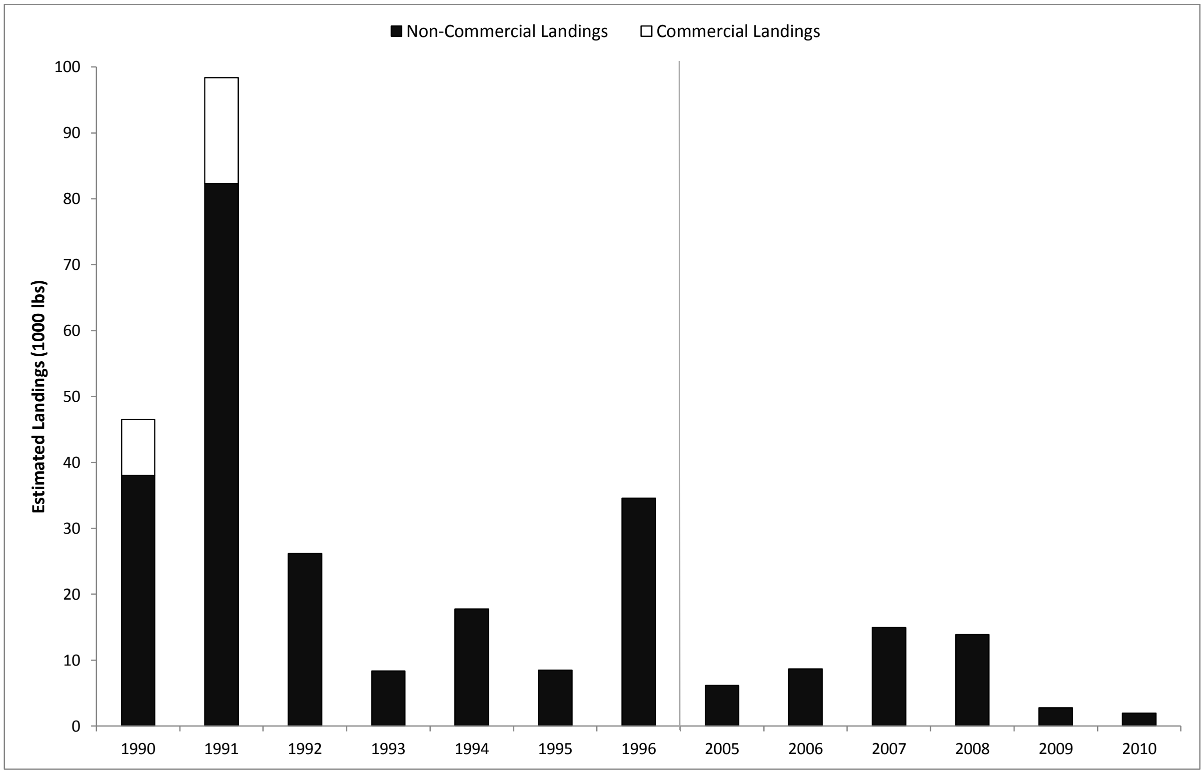

Figure 2.a.2: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the American Samoa shore-based rod and reel fishery

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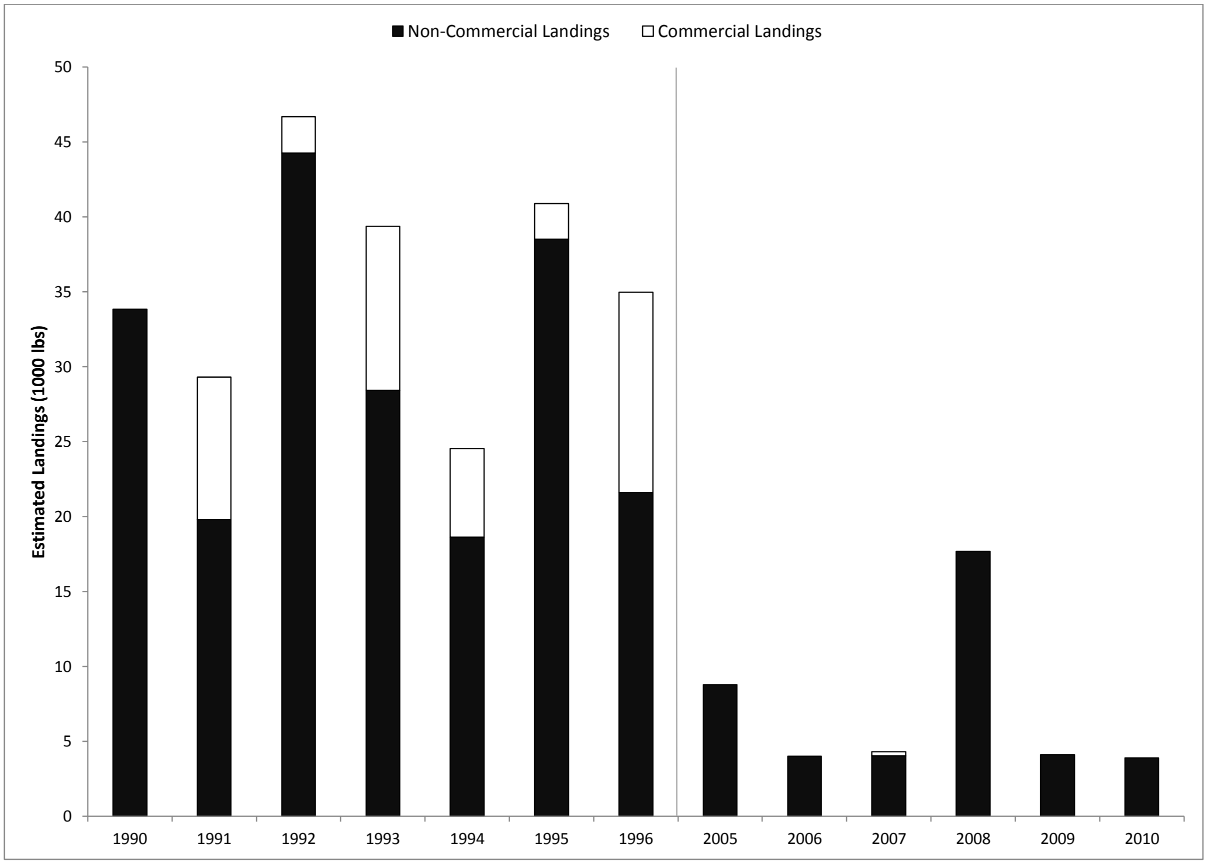

Figure 2.a.3: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the American Samoa shore-based gleaning fishery

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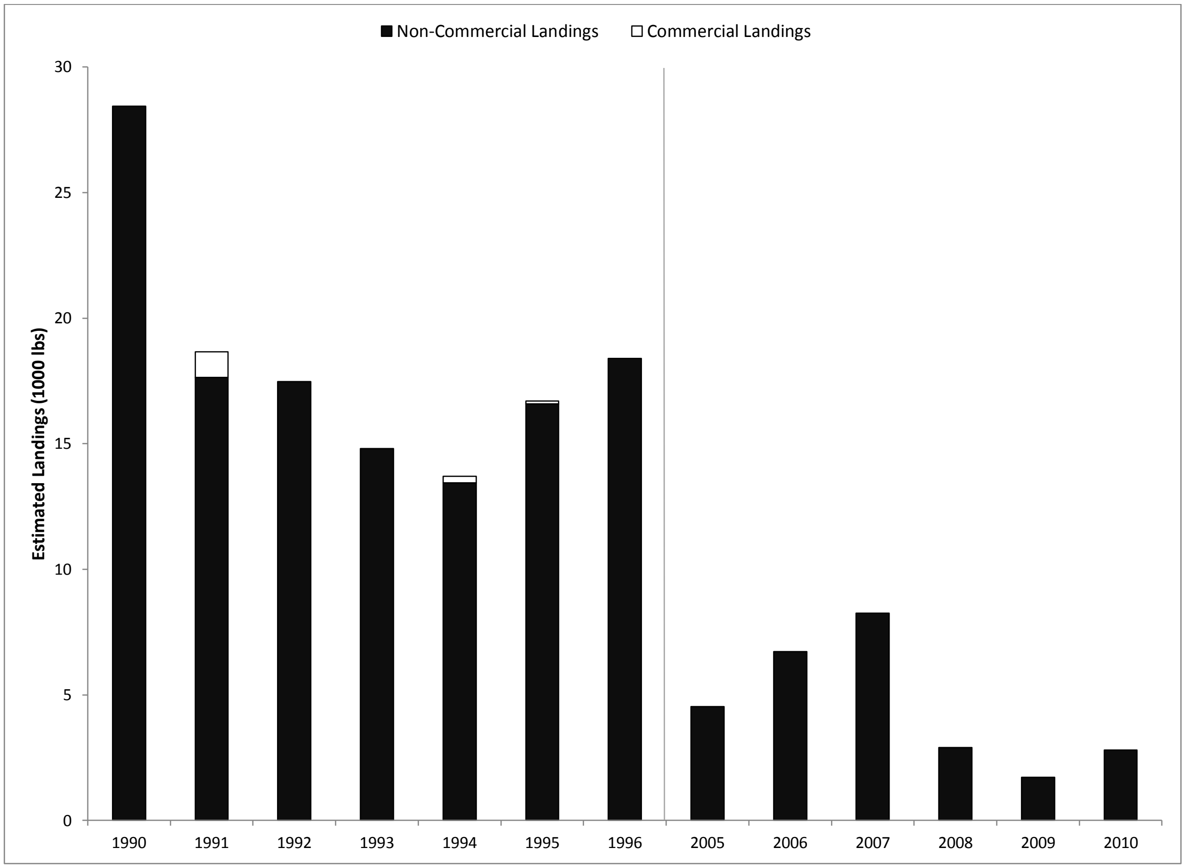

Figure 2.a.4: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the American Samoa shore-based throw net fishery

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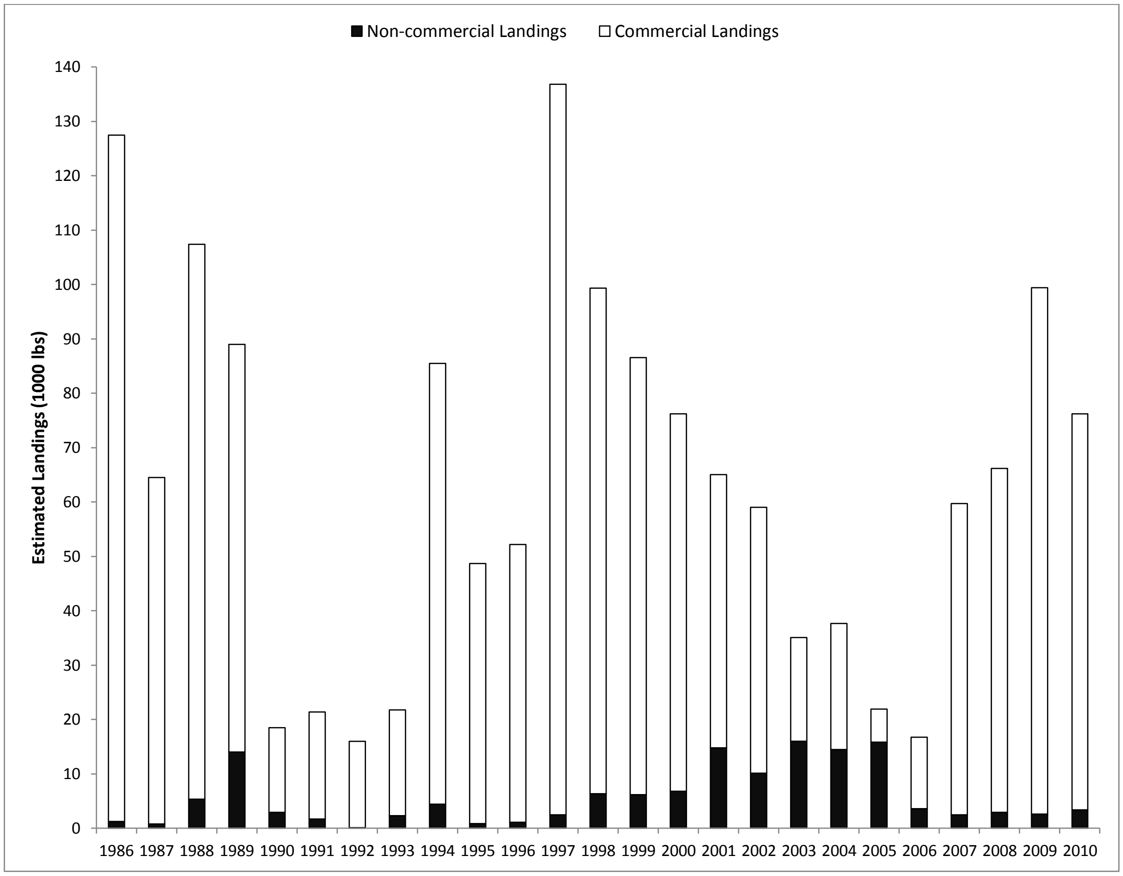

Figure 2.b.1: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the American Samoa boat-based fishery

"Non-commercial Coral Reef Fishery Assessments for the Western Pacific Region", page 128

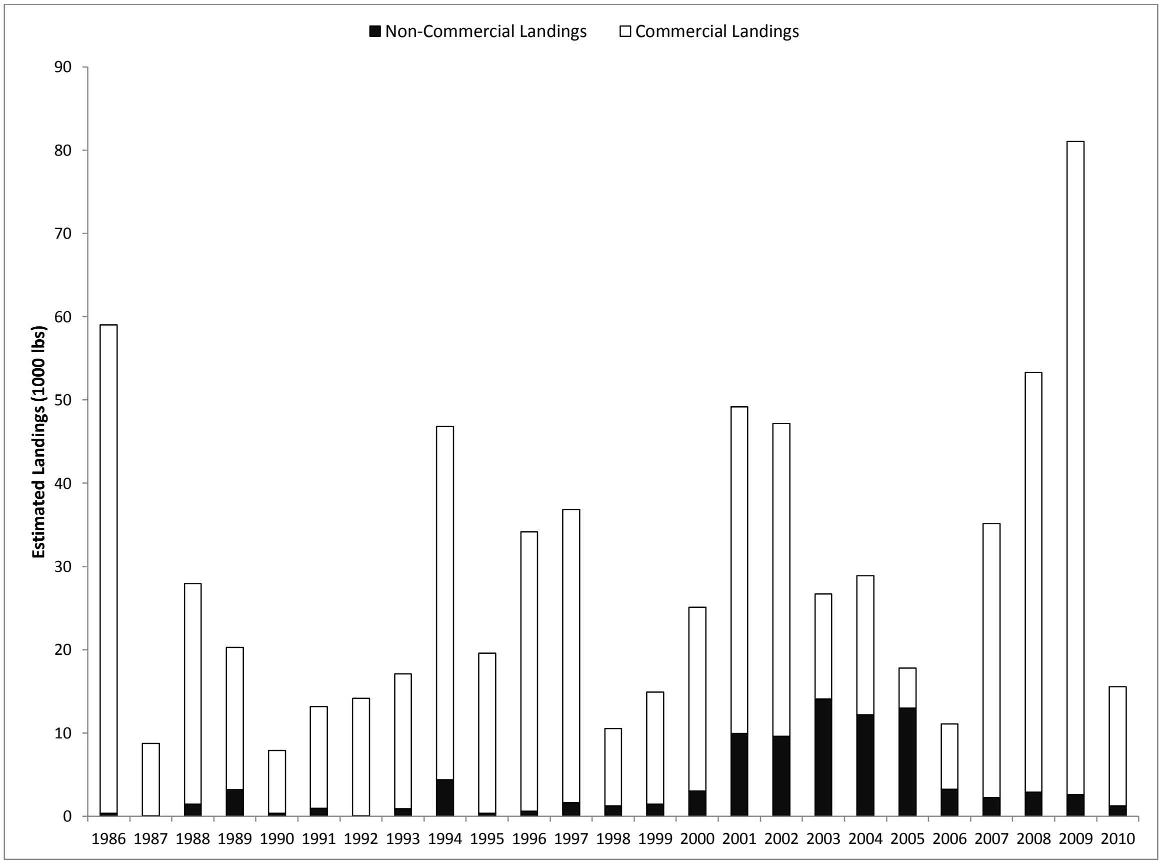

Figure 2.b.2: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the American Samoa boat-based bottomfishing fishery

"Non-commercial Coral Reef Fishery Assessments for the Western Pacific Region", page 129

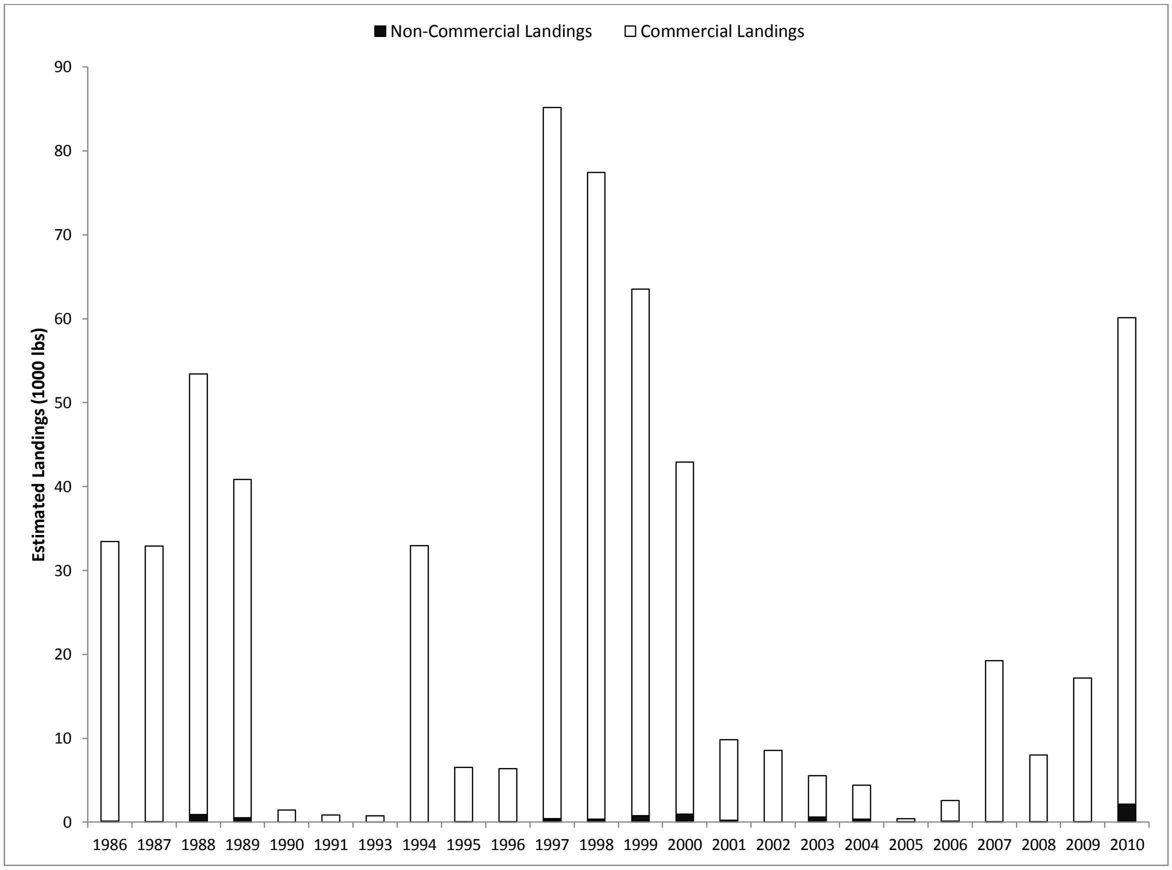

Figure 2.b.3:Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the American Samoa boat-based spearfishing fishery

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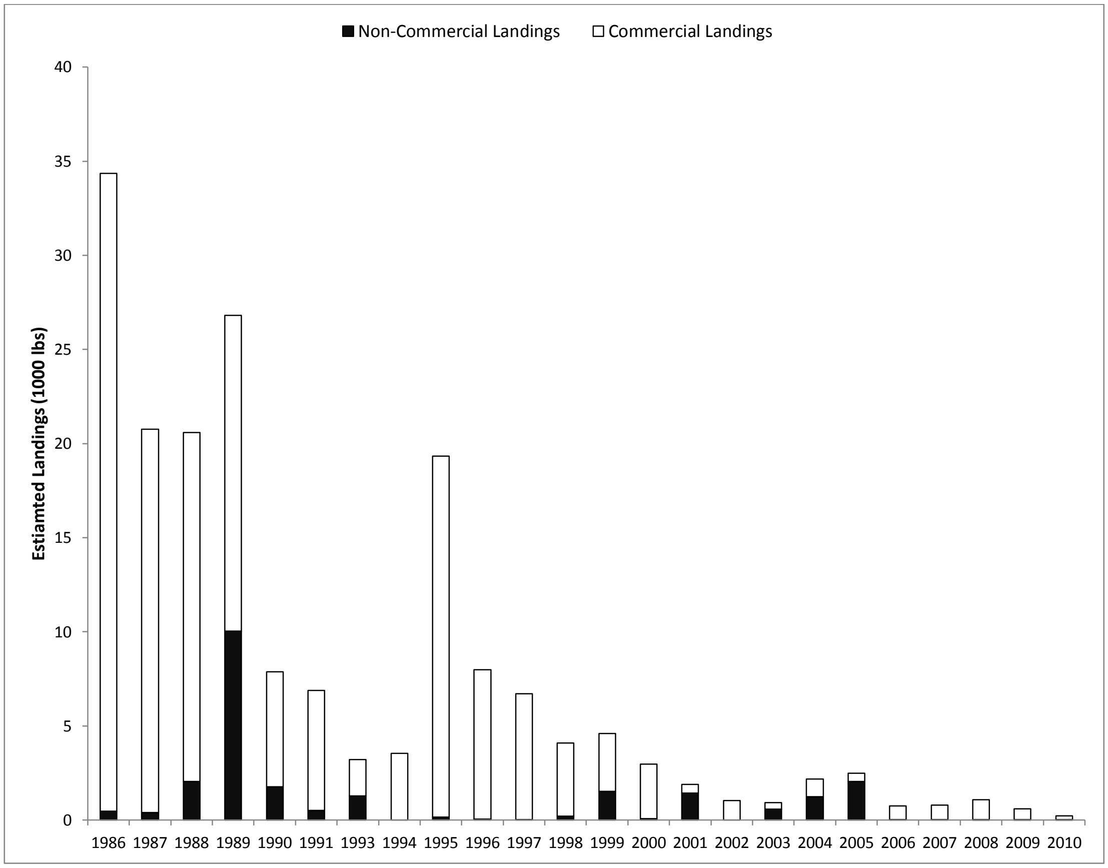

Figure 2.b.4: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the American Samoa boat-based bottomfishing/trolling mixed fishery

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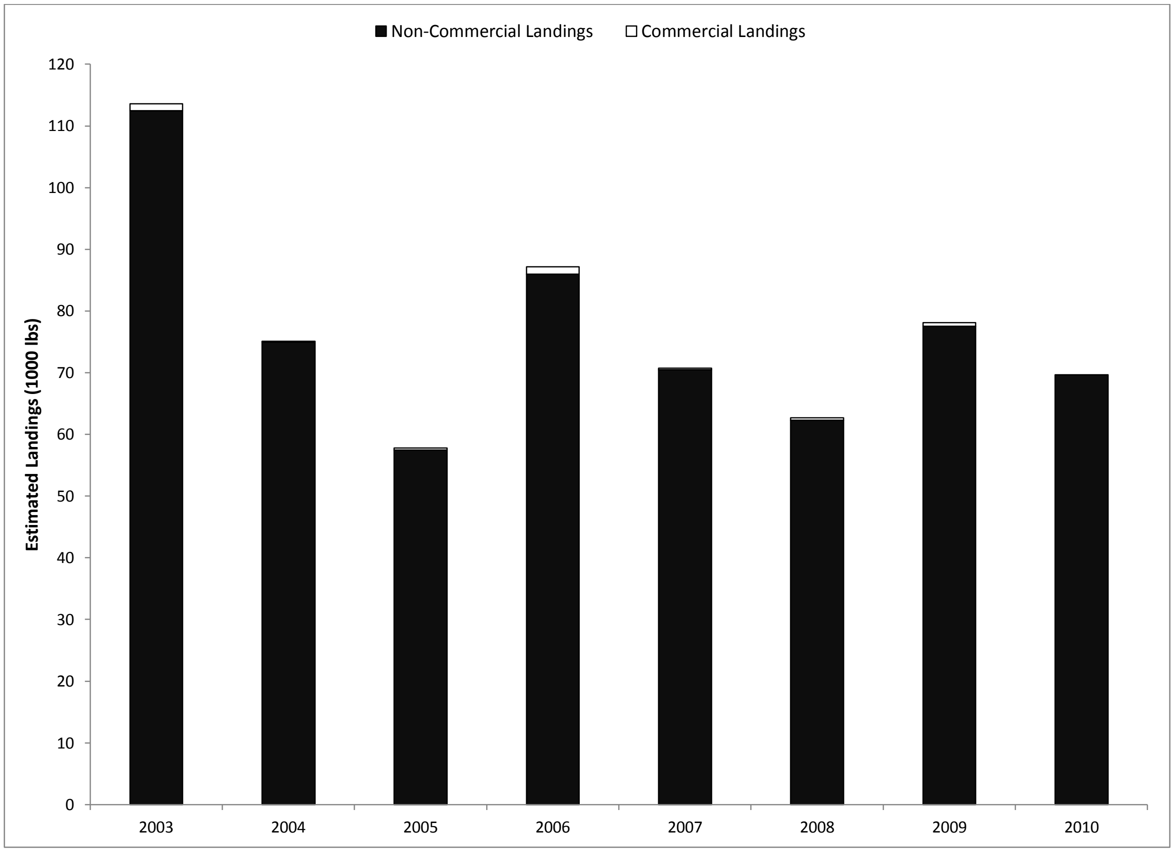

Figure 2.c.1: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the Guam shore-based fishery

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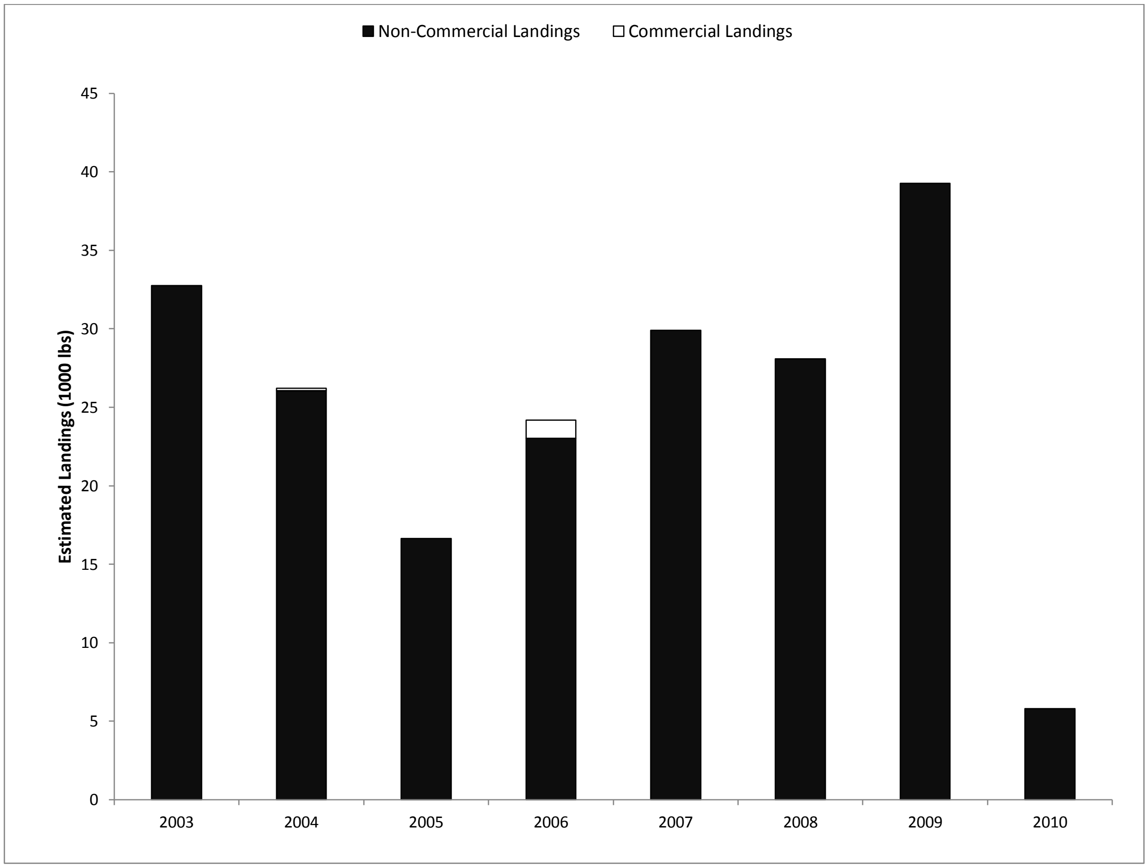

Figure 2.c.2: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the Guam shore-based hook and line fishery

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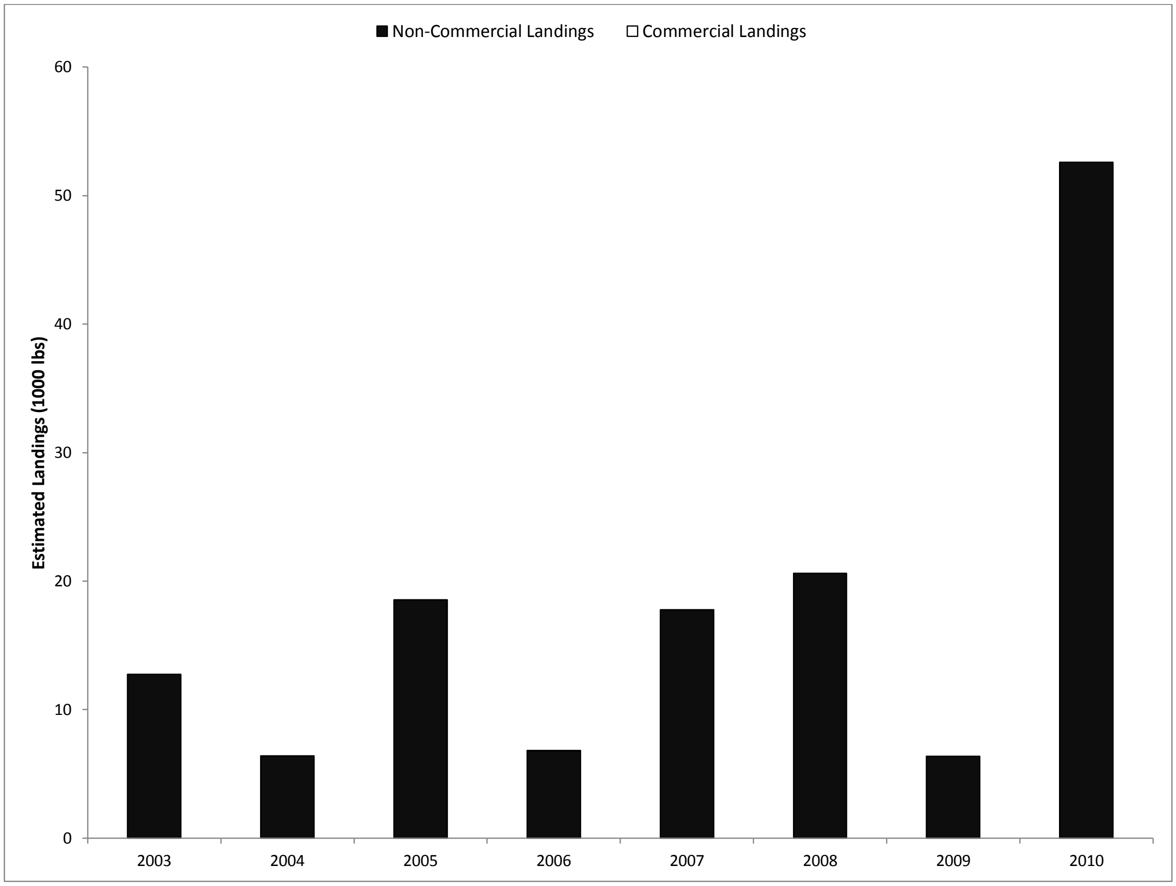

Figure 2.c.3: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the Guam shore-based gill net fishery

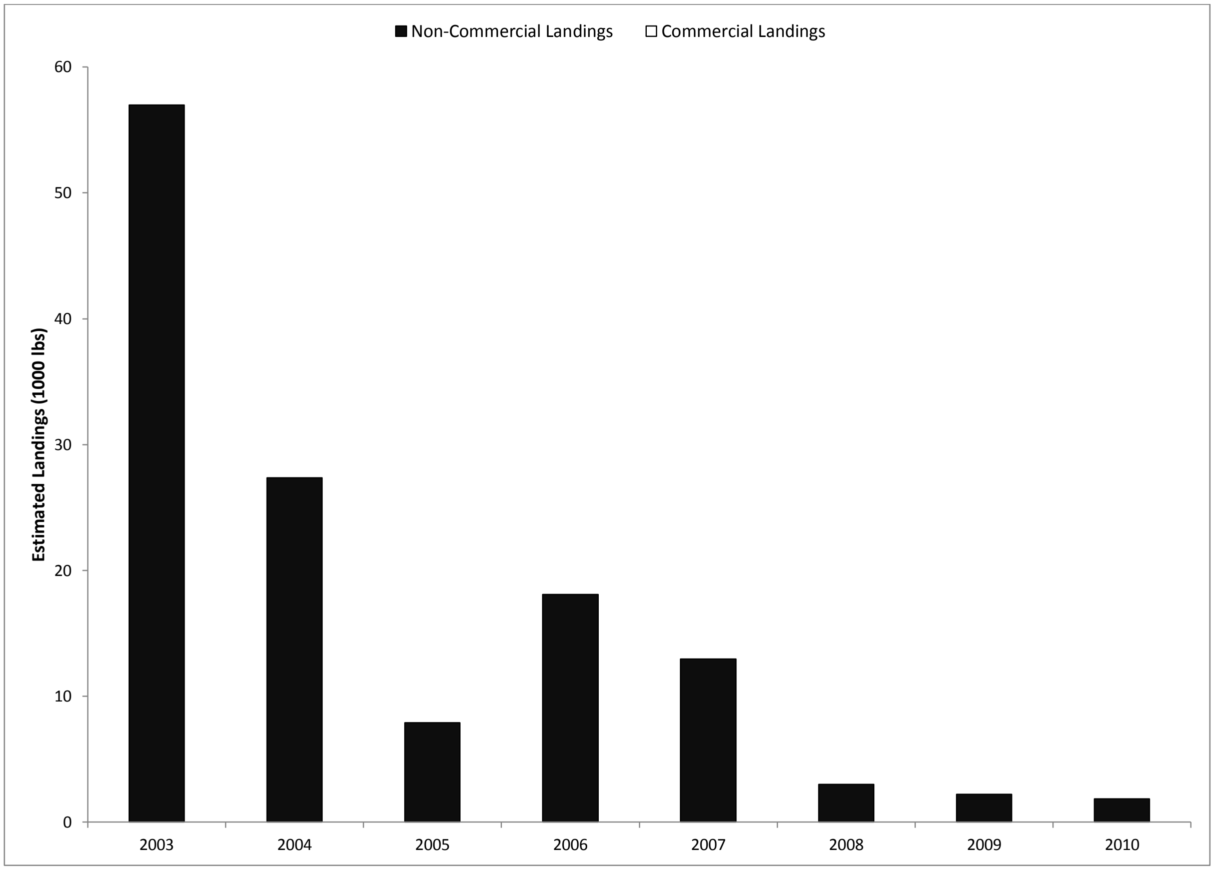

Figure 2.c.4: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the Guam shore-based spear/snorkel fishery

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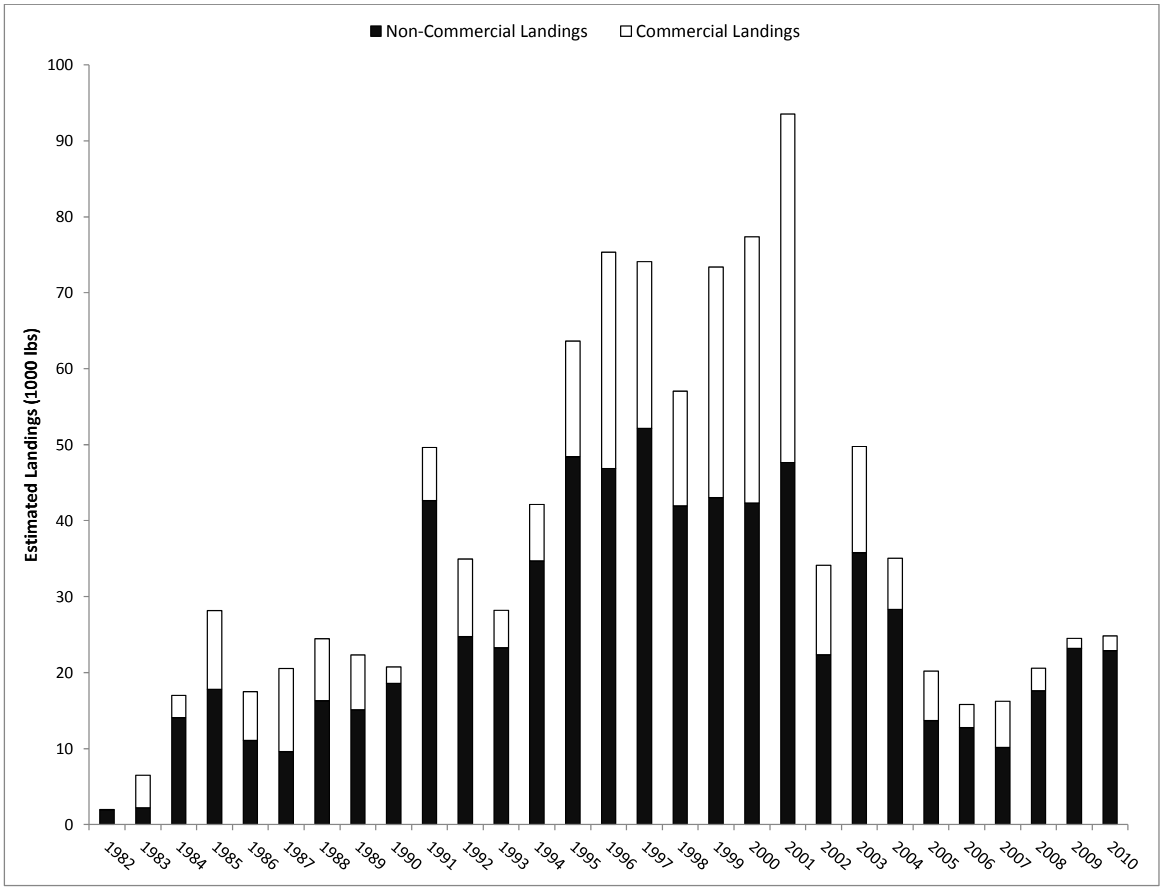

Figure 2.d.1: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the Guam boat-based fishery

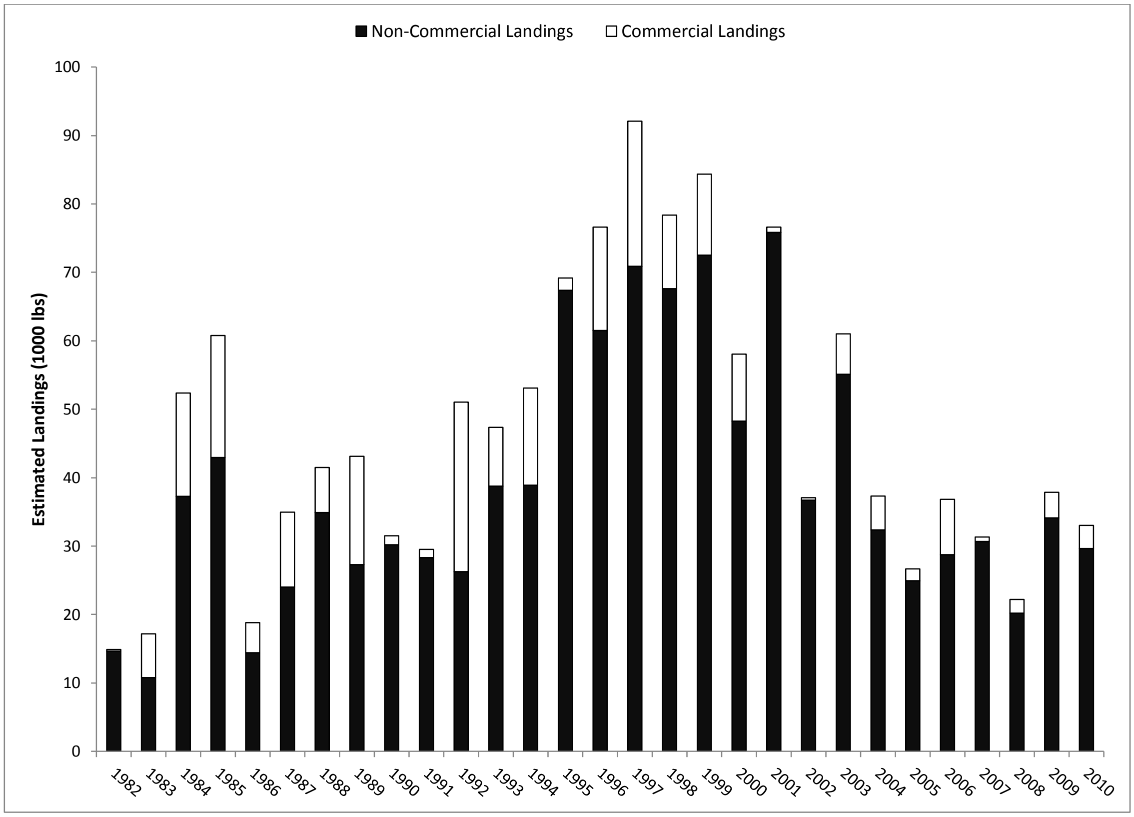

Figure 2.d.2: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the Guam boat-based bottomfishing fishery

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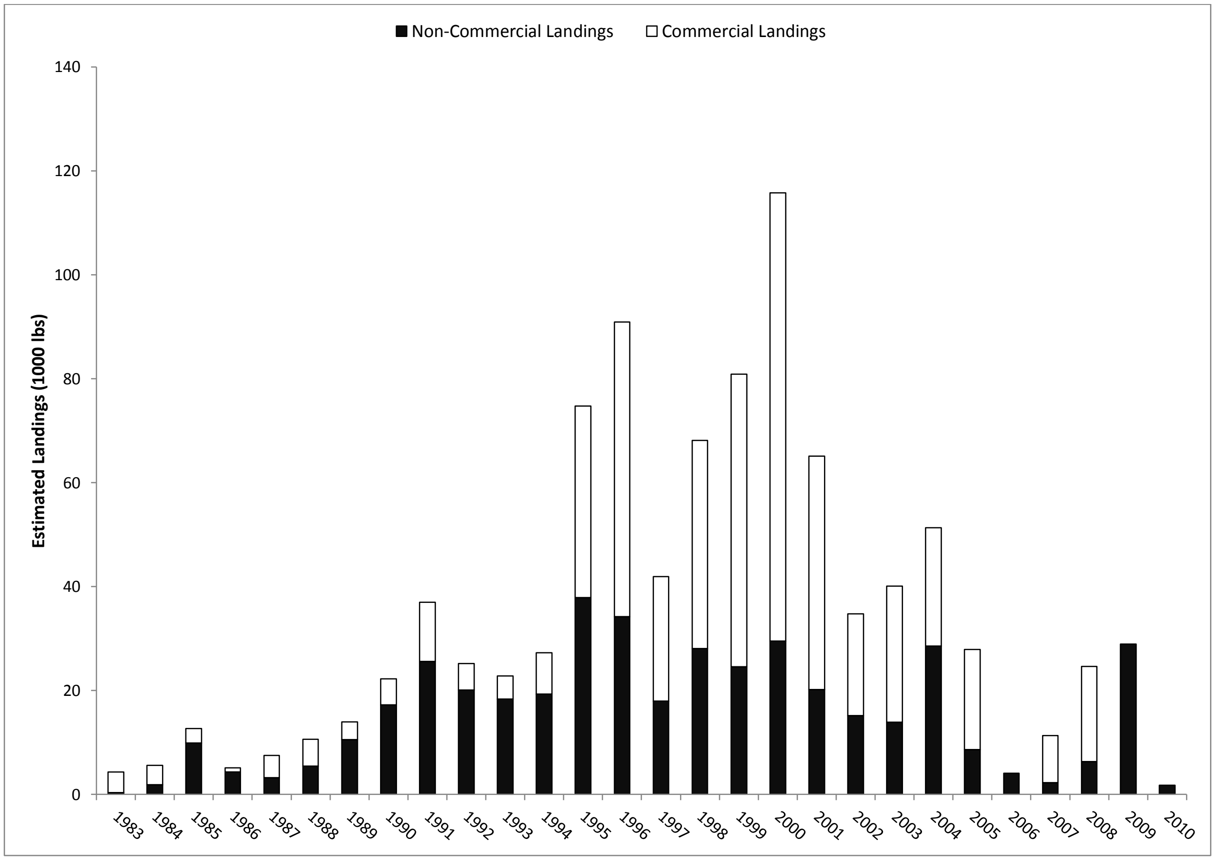

Figure 2.d.3: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the Guam boat-based spear/SCUBA fishery

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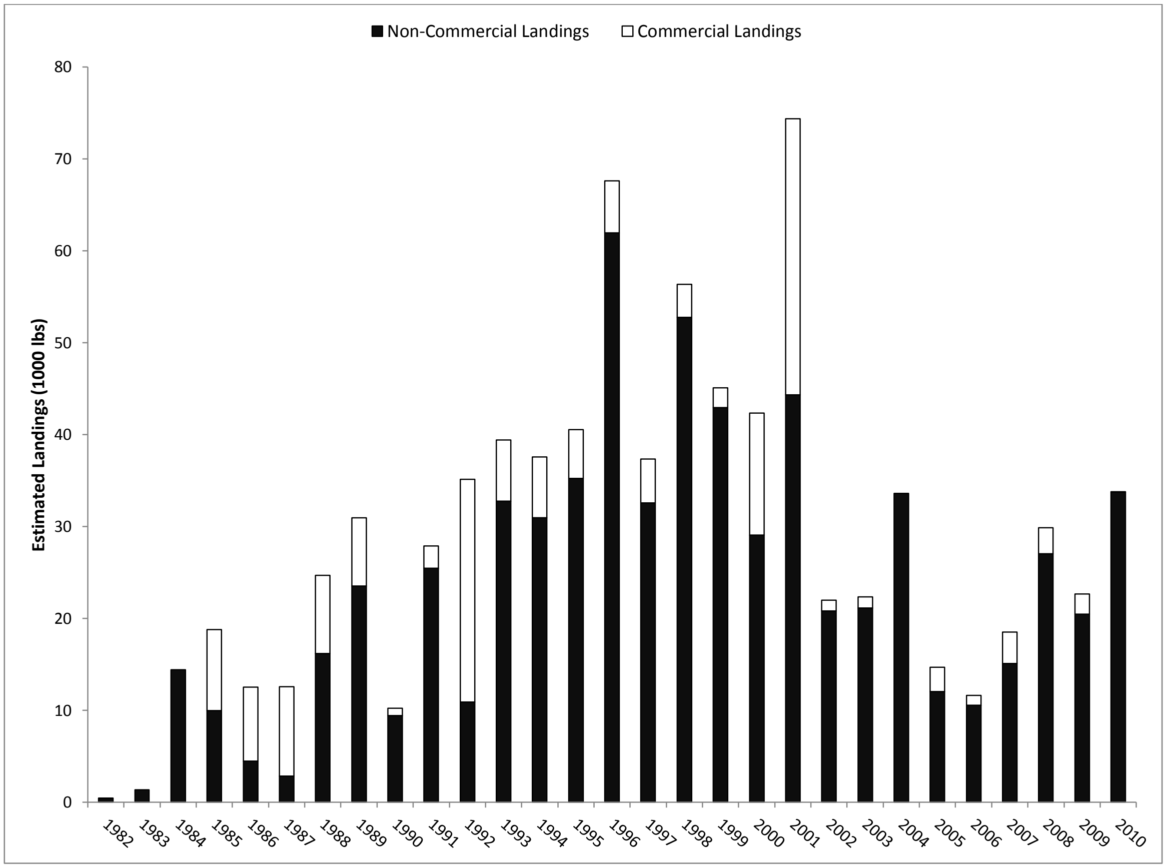

Figure 2.d.4: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the Guam boat-based spear/snorkel fishery

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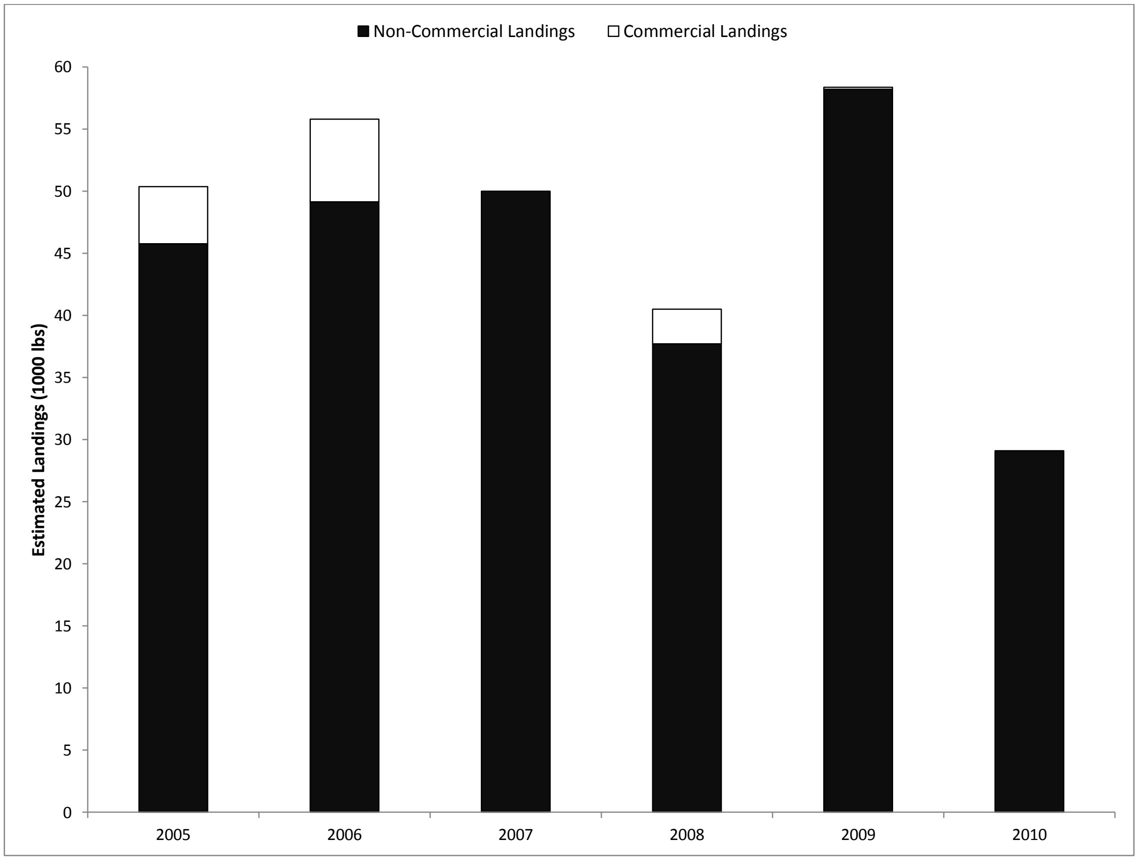

Figure 2.e.1: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the CNMI shore-based fishery

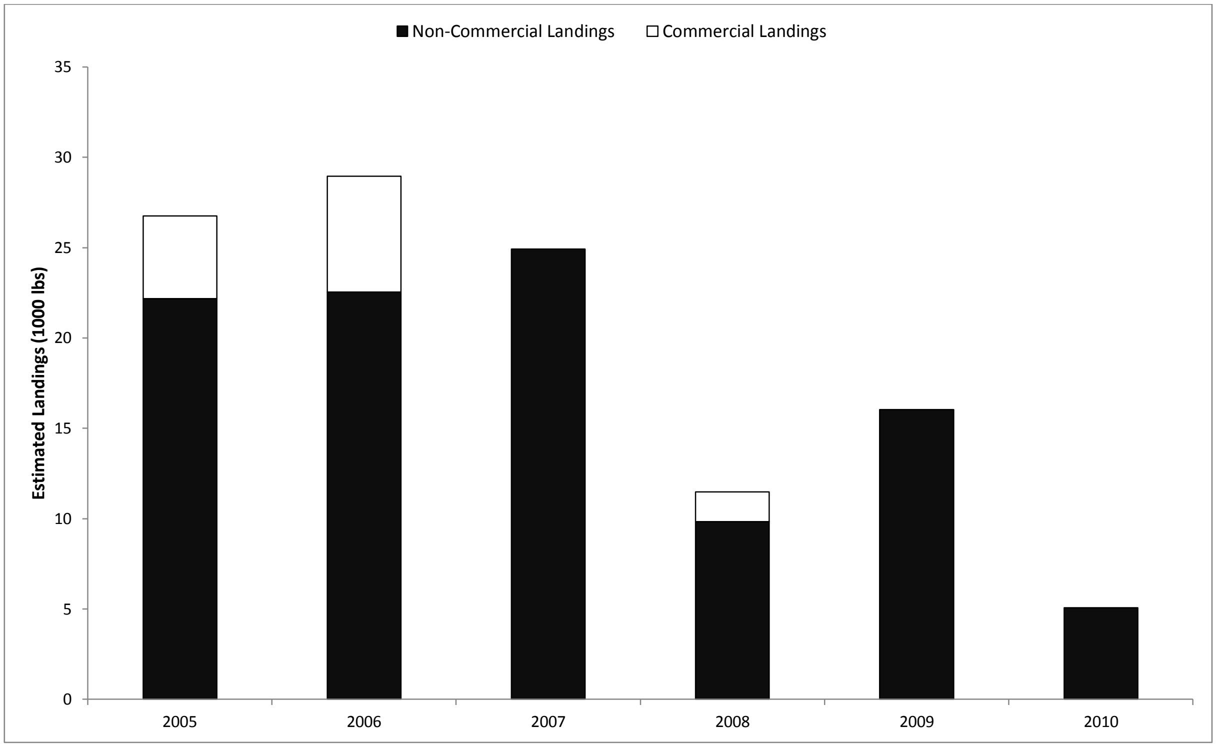

Figure 2.e.2: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the CNMI shore-based spear/snorkel fishery

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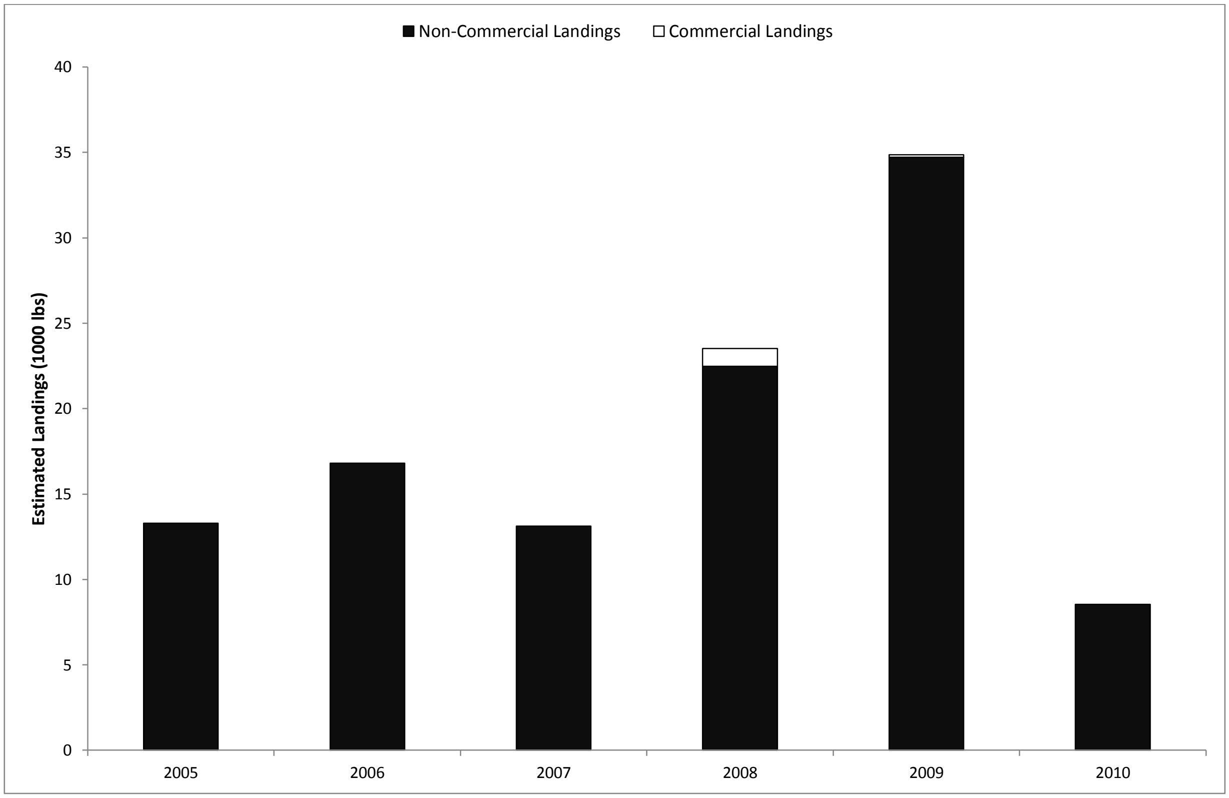

Figure 2.e.3: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the CNMI shore-based hook and line fishery

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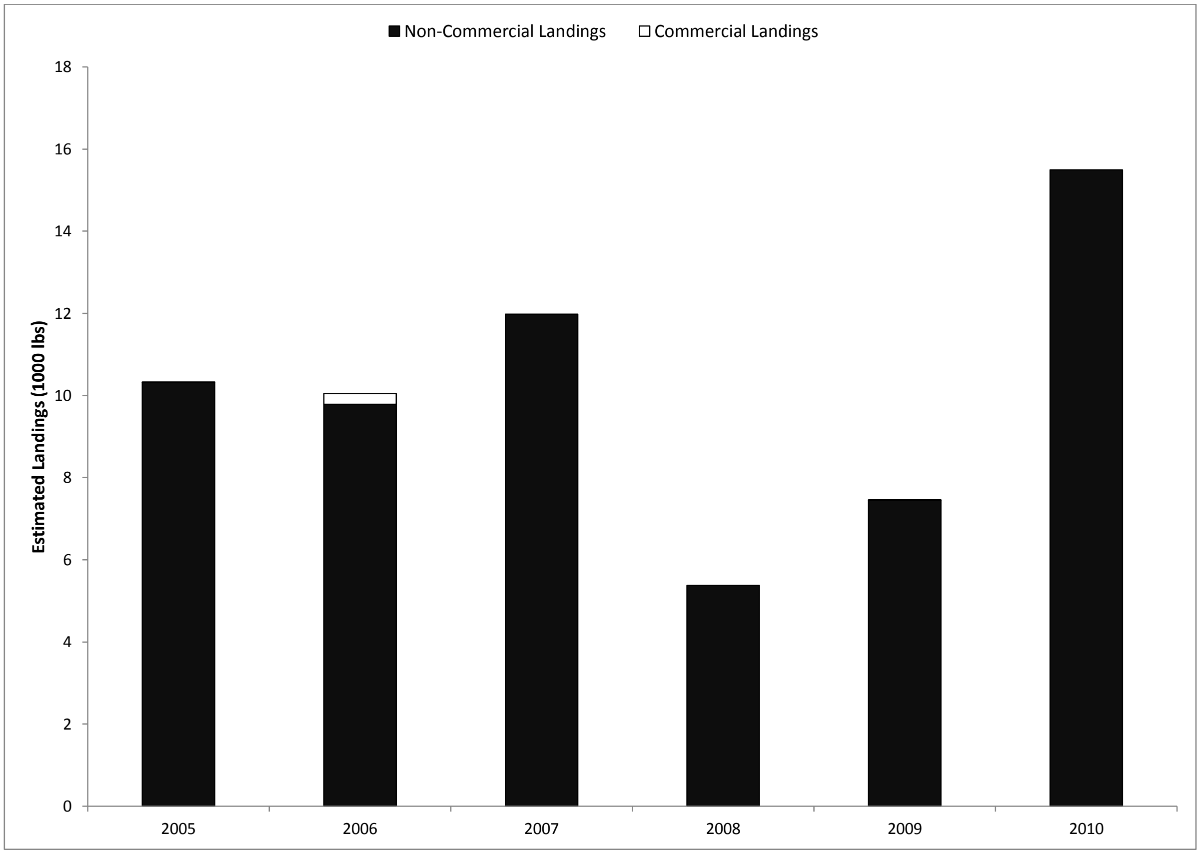

Figure 2.e.4: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the CNMI shore-based cast net fishery

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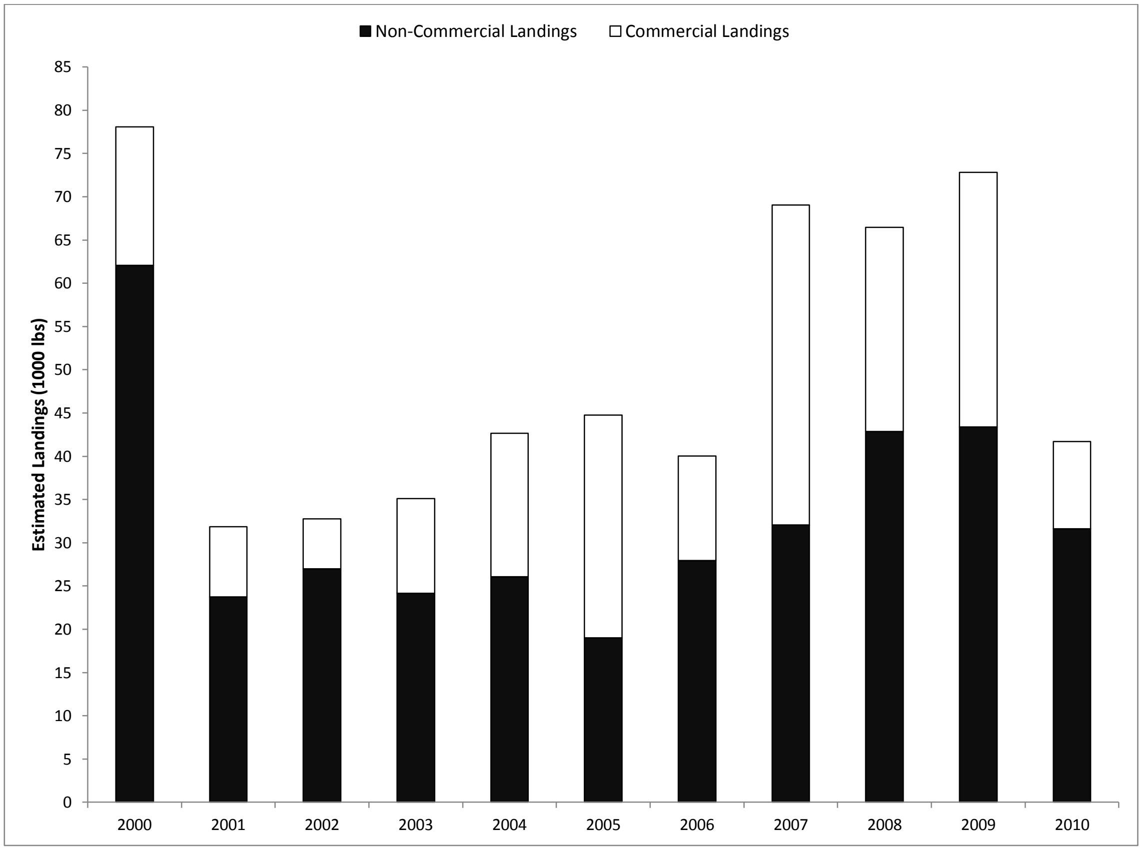

Figure 2.f.1: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the CNMI boat-based fishery

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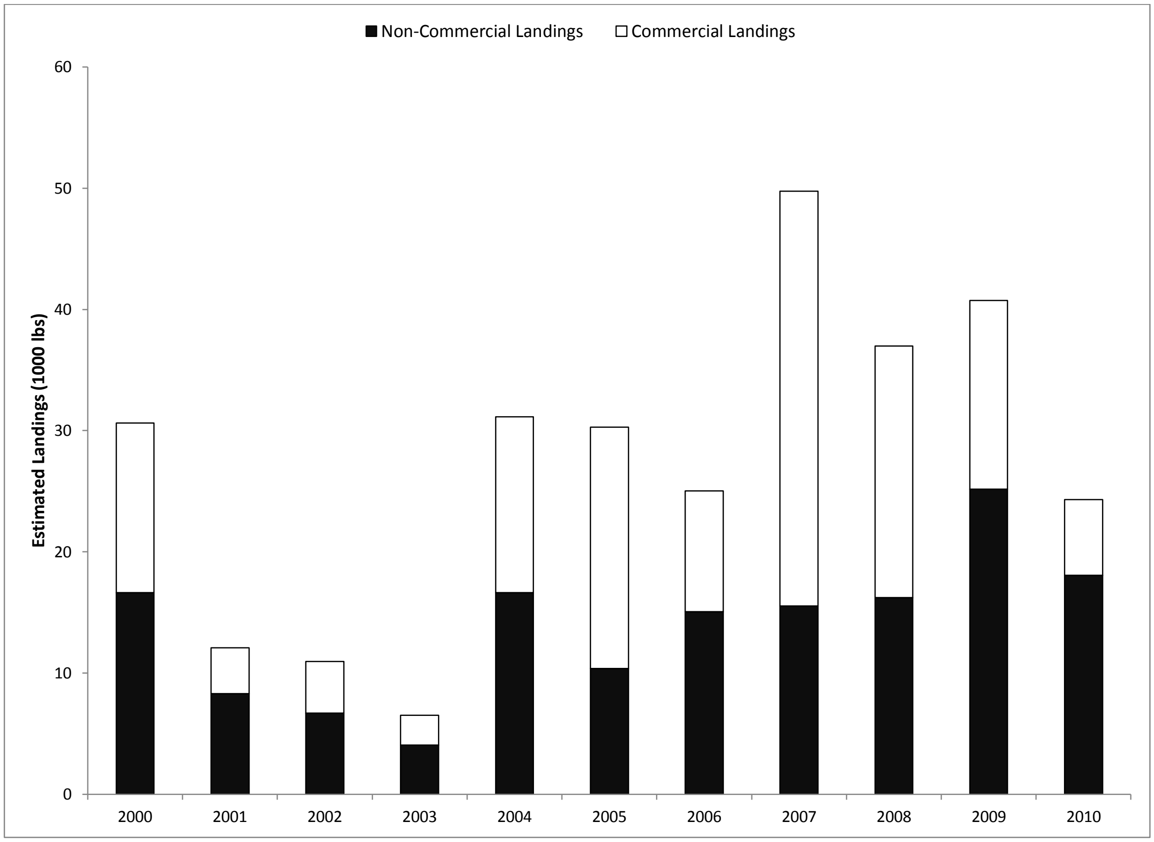

Figure 2.f.2: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the CNMI boat-based bottomfishing fishery

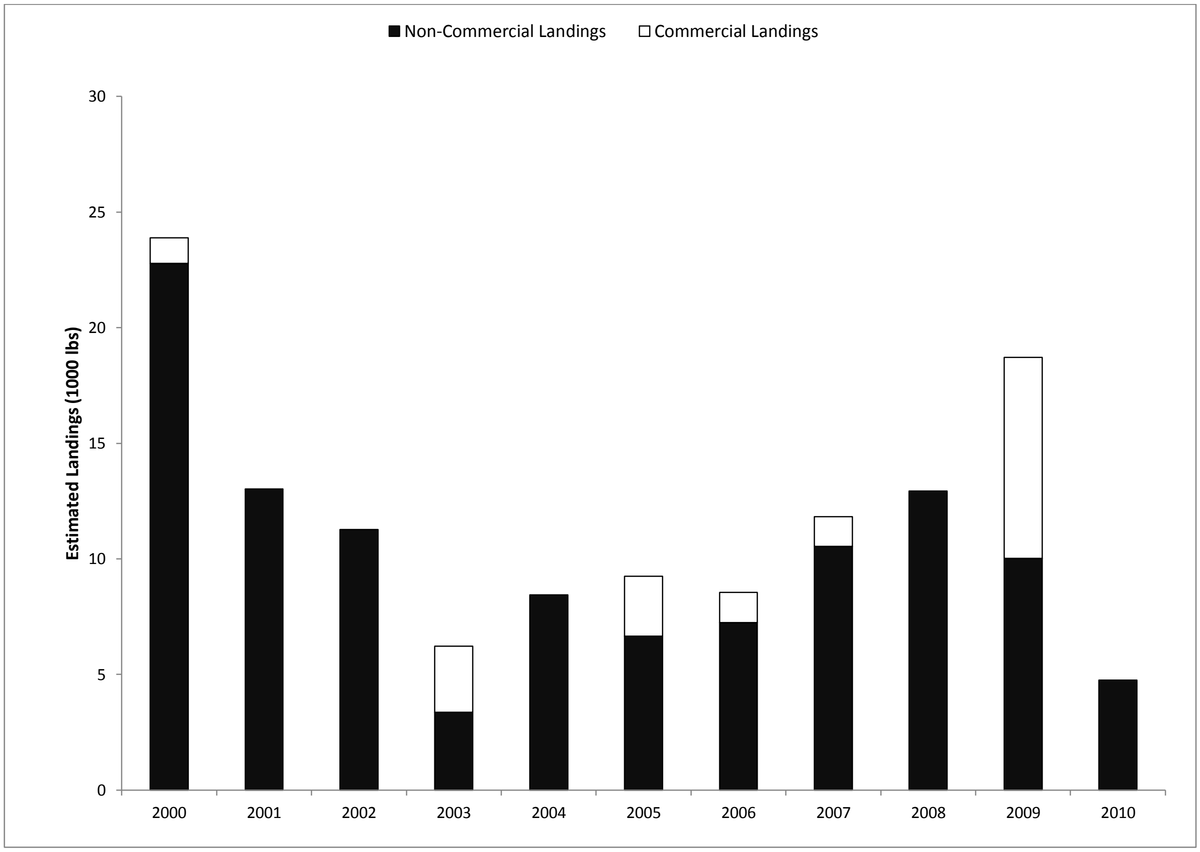

Figure 2.f.3: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the CNMI boat-based spear/snorkel fishery

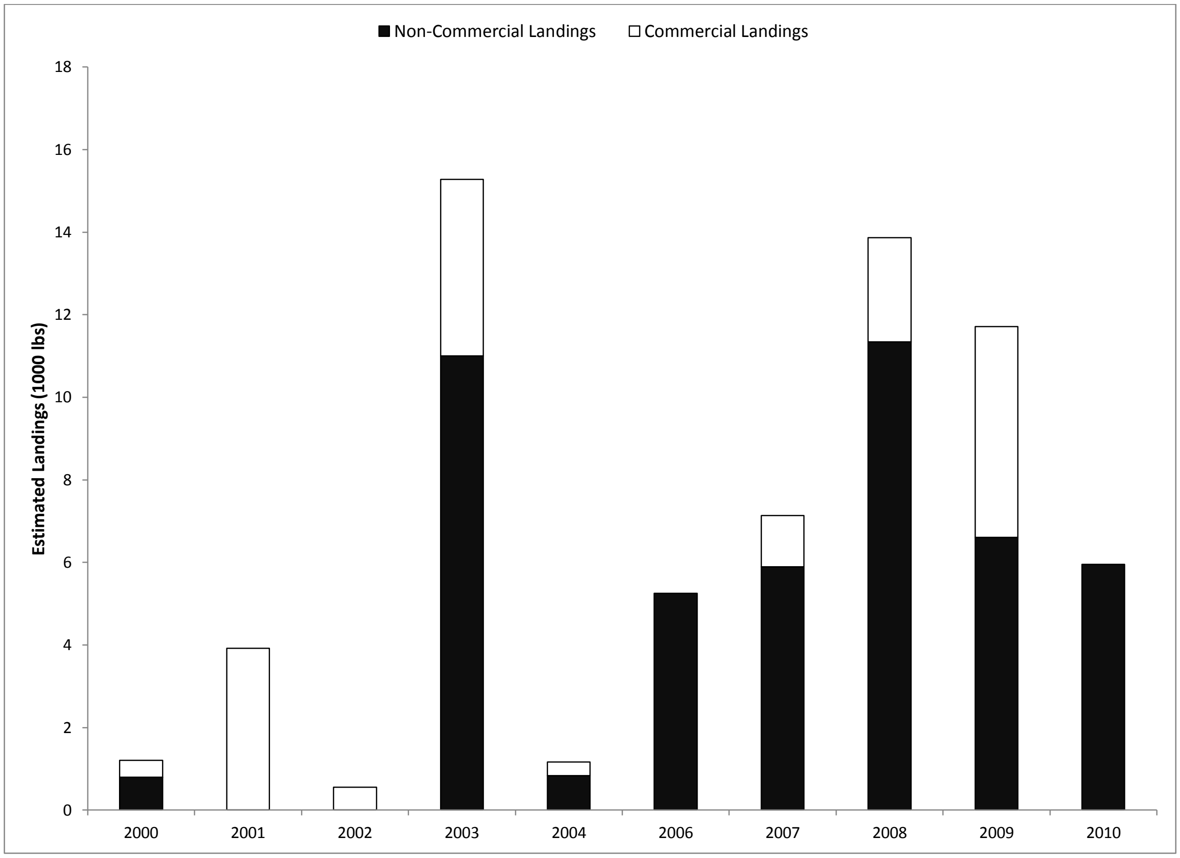

Figure 2.f.4: Annual relative contribution of estimated commercial and non-commercial landings of coral reef species in the atulai method fishery

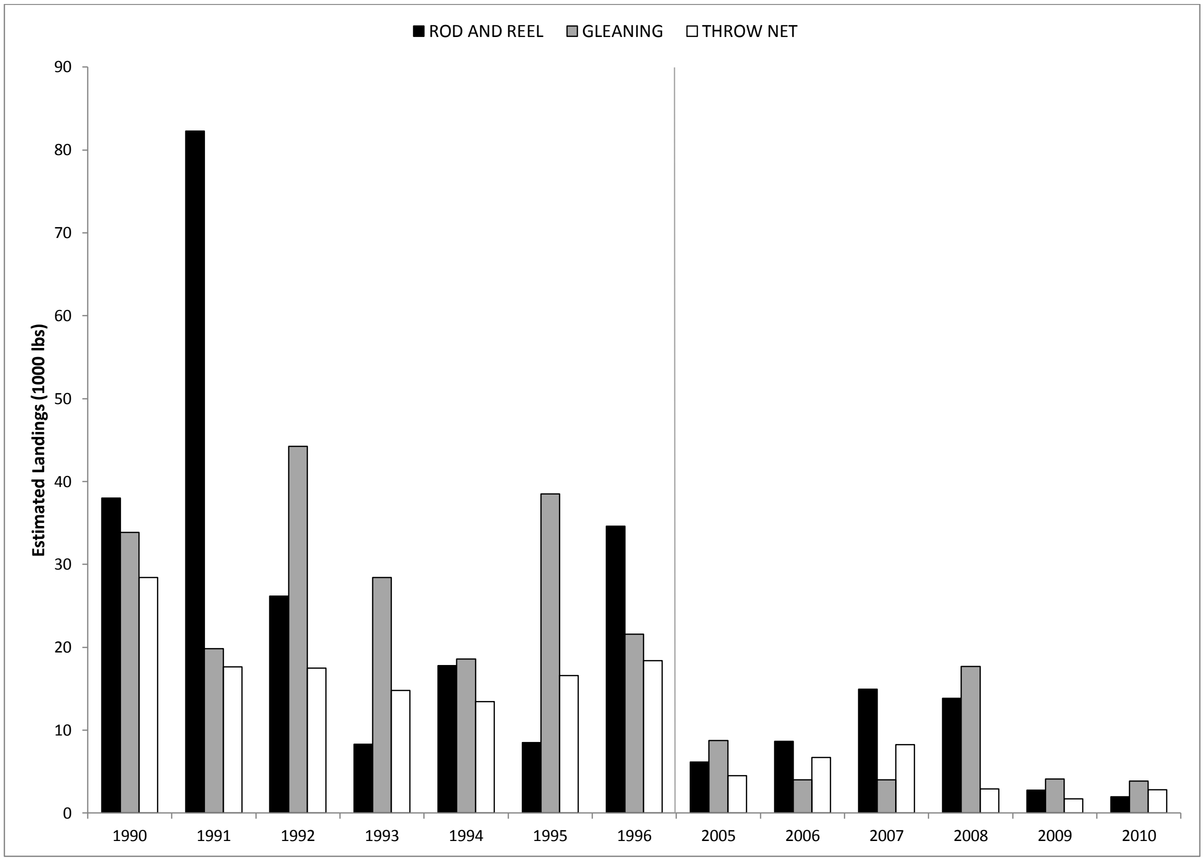

Figure 3.a.1: Annual estimated non-commercial landings of coral reef species by the top one to three methods in the American Samoa shore-based fishery

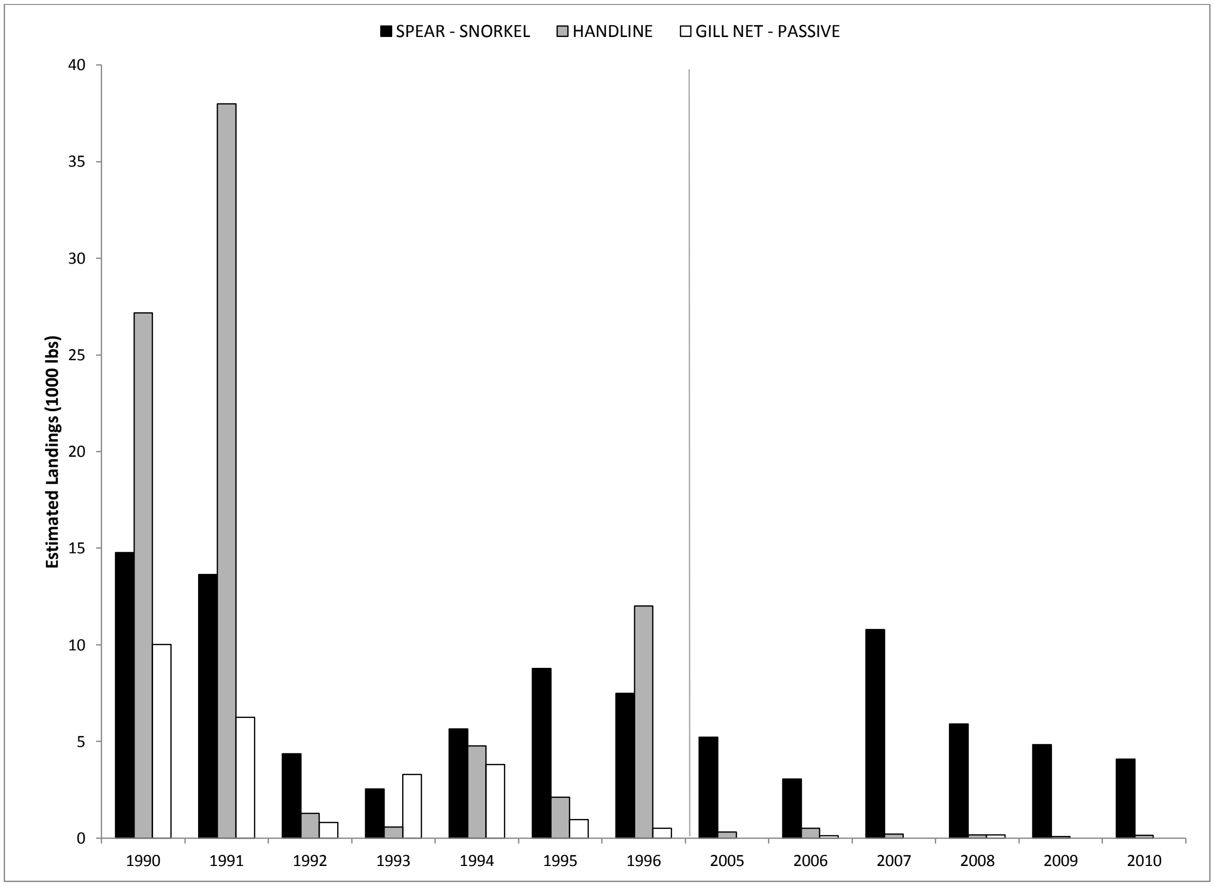

Figure 3.a.2: Annual estimated non-commercial landings of coral reef species by the top four to six methods in the American Samoa shore-based fishery

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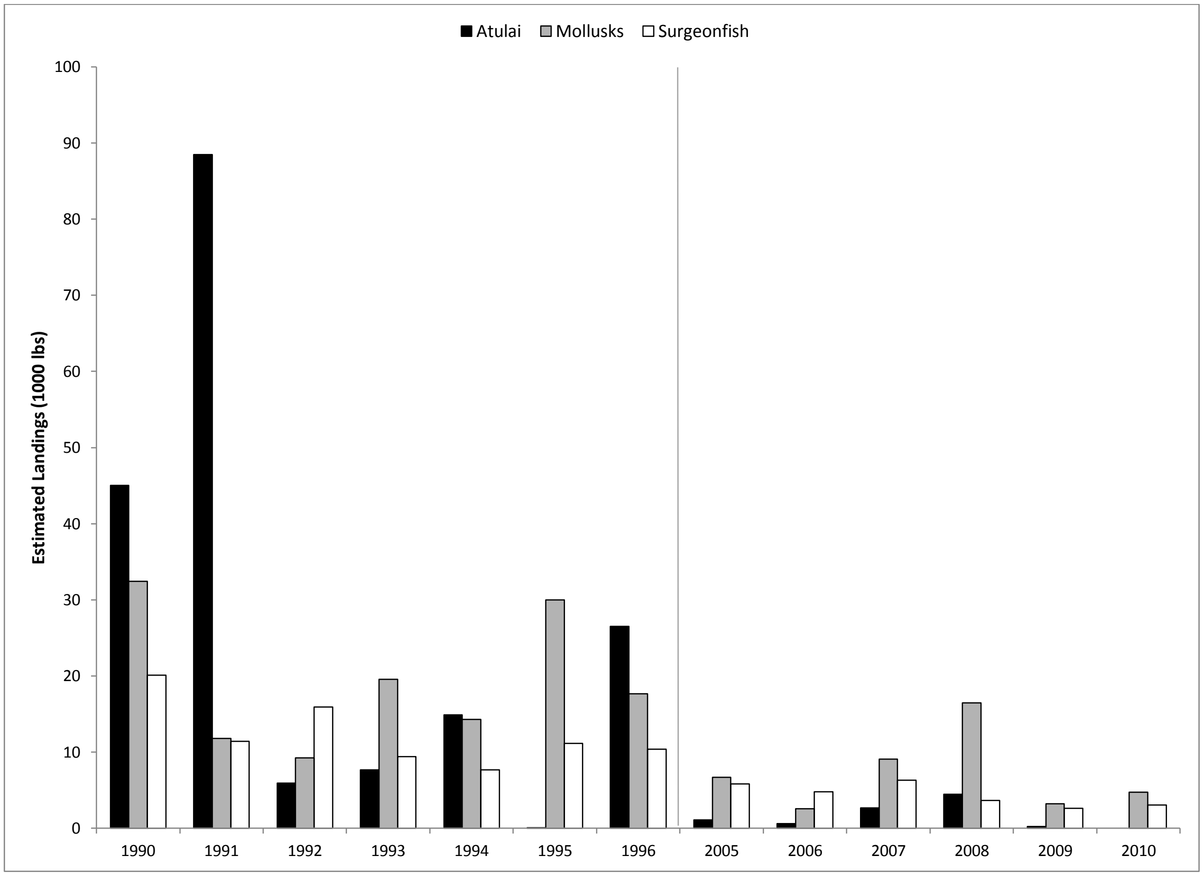

Figure 3.a.3: Annual estimated non-commercial landings of the top one to three coral reef species groups in the American Samoa shore-based fishery

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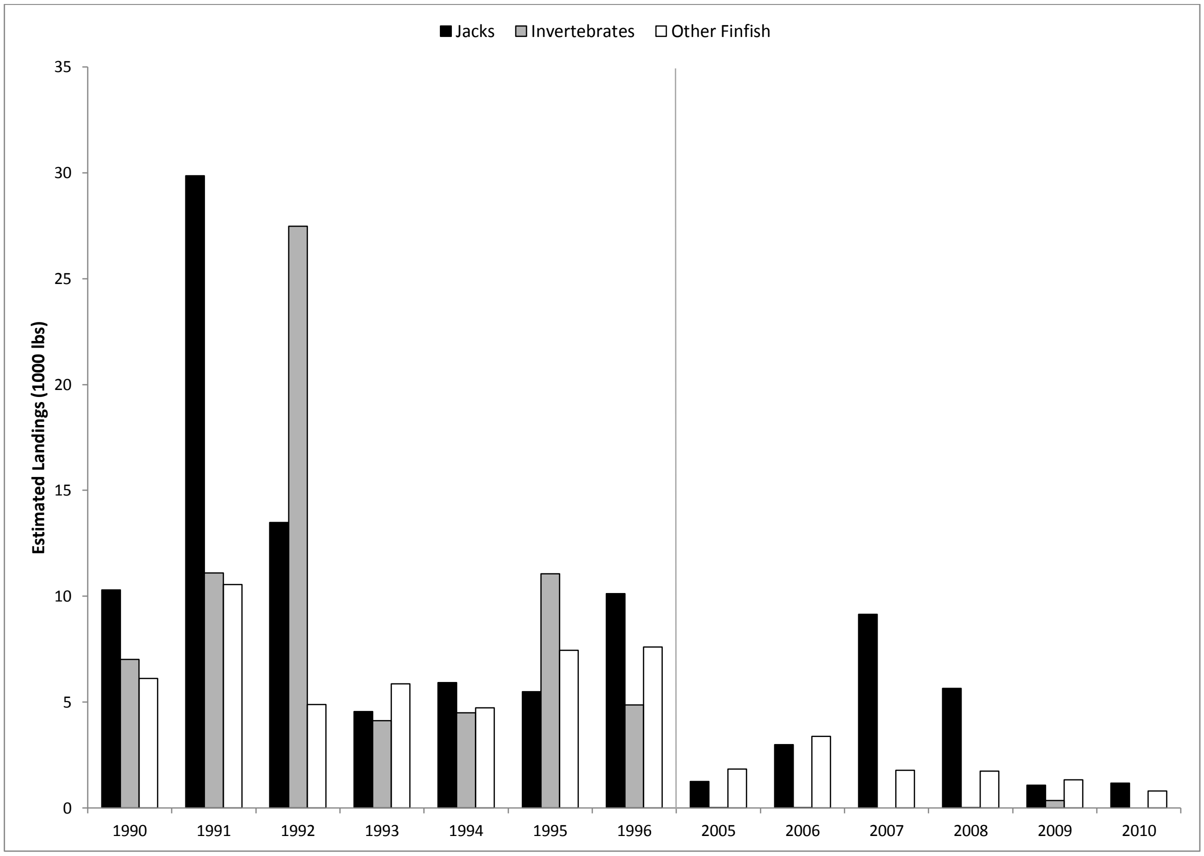

Figure 3.a.4: Annual estimated non-commercial landings of the top four to six coral reef species groups in the American Samoa shore-based fishery

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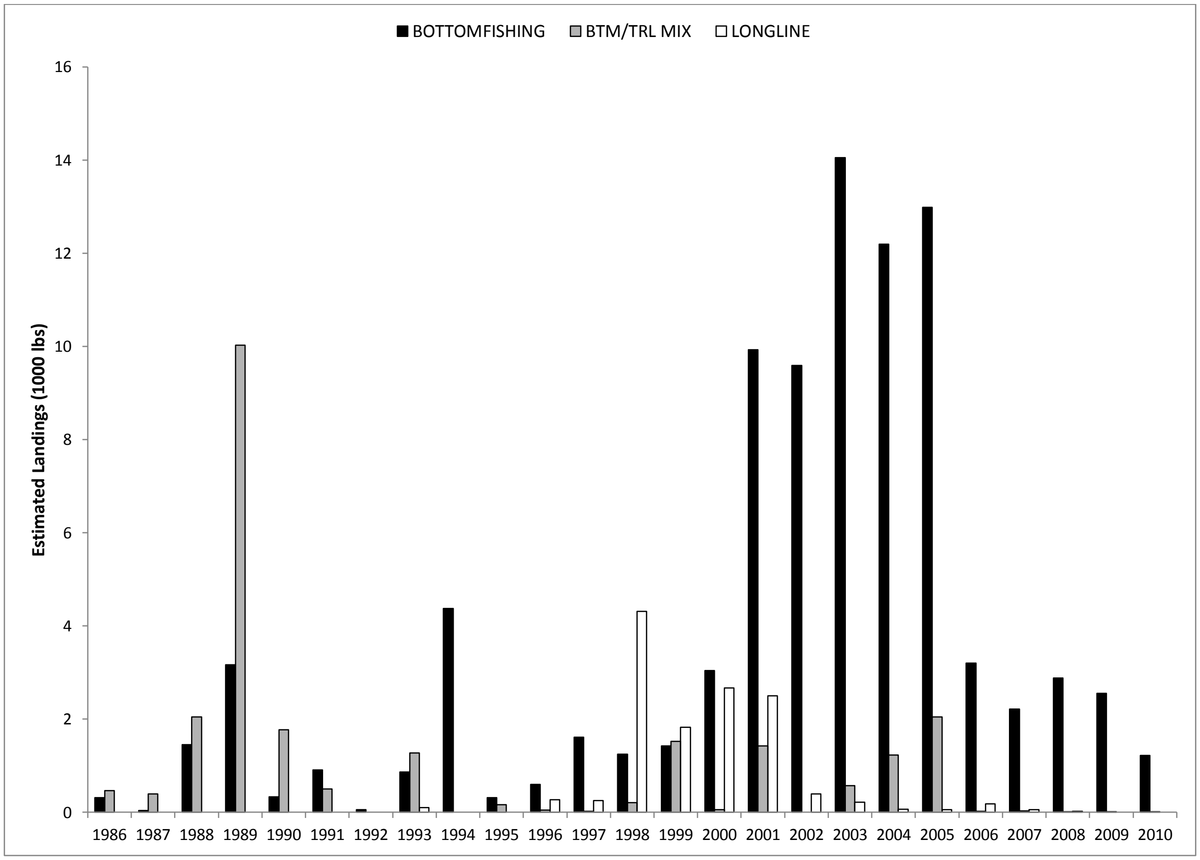

Figure 3.b.1: Annual estimated non-commercial landings of coral reef species by the top one to three methods in the American Samoa boat-based fishery

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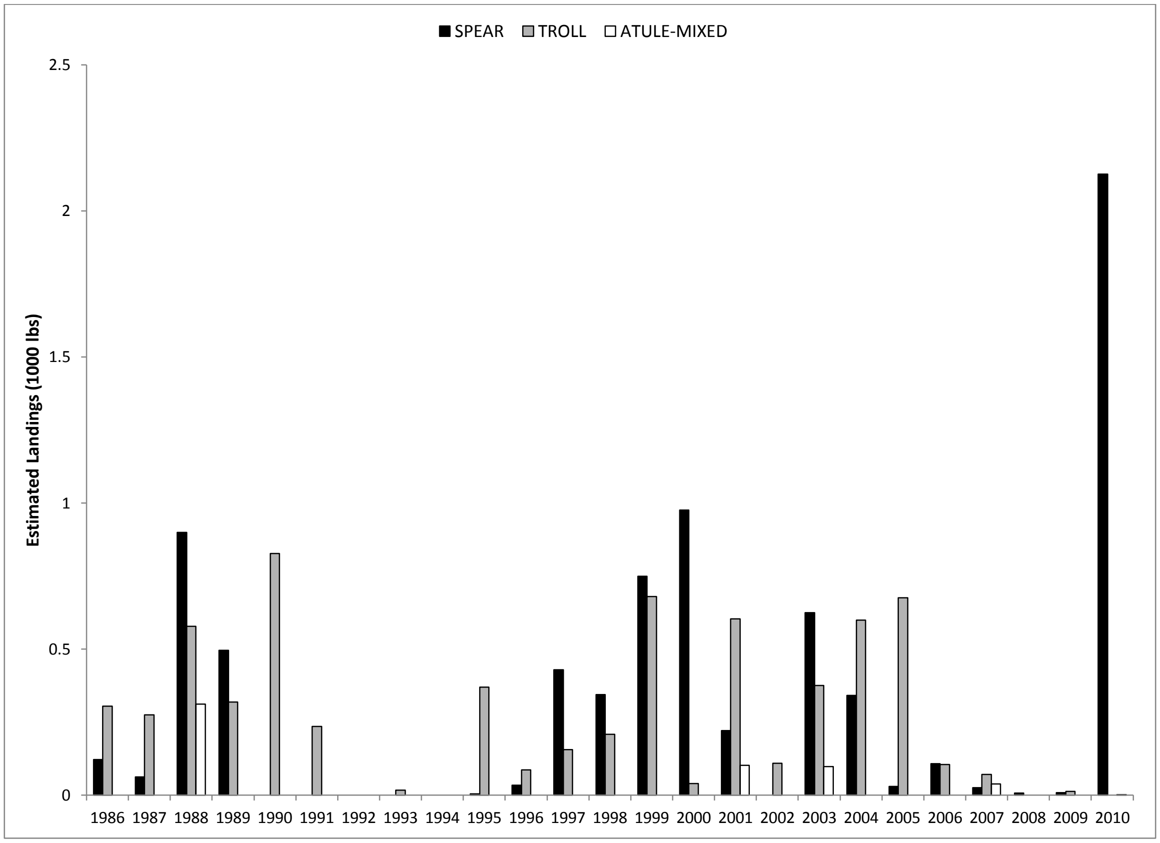

Figure 3.b.2: Annual estimated non-commercial landings of coral reef species by the top four to six methods in the American Samoa boat-based fishery

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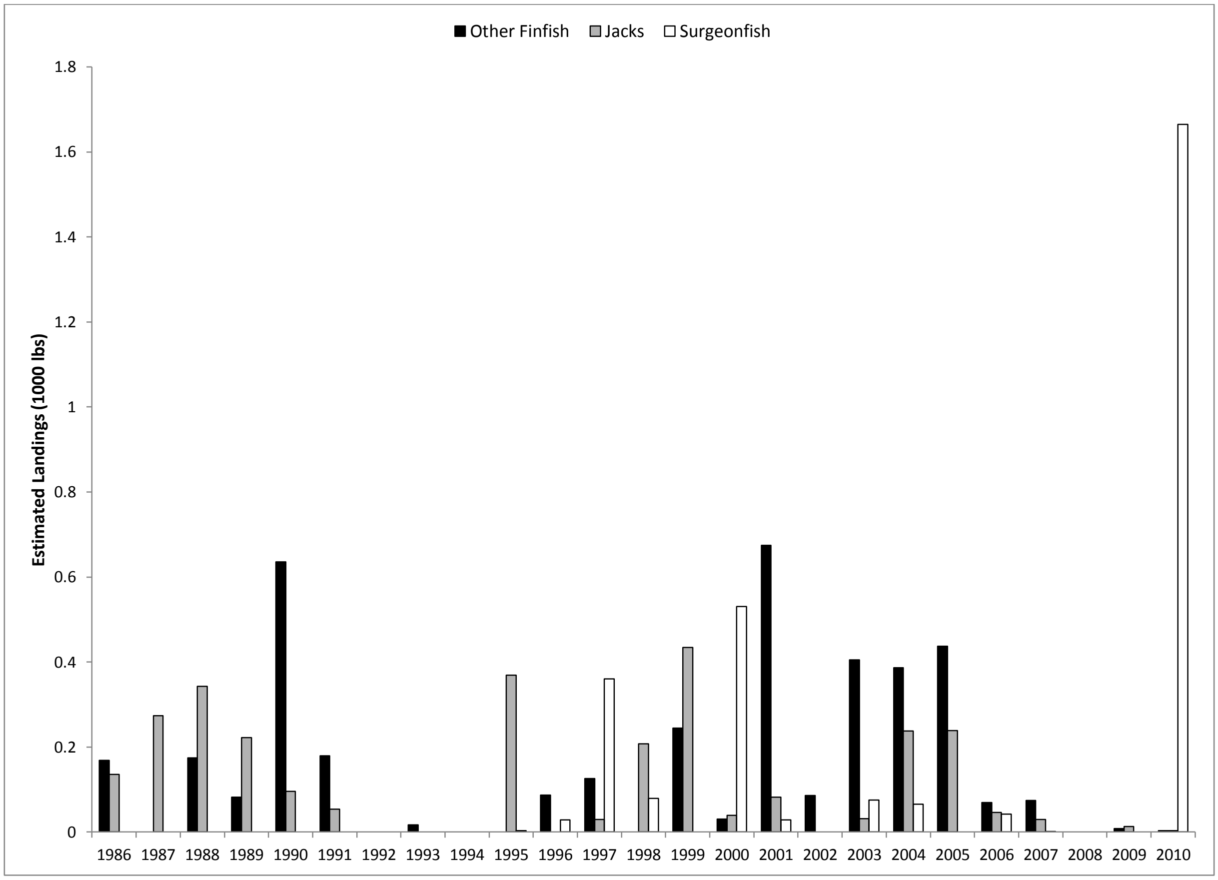

Figure 3.b.3: Annual estimated non-commercial landings of the top one to three coral reef species groups in the American Samoa boat-based fishery

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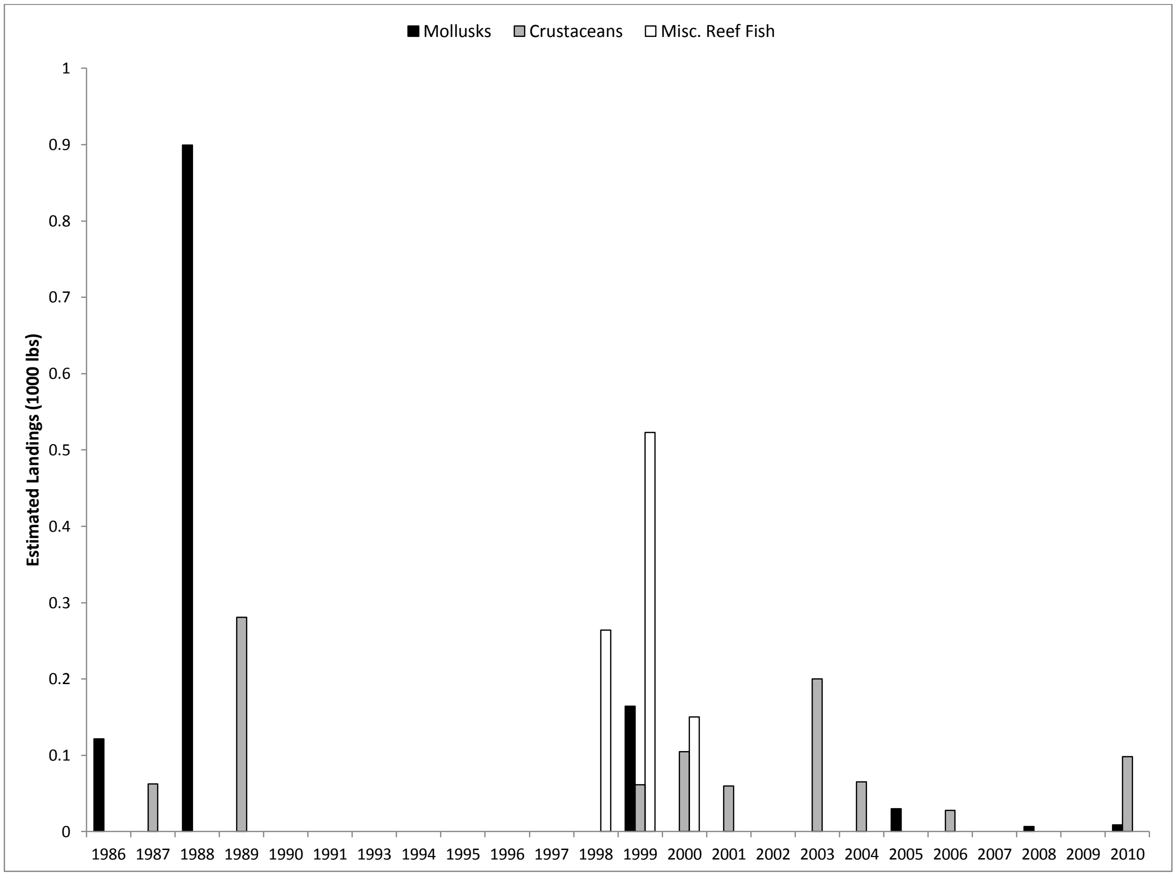

Figure 3.b.4: Annual estimated non-commercial landings of the top four to six coral reef species groups in the American Samoa boat-based fishery

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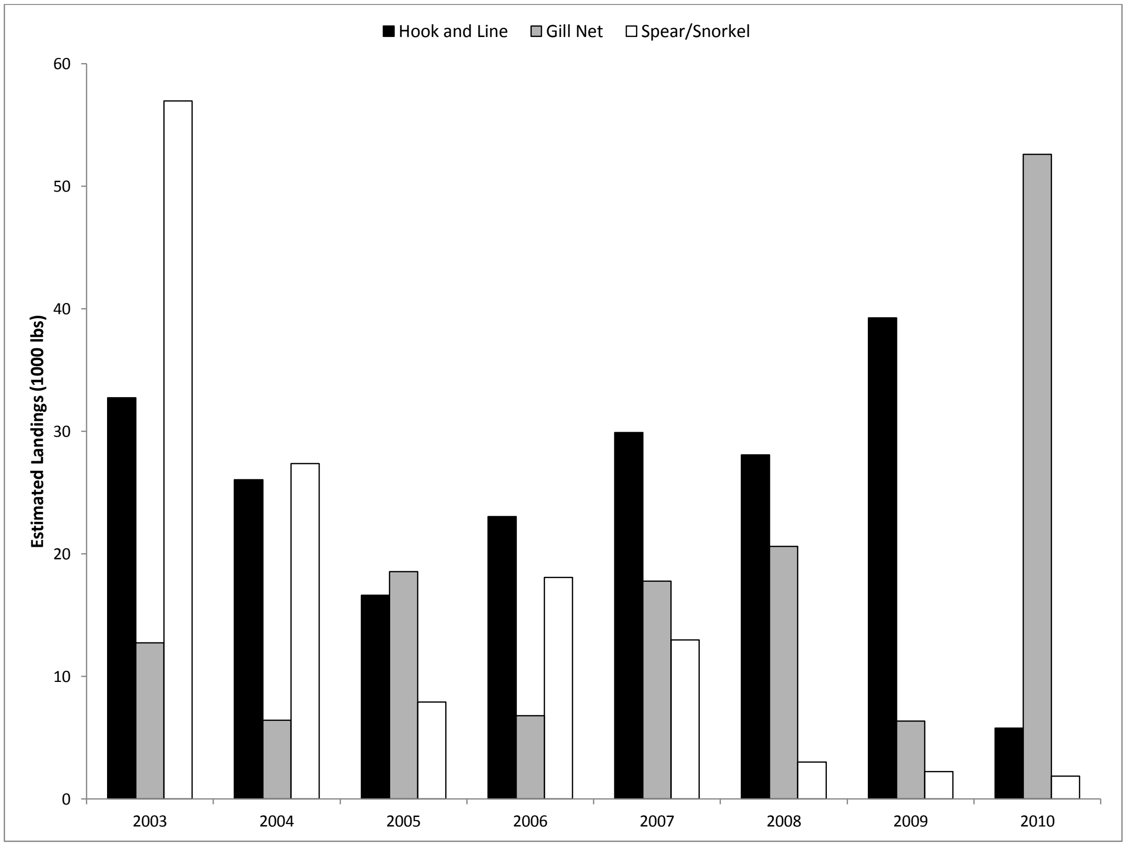

Figure 3.c.1: Annual estimated non-commercial landings of coral reef species by the top one to three methods in the Guam shore-based fishery

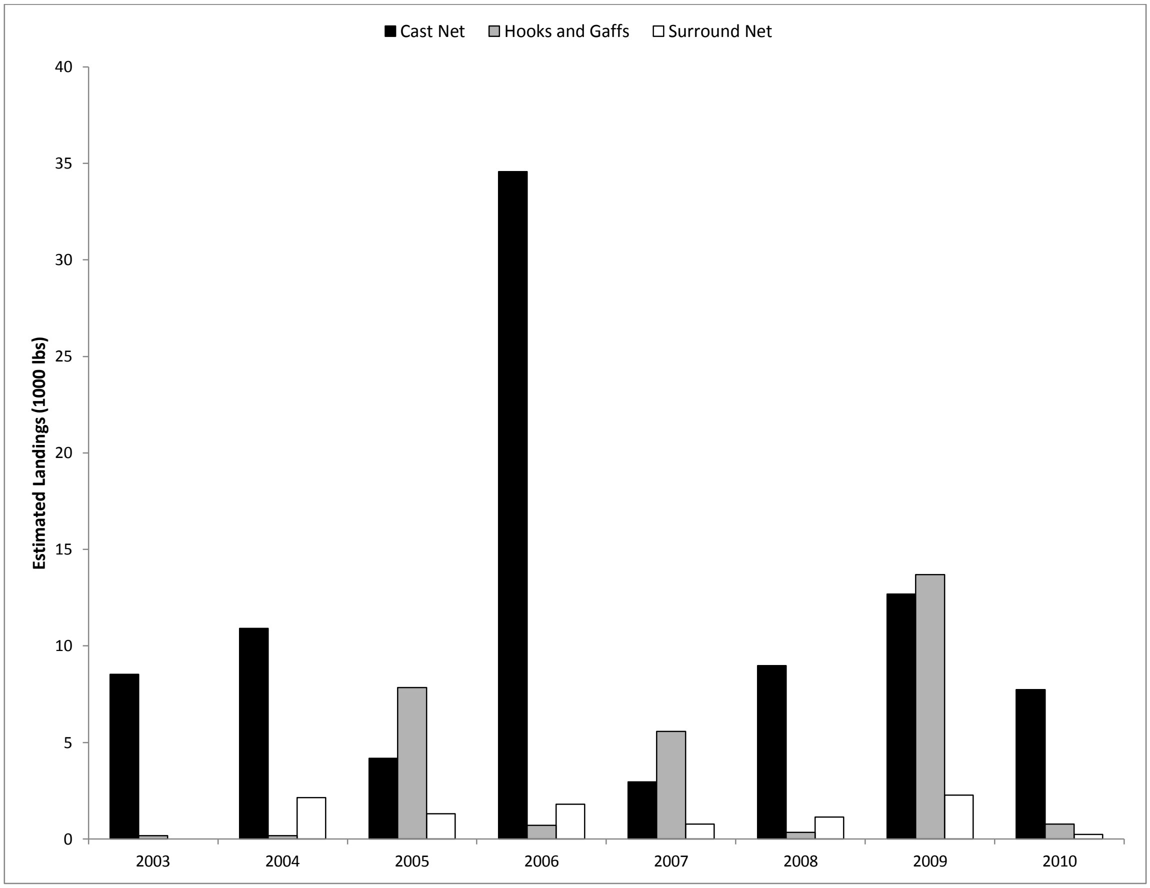

Figure 3.c.2: Annual estimated non-commercial landings of coral reef species by the top four to six methods in the Guam shore-based fishery

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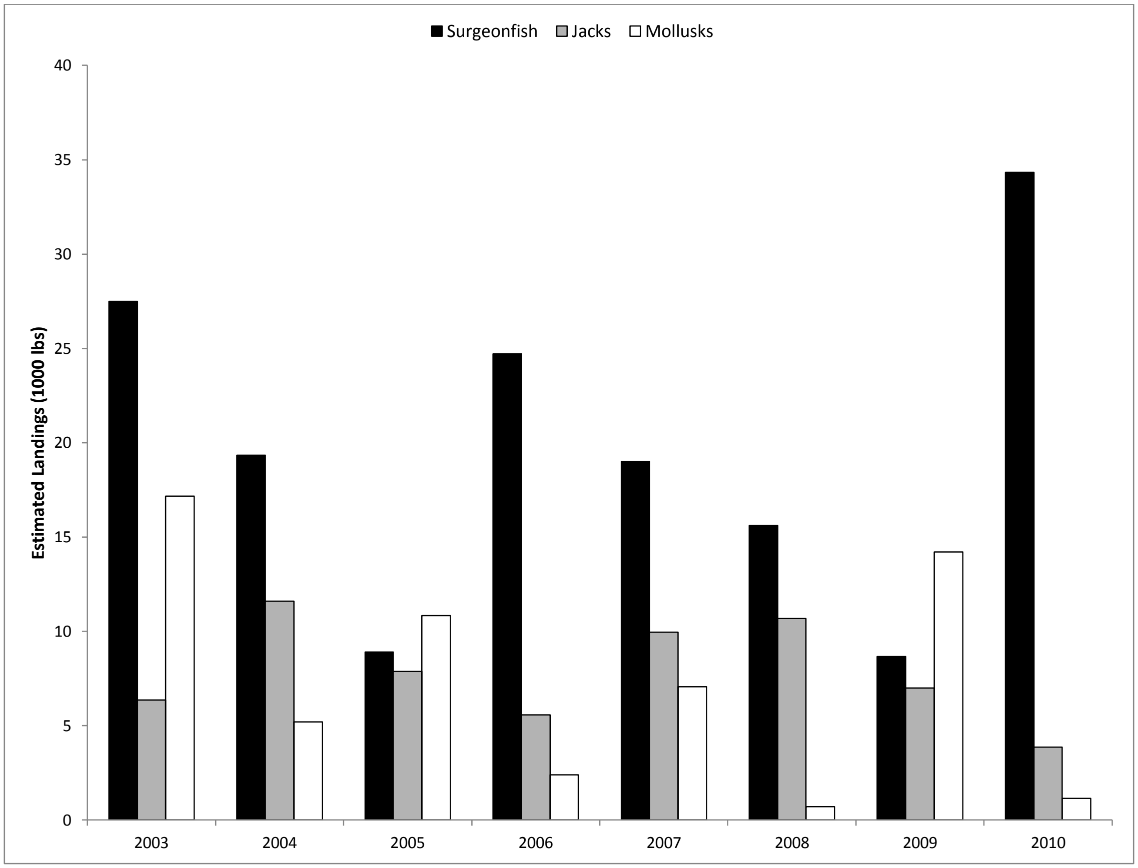

Figure 3.c.3: Annual estimated non-commercial landings of the top one to three coral reef species groups in the Guam shore-based fishery

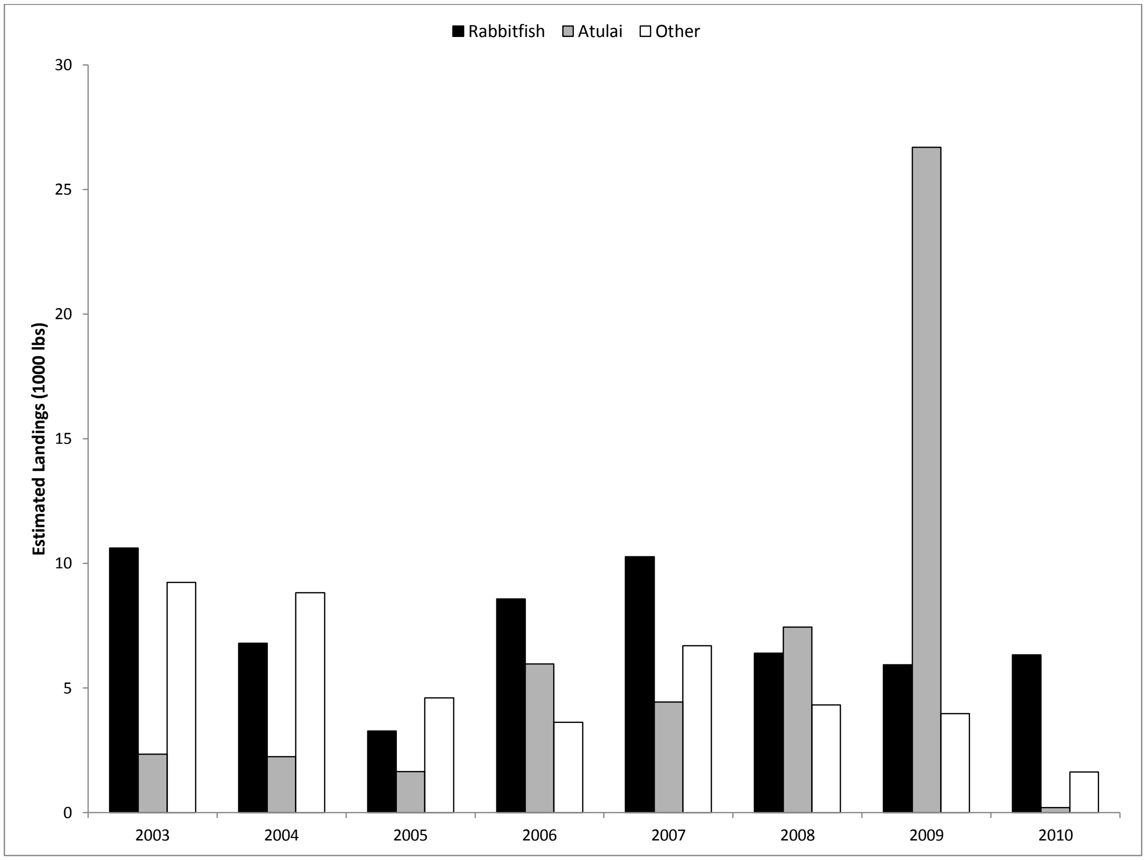

Figure 3.c.4: Annual estimated non-commercial landings of the top four to six coral reef species groups in the Guam shore-based fishery

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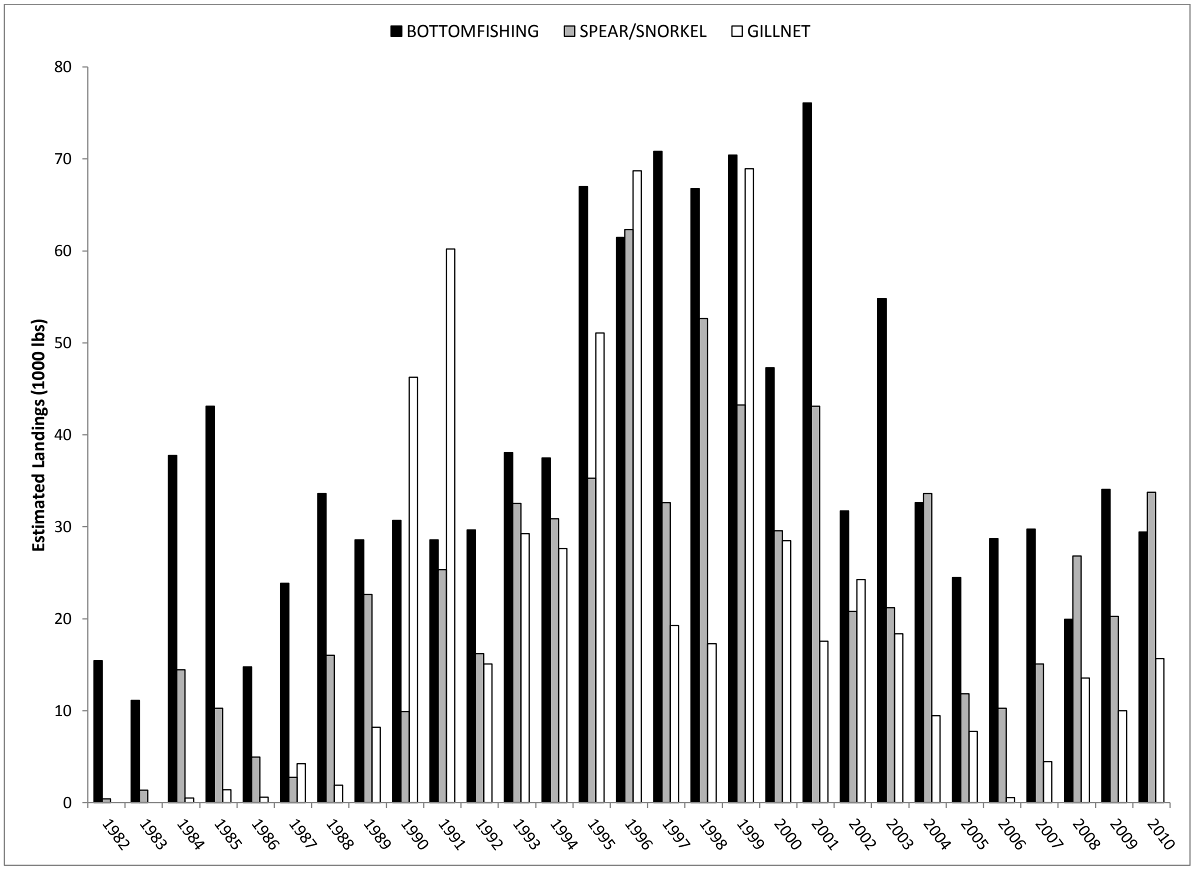

Figure 3.d.1: Annual estimated non-commercial landings of coral reef species by the top one to three methods in the Guam boat-based fishery

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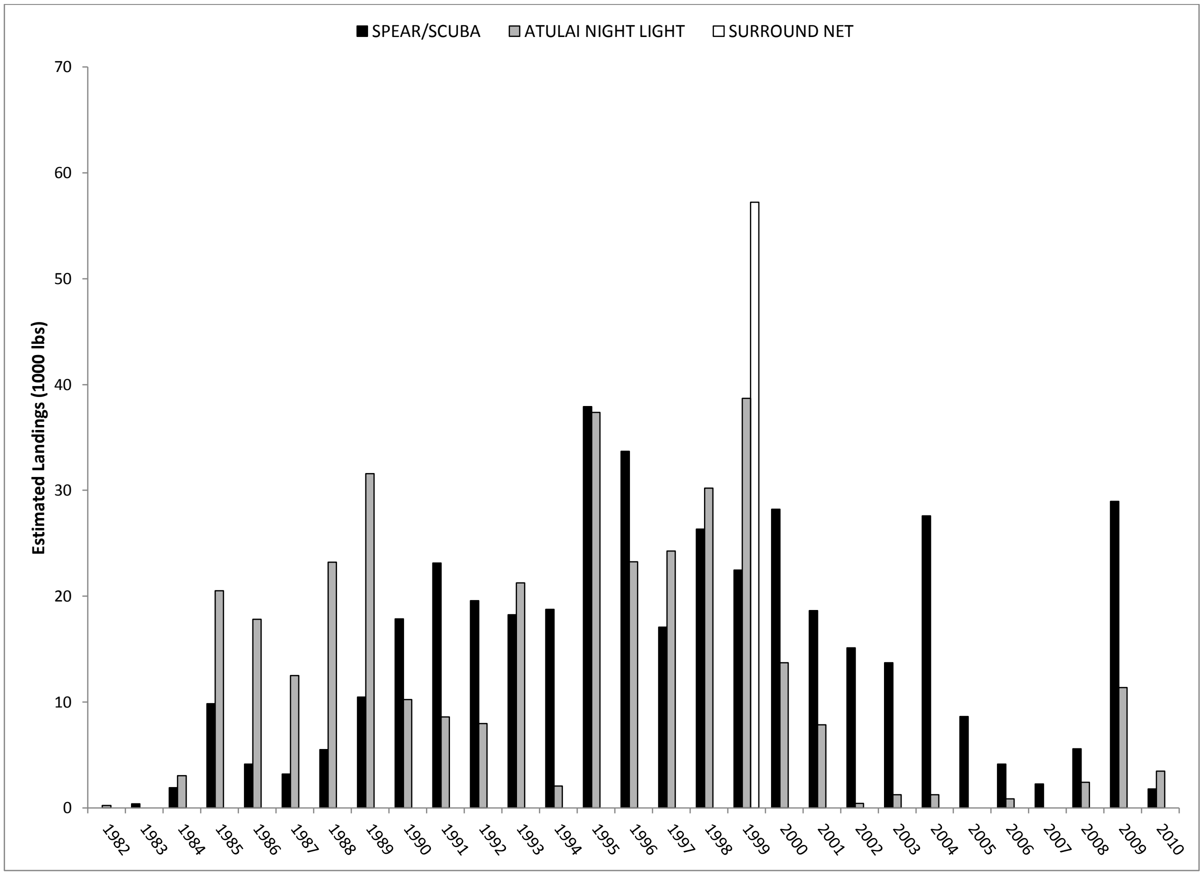

Figure 3.d.2: Annual estimated non-commercial landings of coral reef species by the top four to six methods in the Guam boat-based fishery

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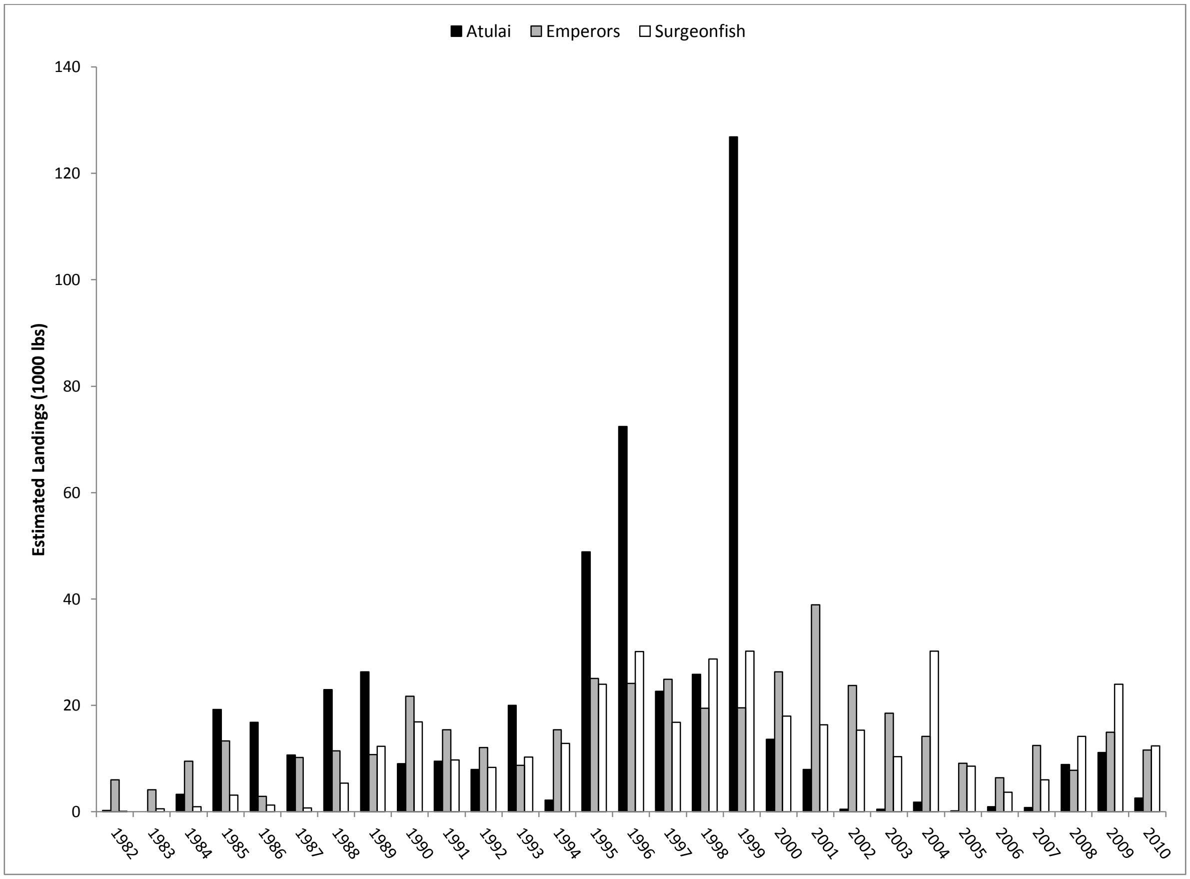

Figure 3.d.3: Annual estimated non-commercial landings of the top one to three coral reef species groups in the Guam boat-based fishery

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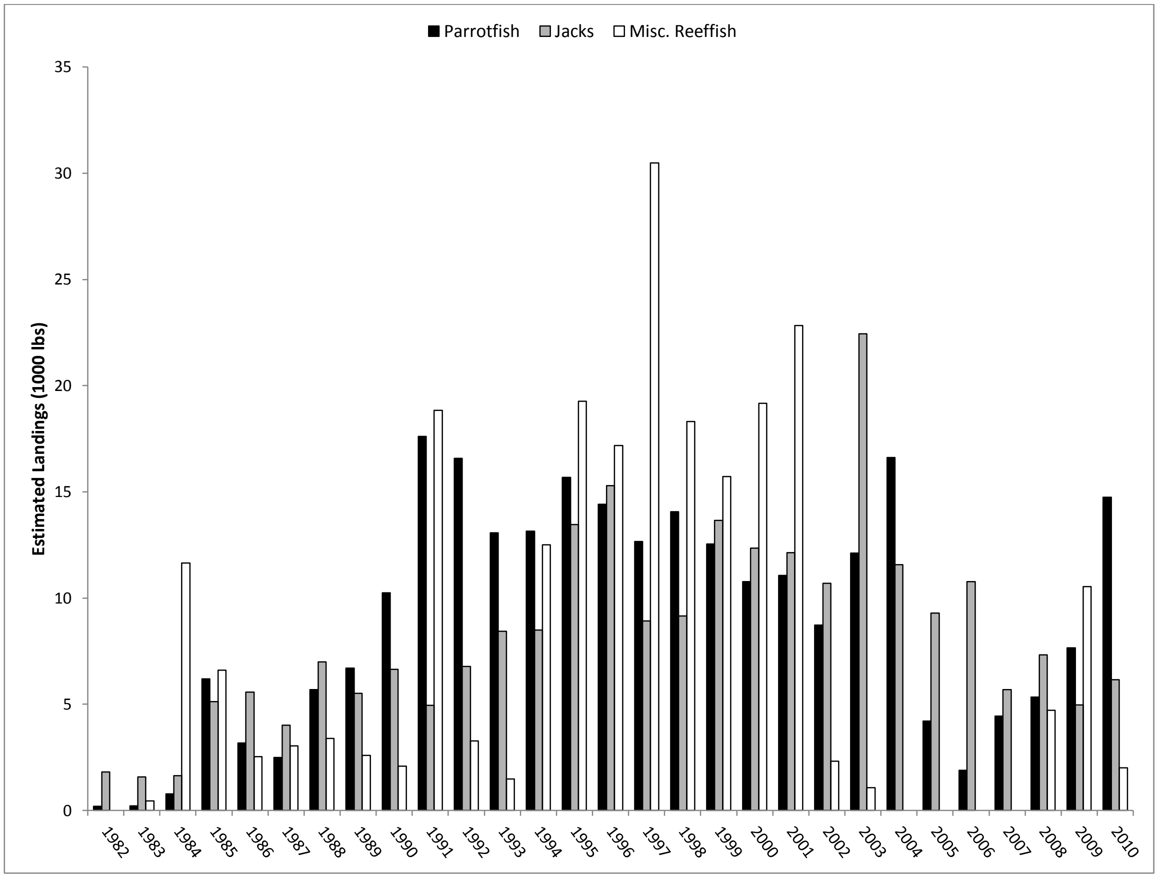

Figure 3.d.4: Annual estimated non-commercial landings of the top four to six coral reef species groups in the Guam boat-based fishery

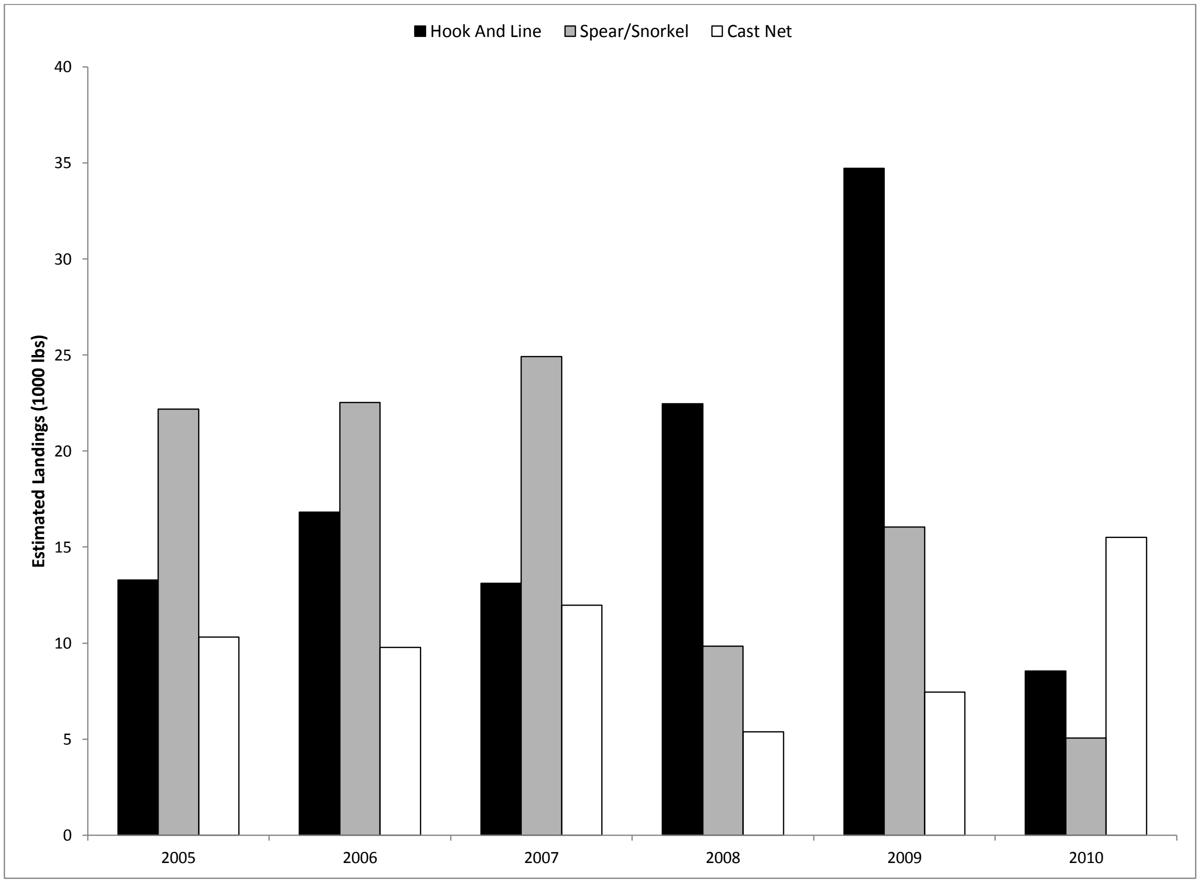

Figure 3.e.1: Annual estimated non-commercial landings of coral reef species by the top one to three methods in the CNMI shore-based fishery

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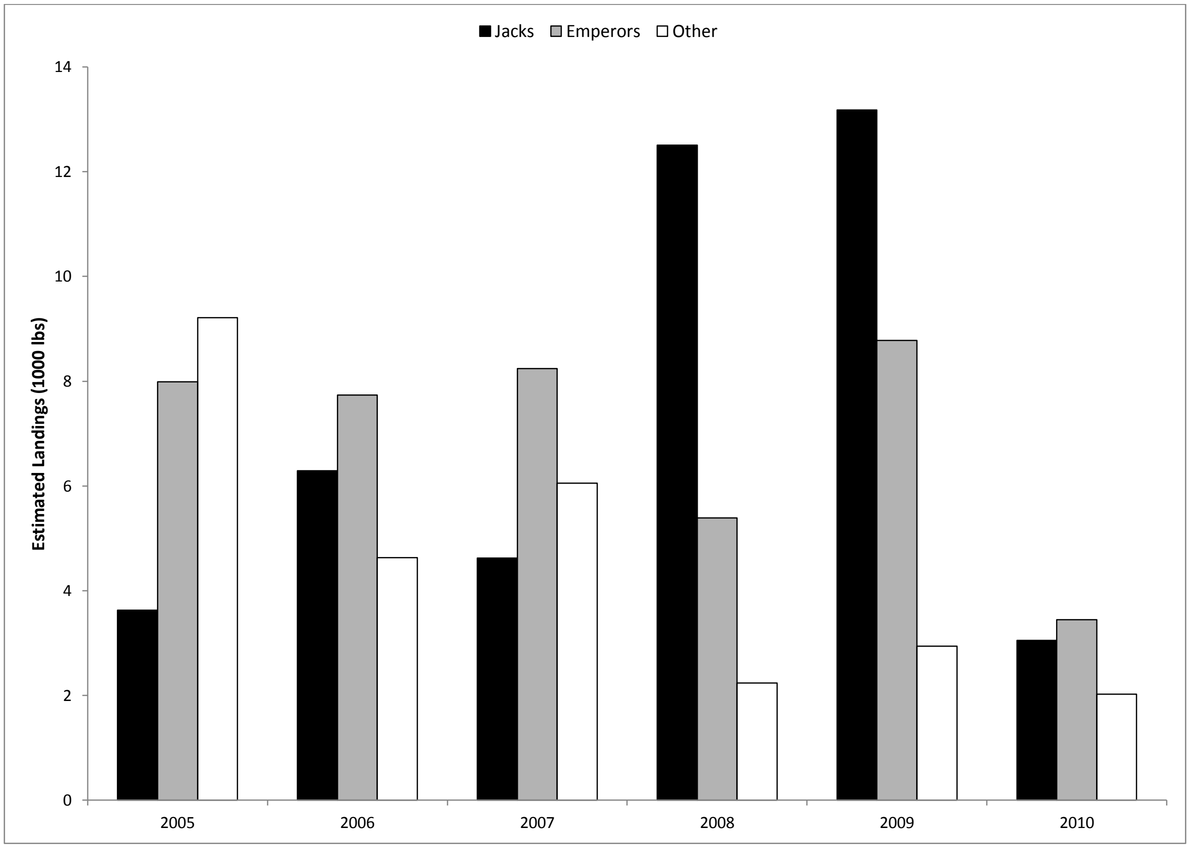

Figure 3.e.2: Annual estimated non-commercial landings of the top one to three coral reef species groups in the CNMI shore-based fishery

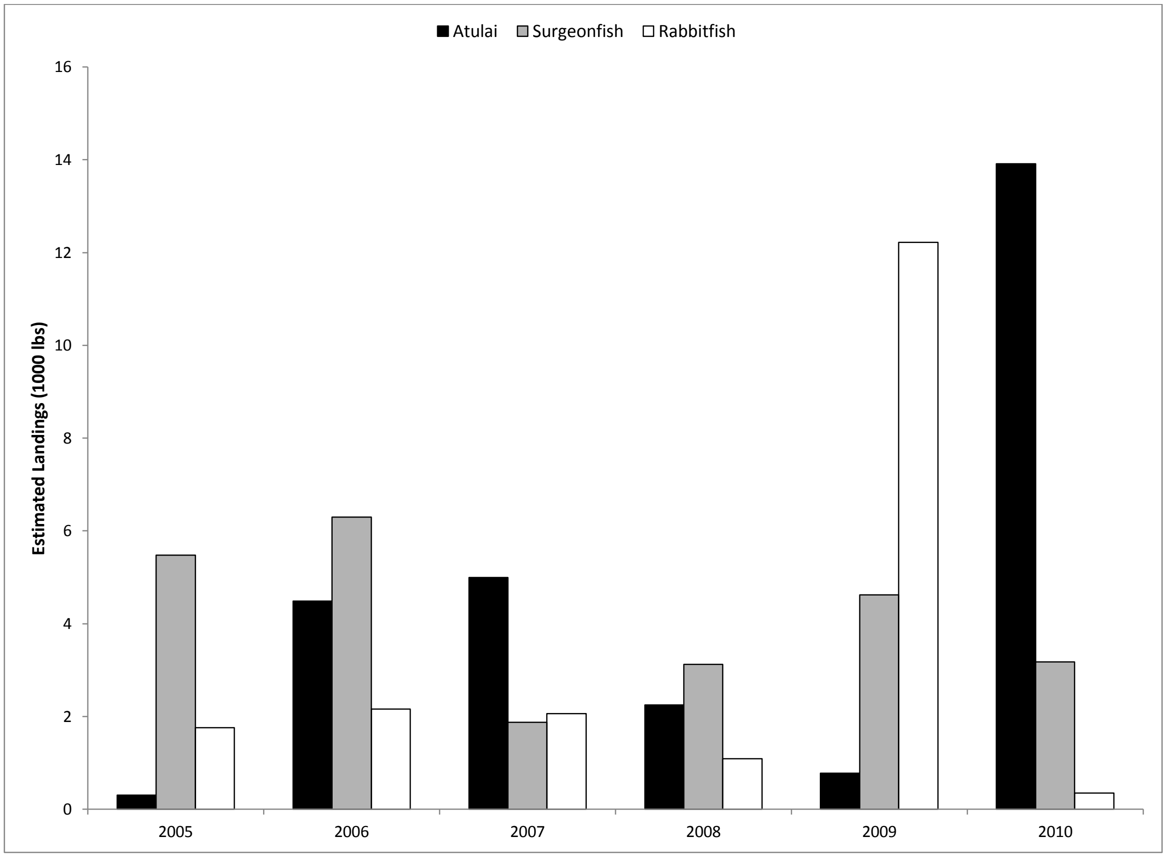

Figure 3.e.3: Annual estimated non-commercial landings of the top four to six coral reef species groups in the CNMI shore-based fishery. Akule were overestimated in 2010; refer to text.

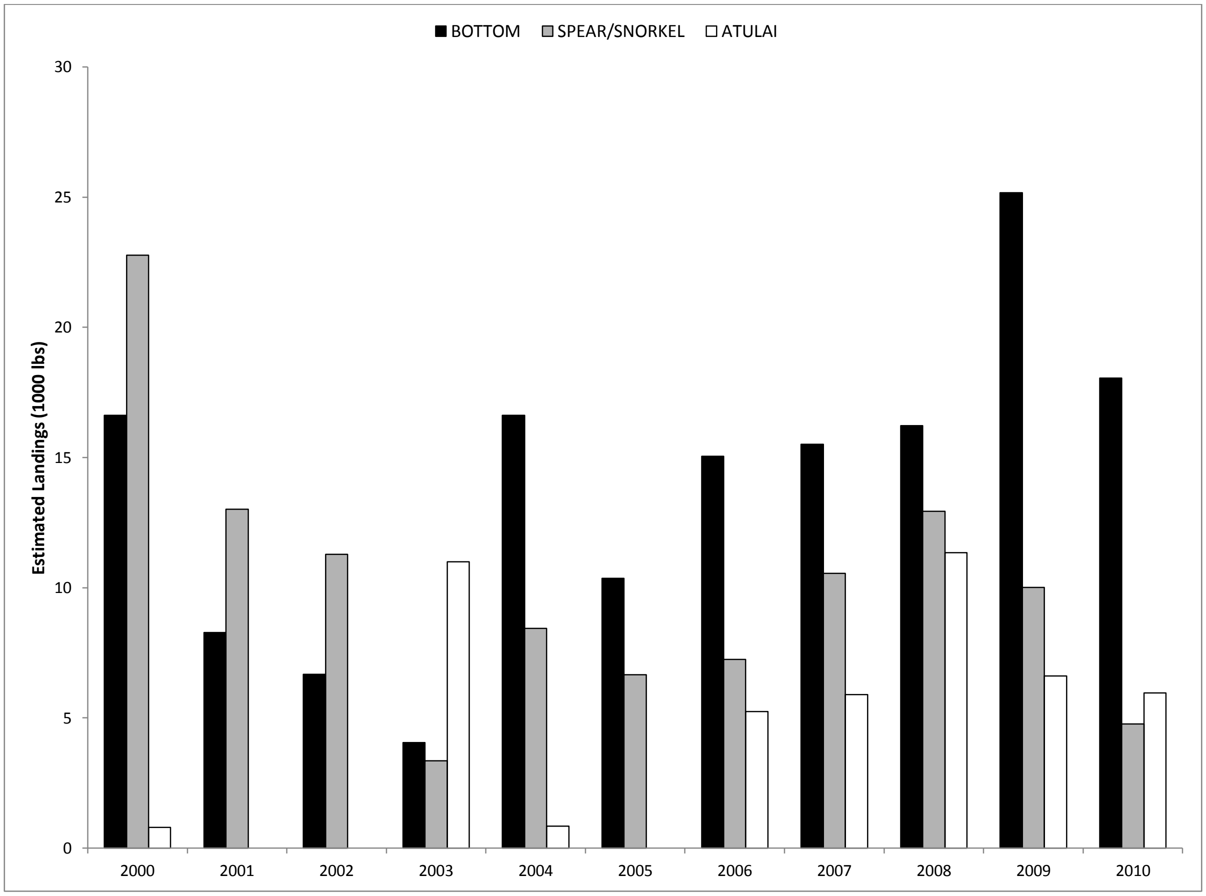

Figure 3.f.1: Annual estimated non-commercial landings of coral reef species by the top one to three methods in the CNMI boat-based fishery

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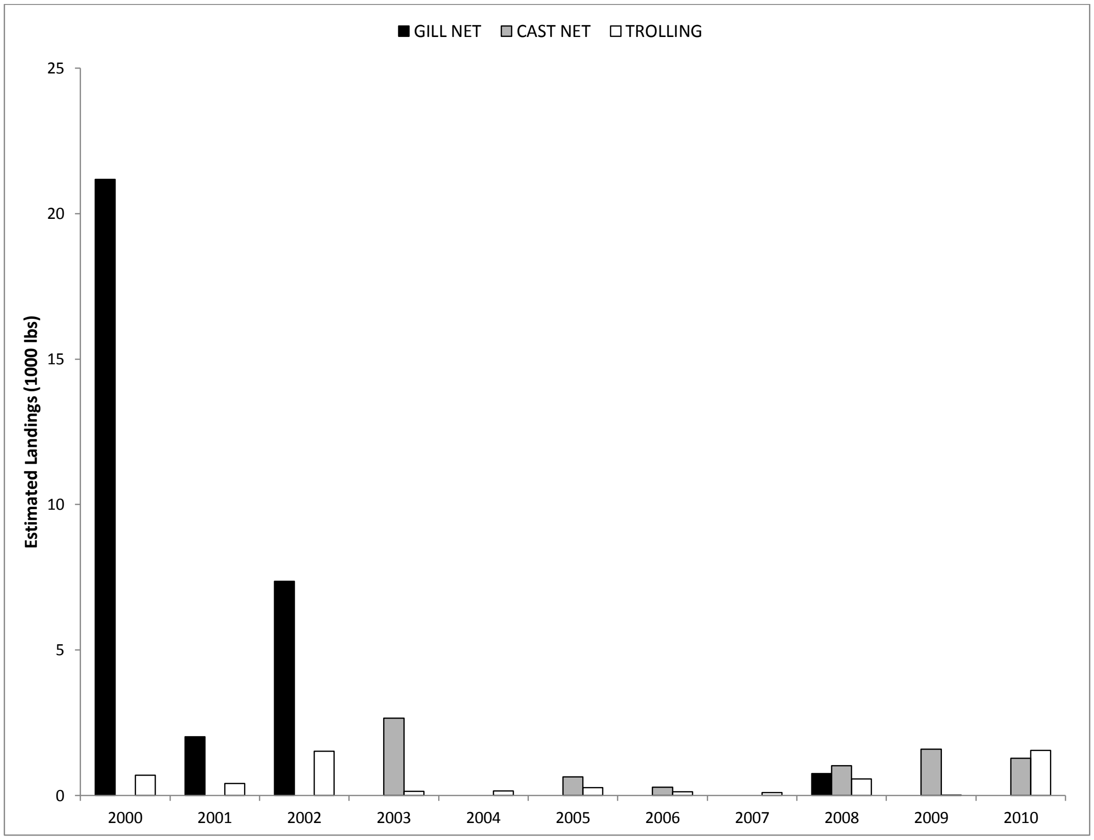

Figure 3.f.2: Annual estimated non-commercial landings of coral reef species by the top four to six methods in the CNMI boat-based fishery

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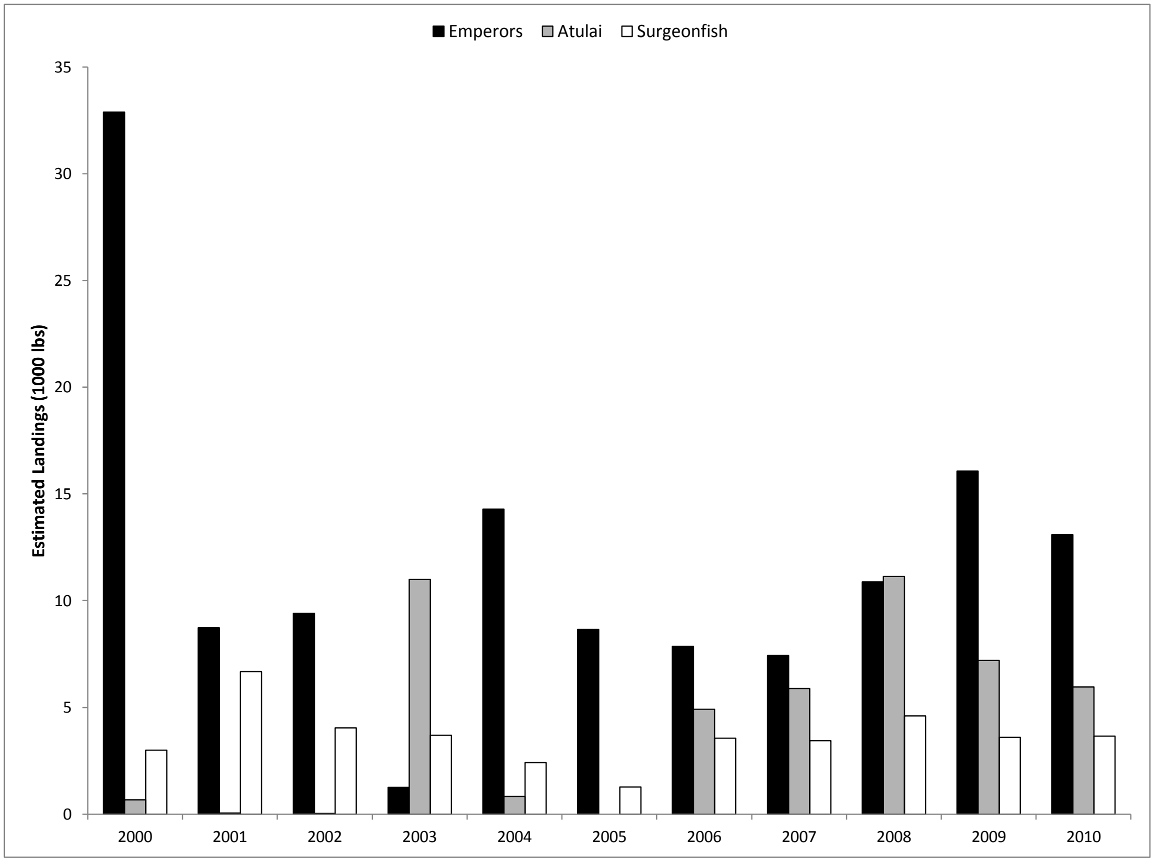

Figure 3.f.3: Annual estimated non-commercial landings of the top one to three coral reef species groups in the CNMI shore-based fishery

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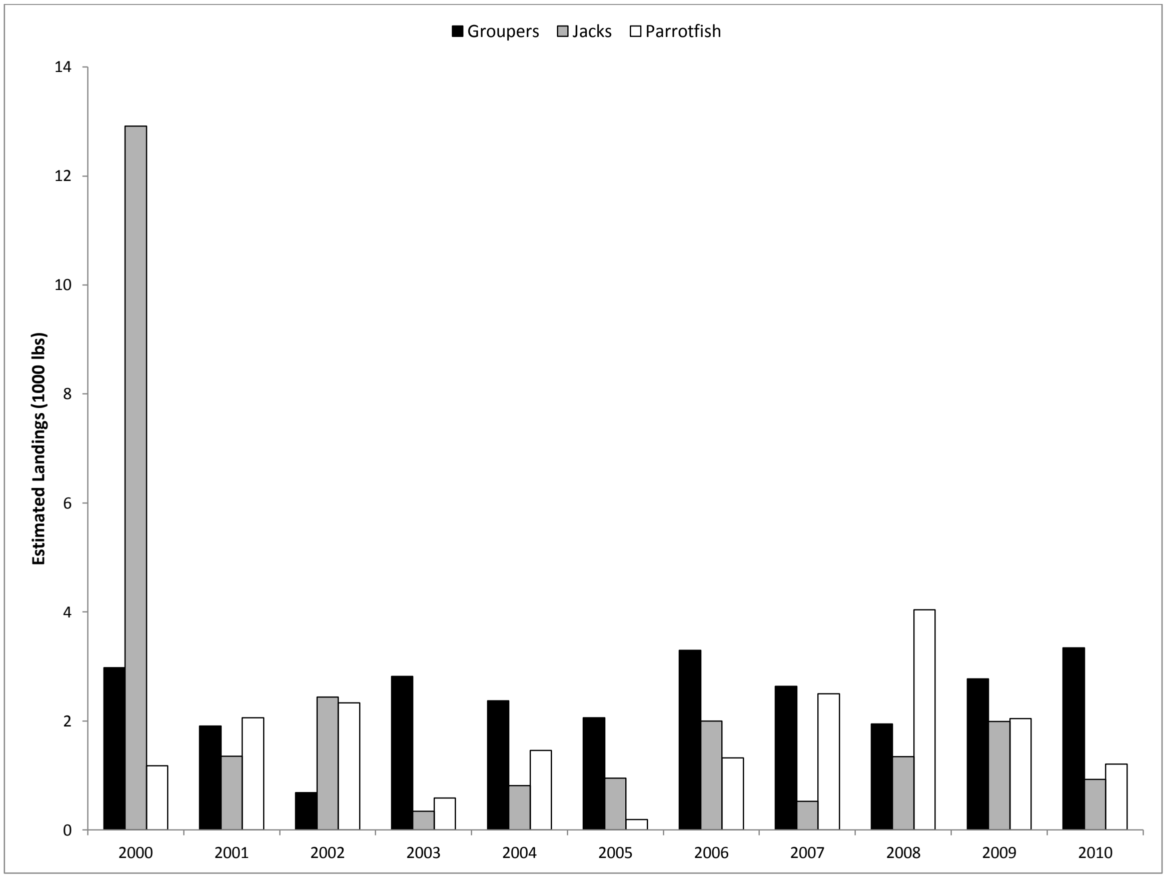

Figure 3.f.4: Annual estimated non-commercial landings of the top four to six coral reef species groups in the CNMI shore-based fishery

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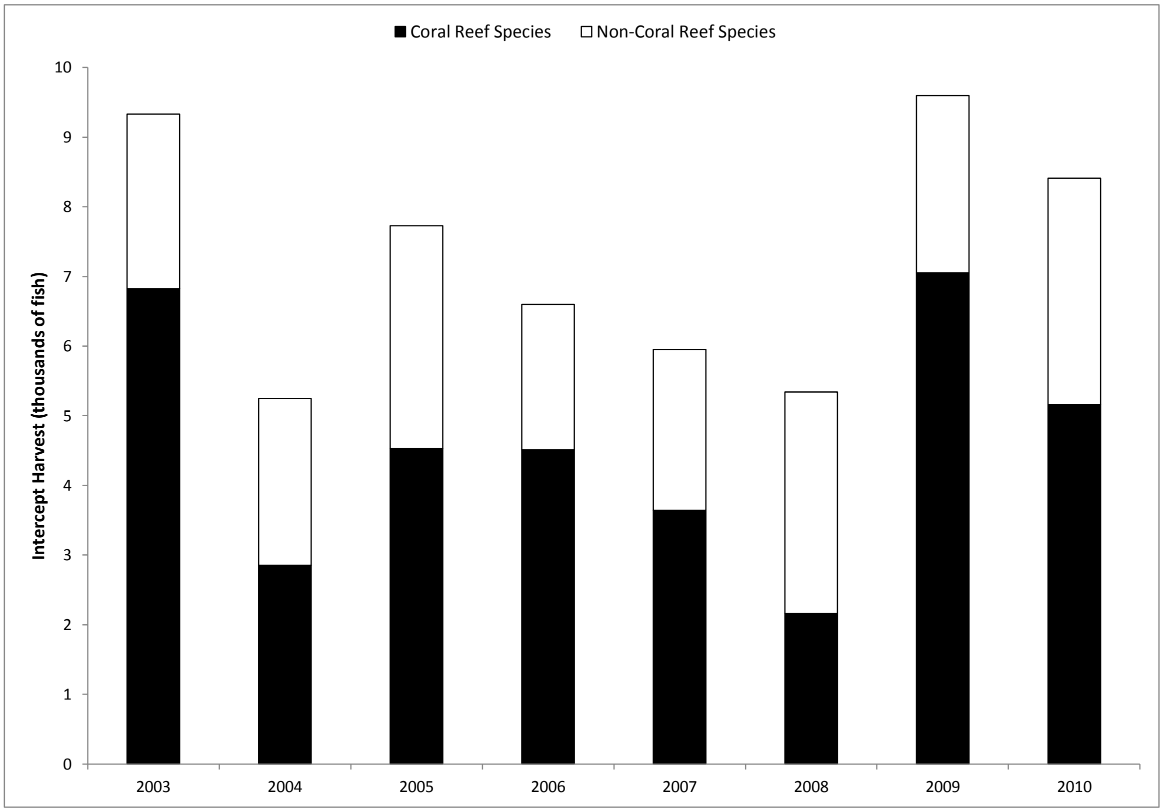

Figure 3.g.1: Annual Hawai'i intercept harvest (number of fish) of all species in the non-commercial fishery.

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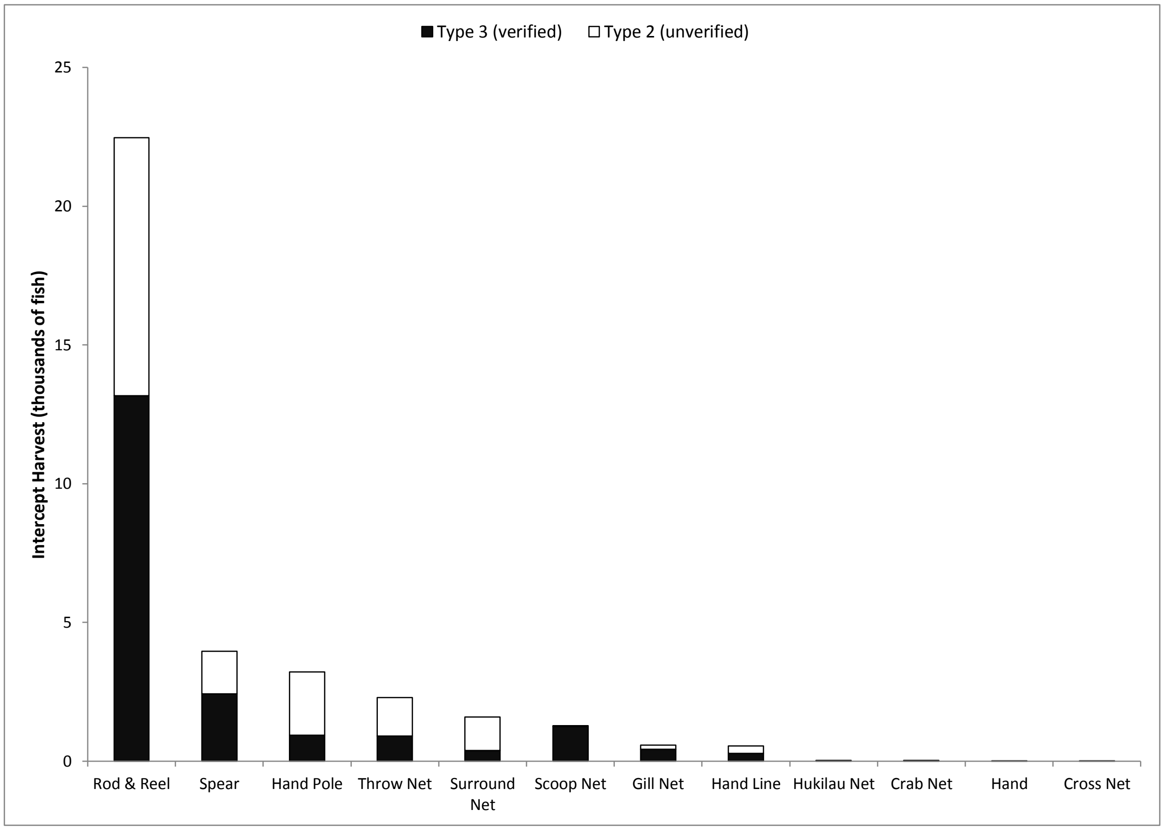

Figure 3.g.2: Overall Hawaiʻi intercept harvest (number of fish) of all coral reef species by gear type in the non-commercial fishery from 2003-2010.

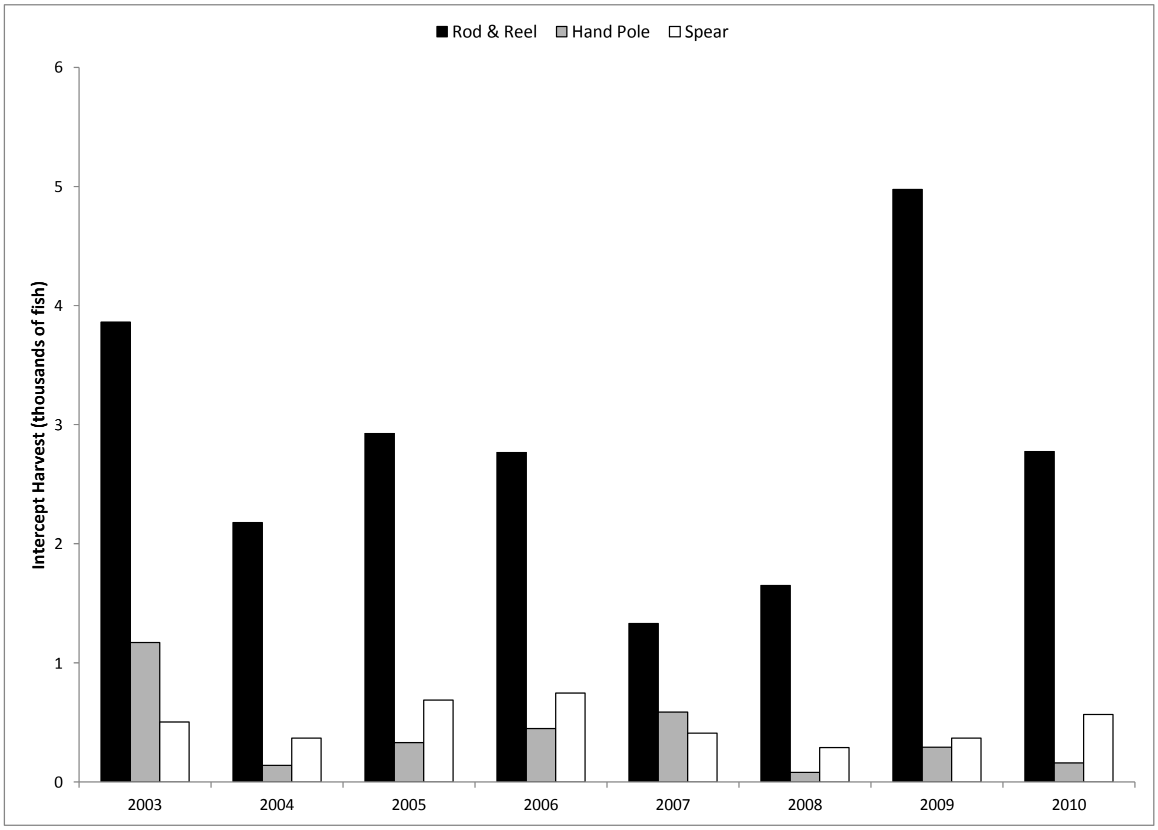

Figure 3.g.3. Annual Hawai'i intercept harvest (number of fish) of all coral reef species in the top three gear types in the non-commercial fishery from 2003-2010.

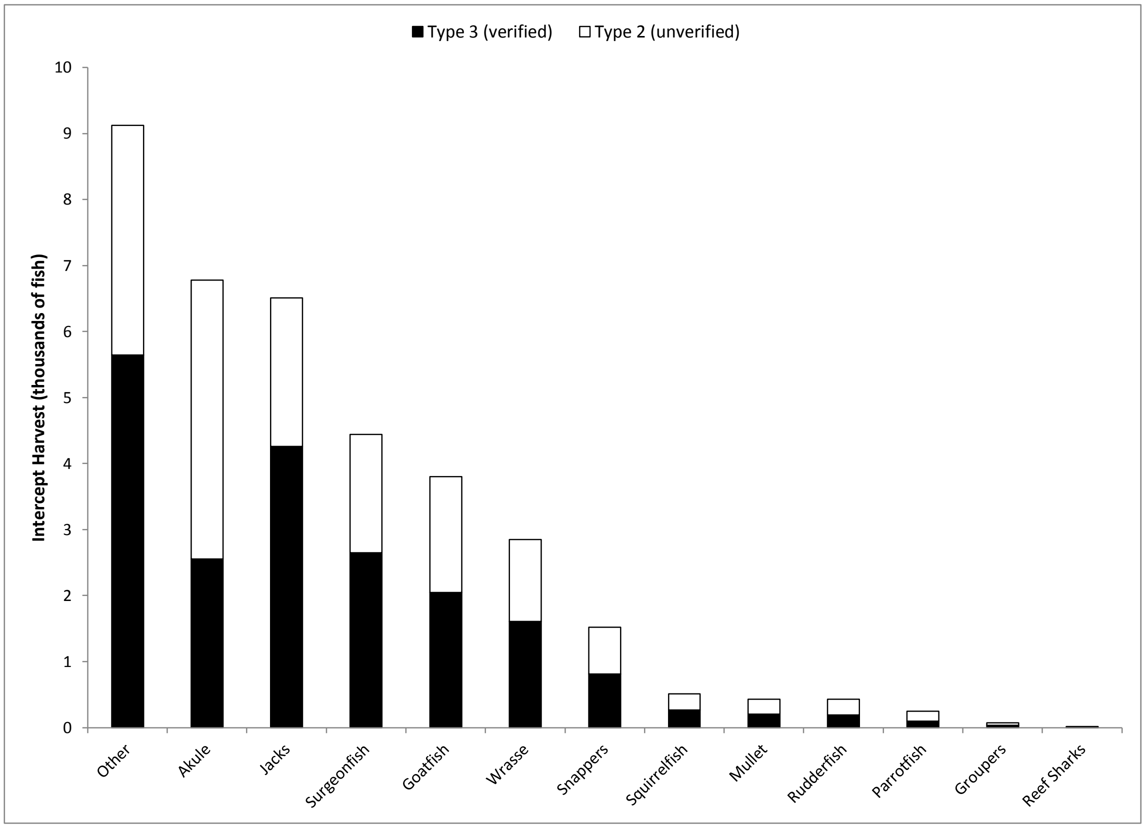

Figure 3.g.4: Overall Hawai'i intercept harvest (number of fish) of all coral reef species groups in the non-commercial fishery from 2003-2010.

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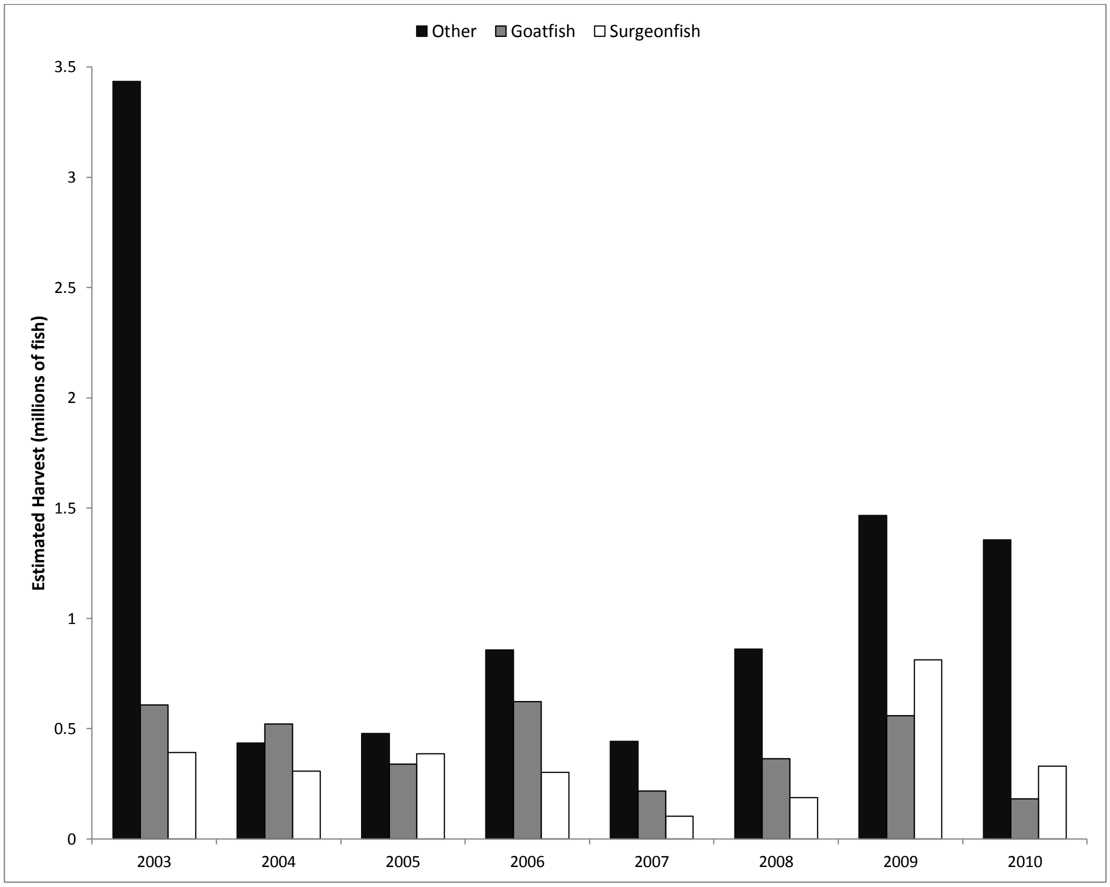

Figure 3.h.1: Shore-based top one to three coral reef species groups in the Hawaiʻi estimated non-commercial harvest (number of fish).

"Non-commercial Coral Reef Fishery Assessments for the Western Pacific Region", page 175

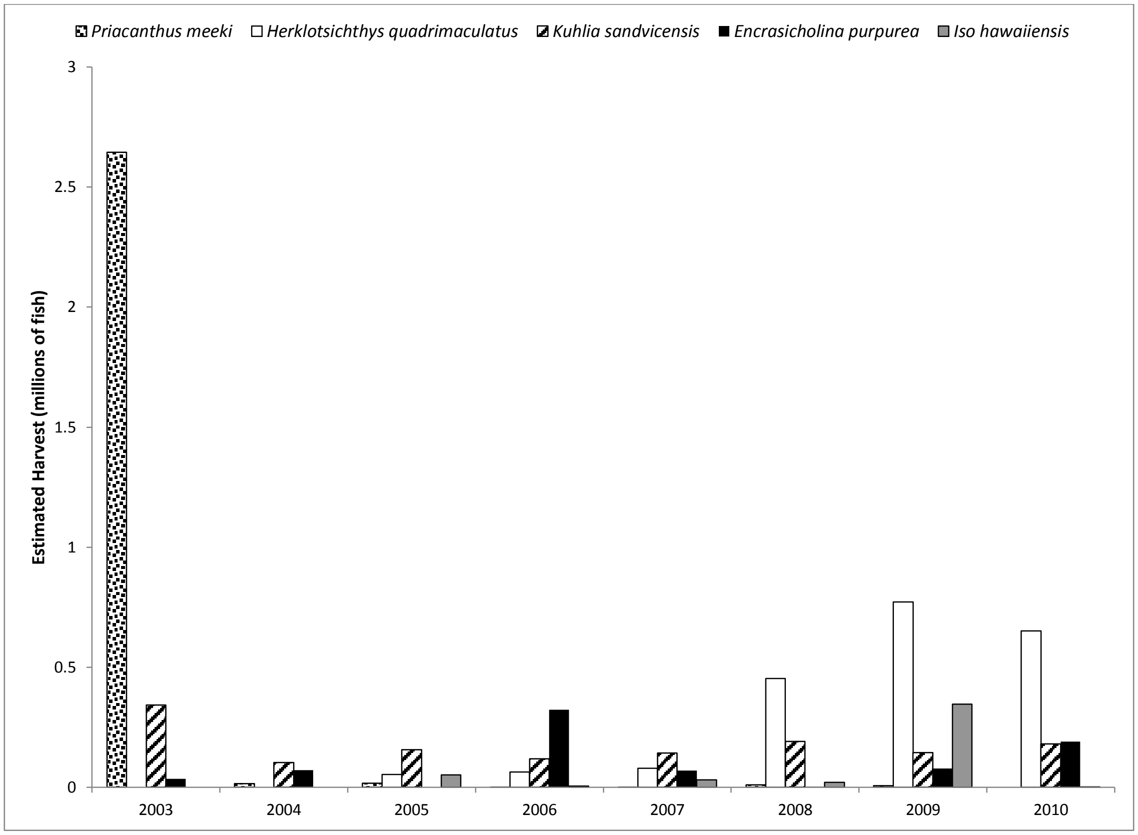

Figure 3.h.2: Shore-based top one to five "other" coral reef species in the Hawai'i estimated non-commercial harvest (number of fish).

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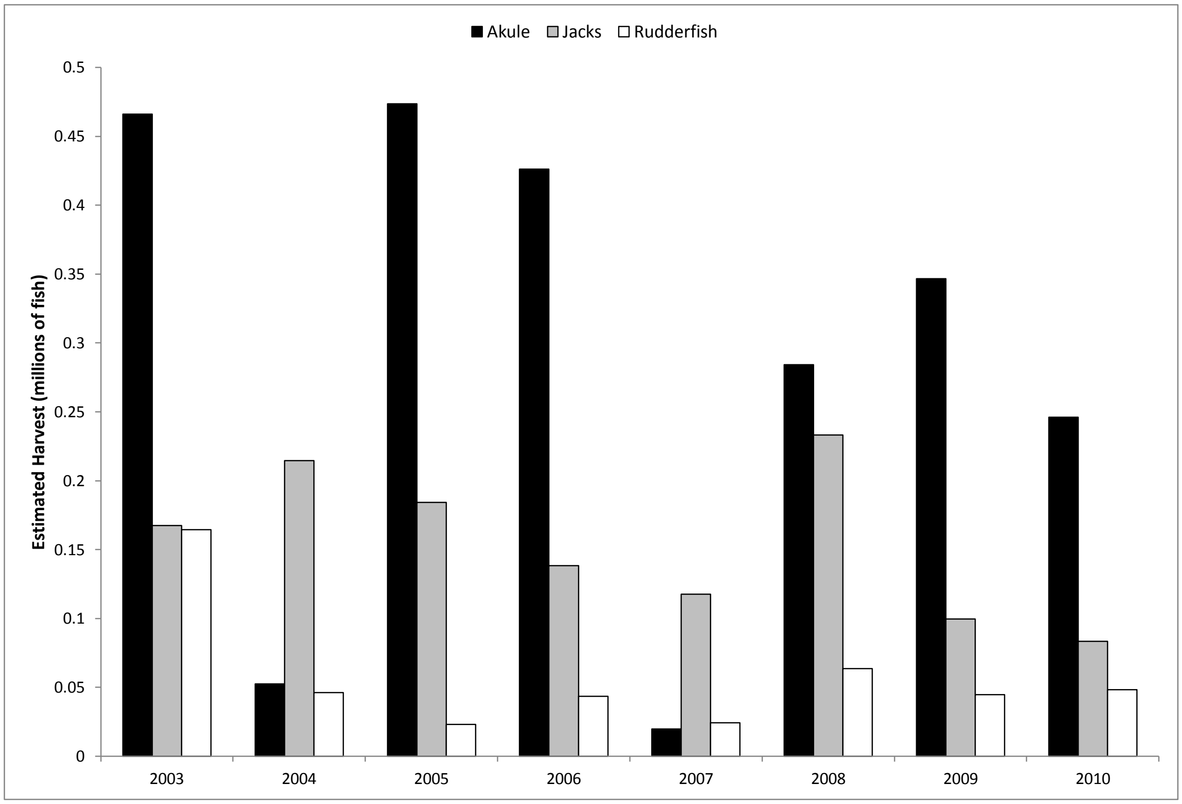

Figure 3.h.3: Shore-based top four to six coral reef species groups in the Hawaiʻi estimated non-commercial harvest (number of fish).

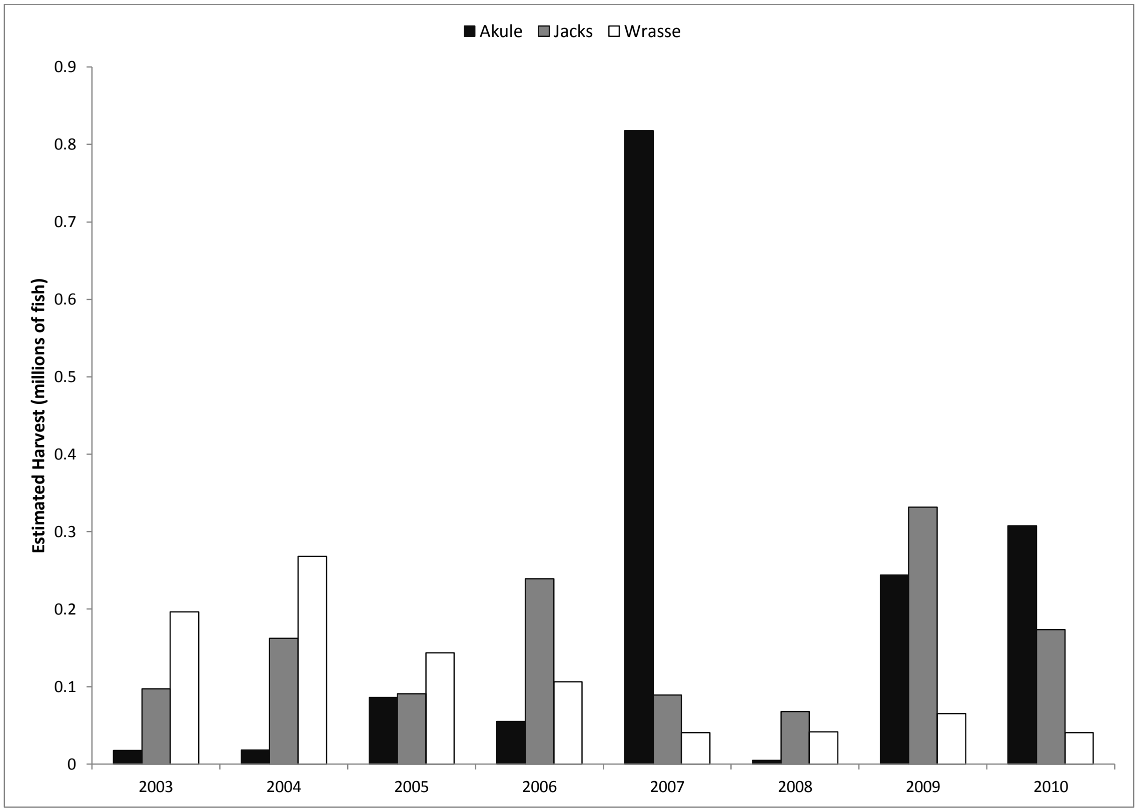

Figure 3.h.4: Boat-based top one to three coral reef species groups in the Hawai'i estimated non-commercial harvest (number of fish).

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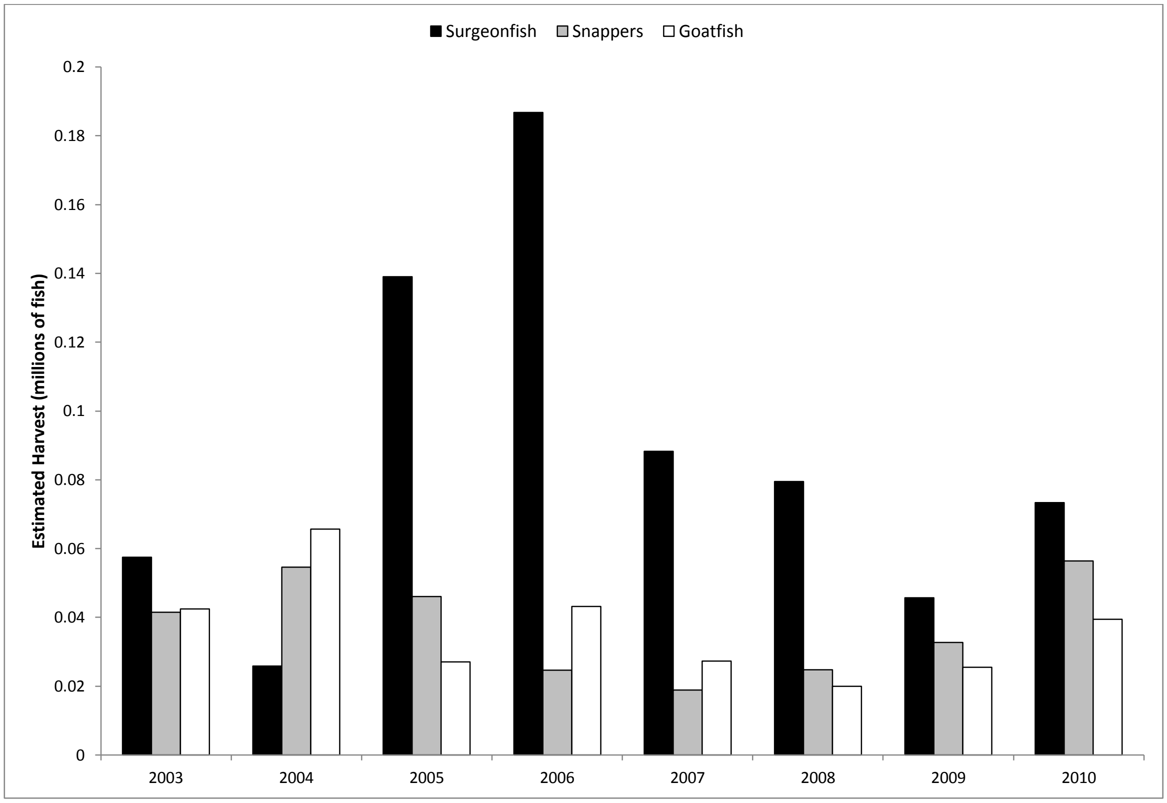

Figure 3.h.5: Boat-based top four to six coral reef species groups in the Hawaiʻi estimated non-commercial harvest (number of fish).

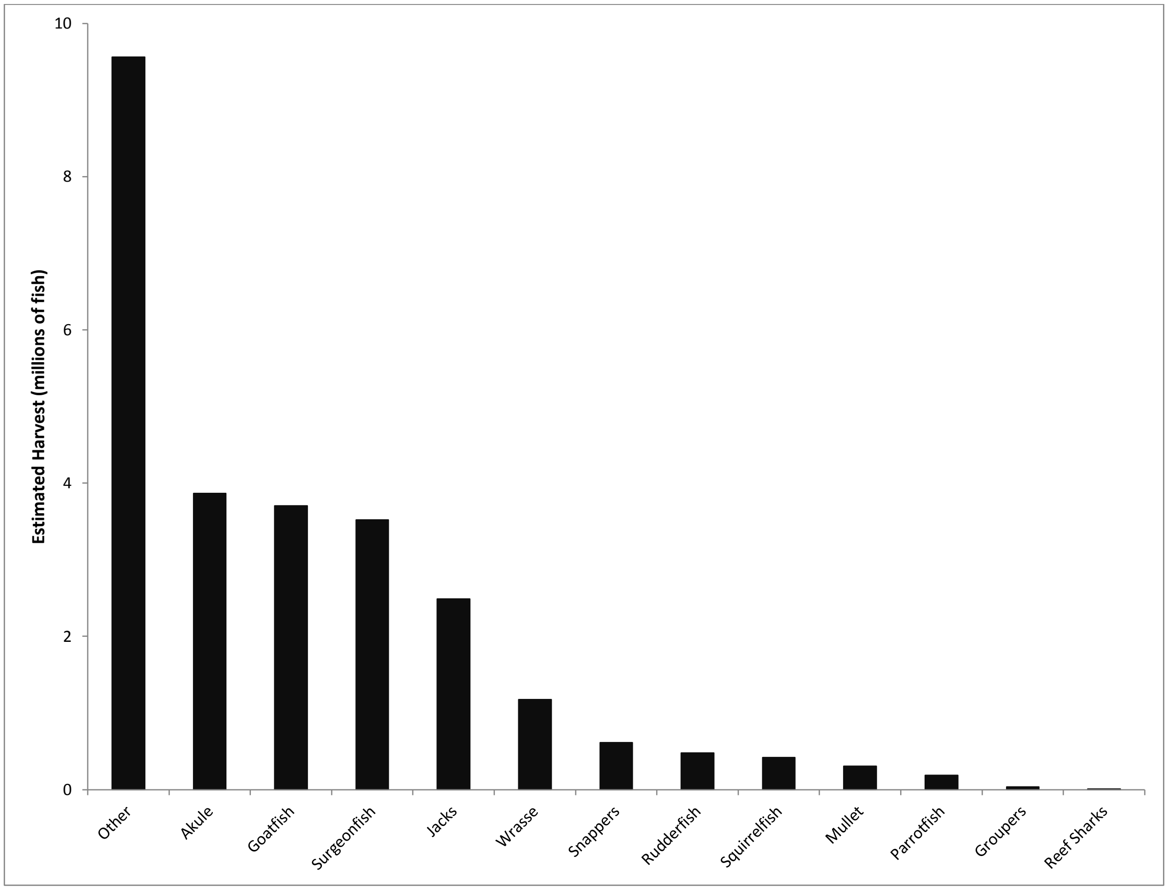

Figure 3.h.6: Overall Hawai'i estimated harvest (number of fish) of all coral reef species groups in the non-commercial fishery from 2003-2010.

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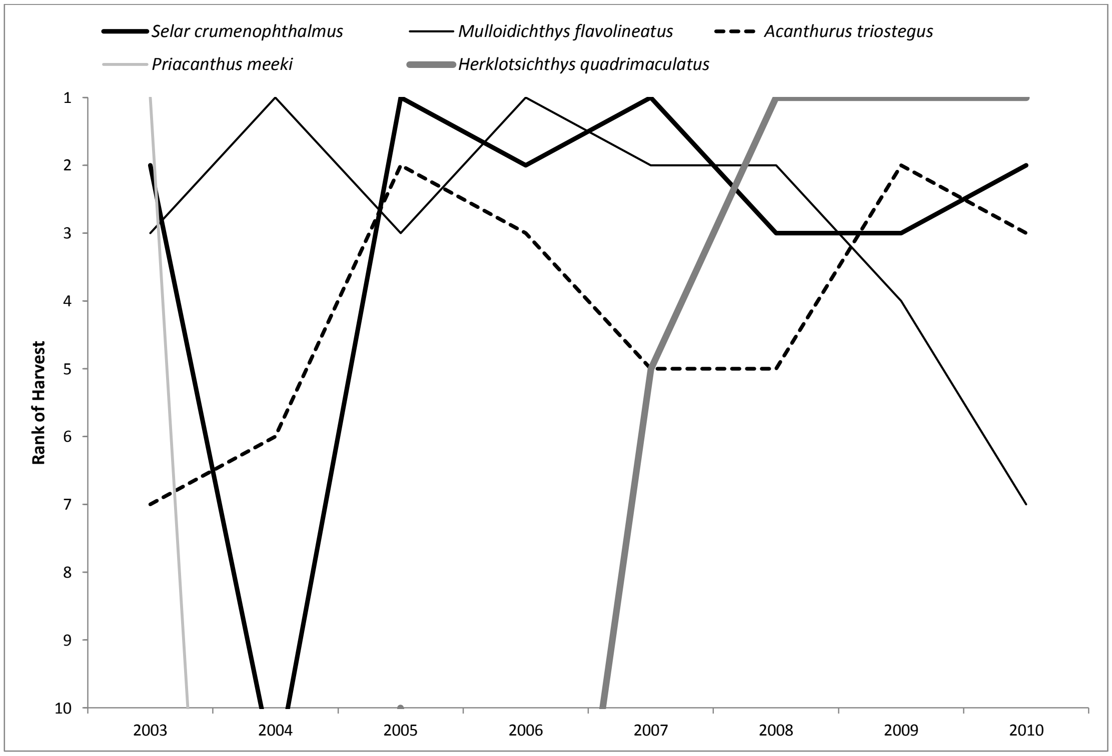

Figure 3.h.7: Rank of top five overall harvested species by year, determined by estimated numbers of fish harvested, in the Hawai'i non-commercial fishery

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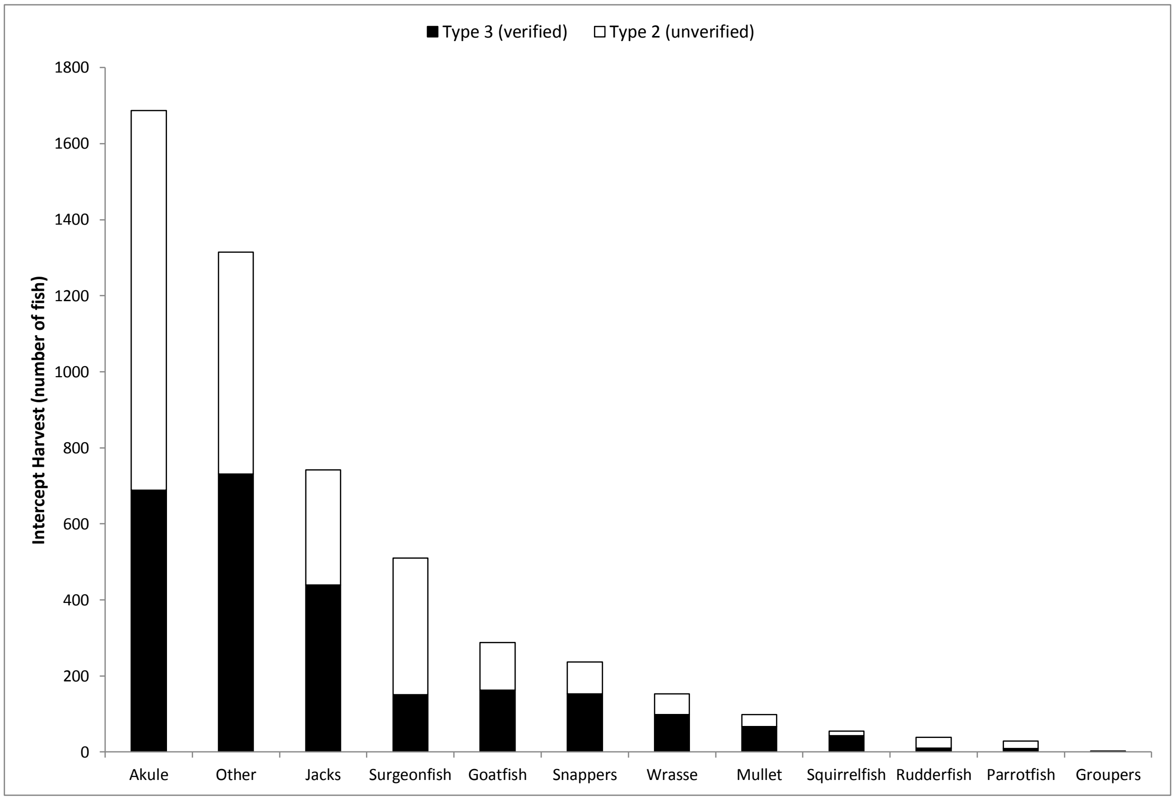

Figure 3.i.1: 2010 intercept harvest (number of fish) of all coral reef species groups in the Hawai'i non-commercial fishery.

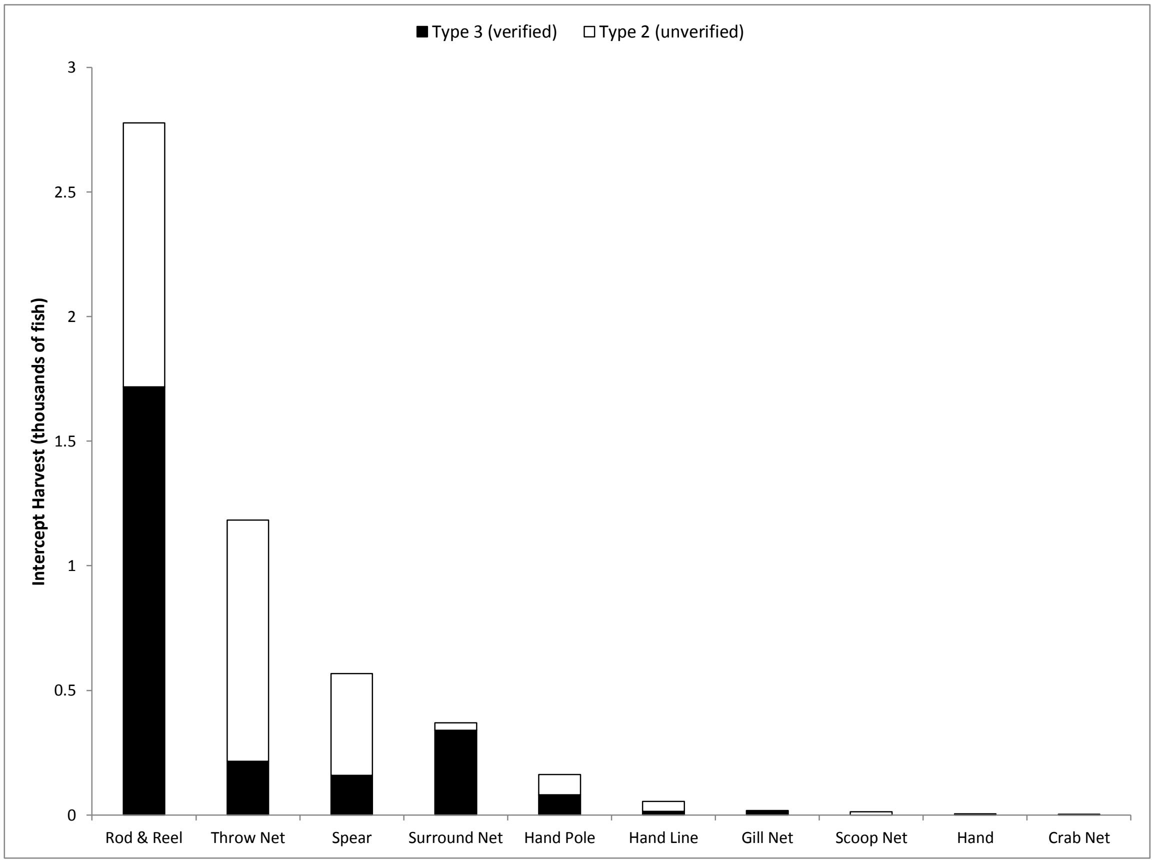

Figure 3.i.2: 2010 intercept harvest (number of fish) of all coral reef species by gear type in the Hawaiʻi non-commercial fishery.

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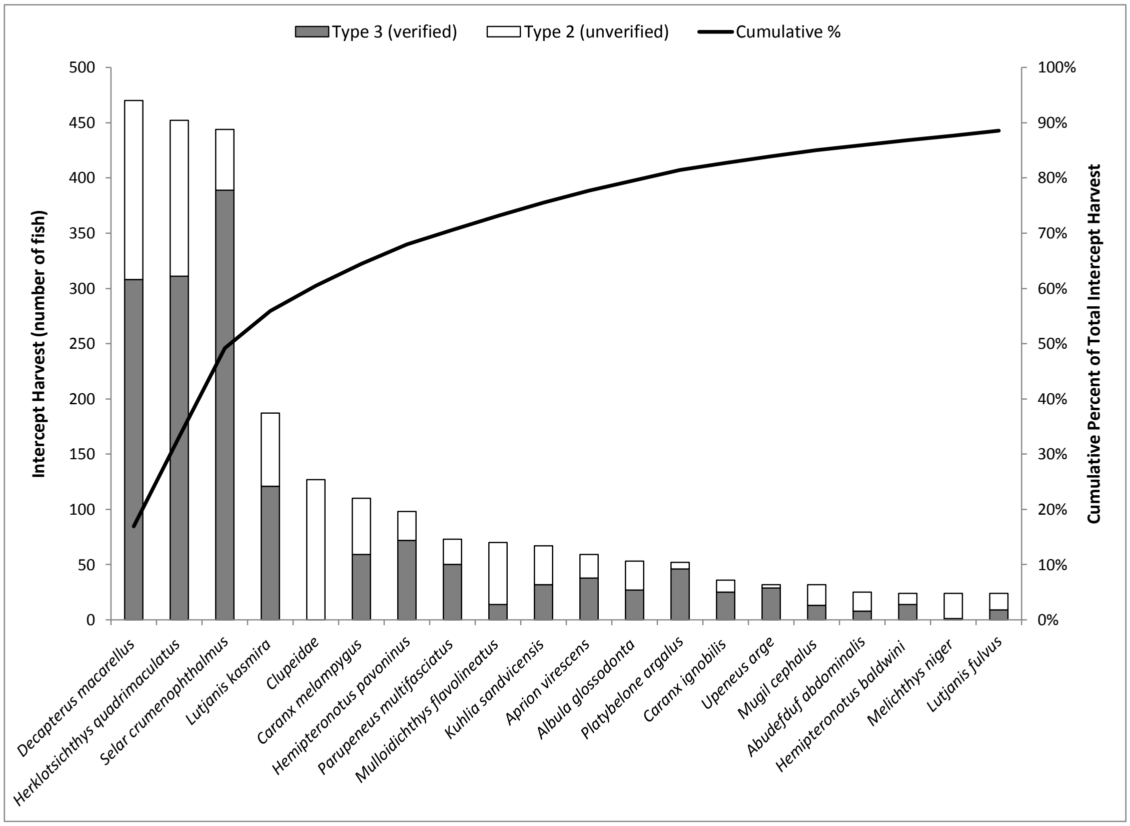

Figure 3.i.3: 2010 rod and reel intercept harvest (number of fish) of the top 20 coral reef taxa in the Hawai'i non-commercial fishery.

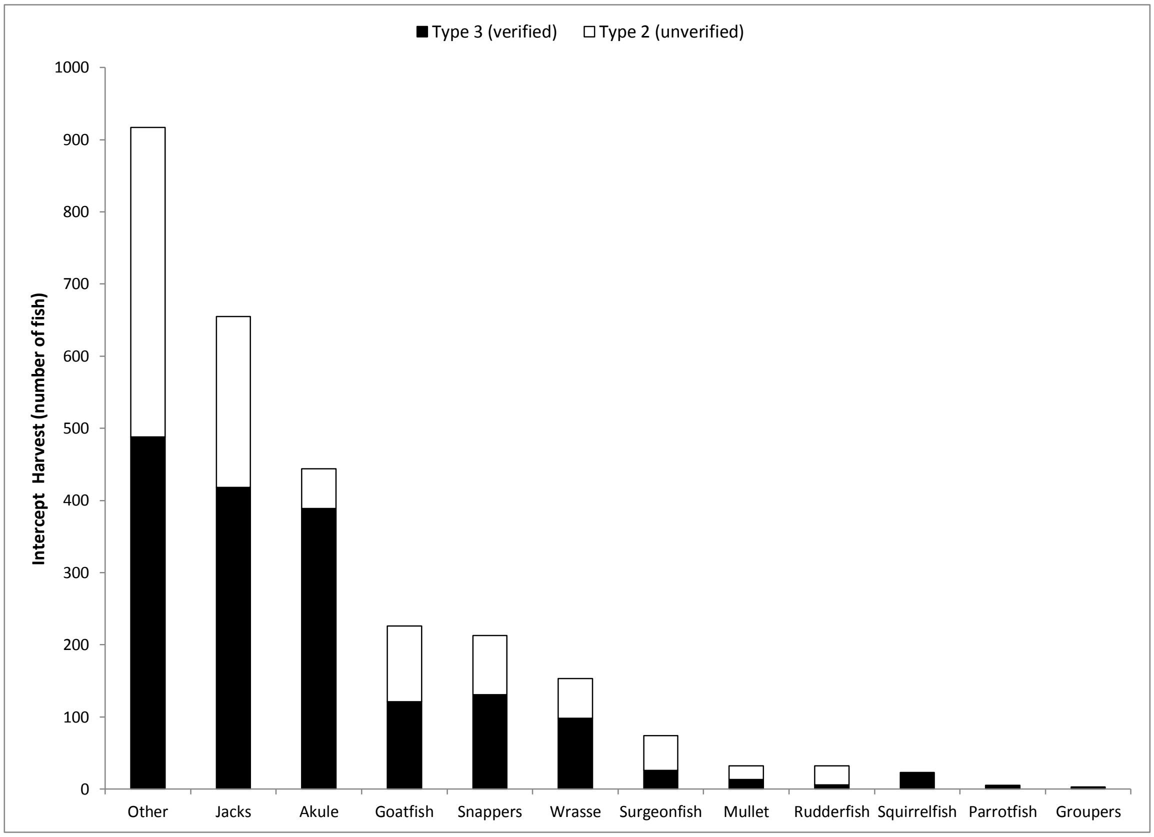

Figure 3.i.4: 2010 rod and reel intercept harvest (number of fish) of all coral reef species groups in the Hawai'i non-commercial fishery.

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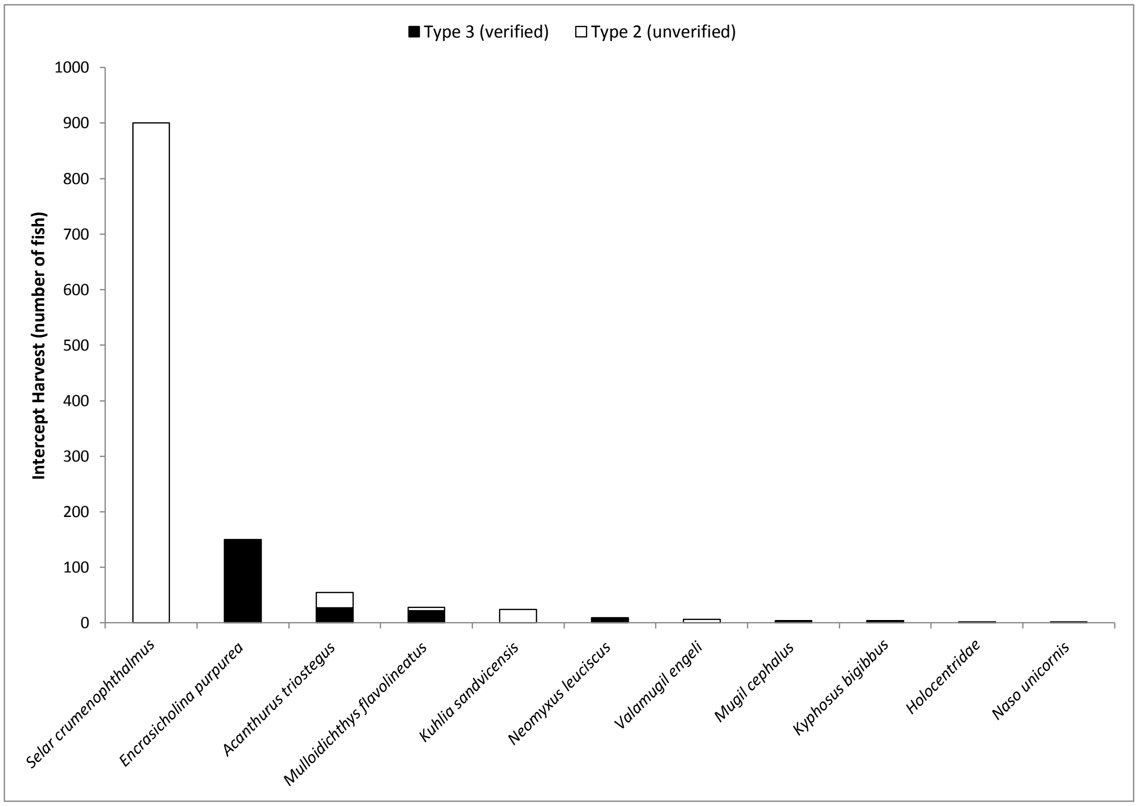

Figure 3.i.5: 2010 throw net intercept harvest (number of fish) of all coral reef species in the Hawai'i non-commercial fishery.

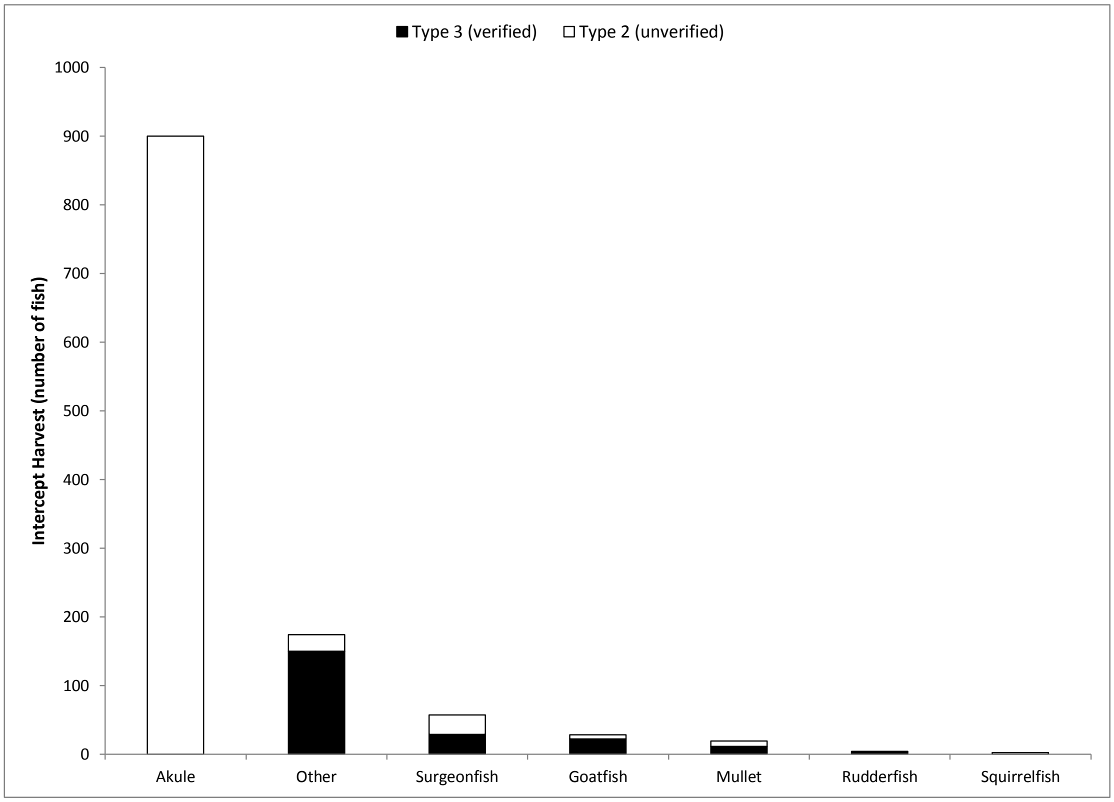

Figure 3.i.6: 2010 throw net intercept harvest (number of fish) of all coral reef species groups in the Hawaiʻi non-commercial fishery.

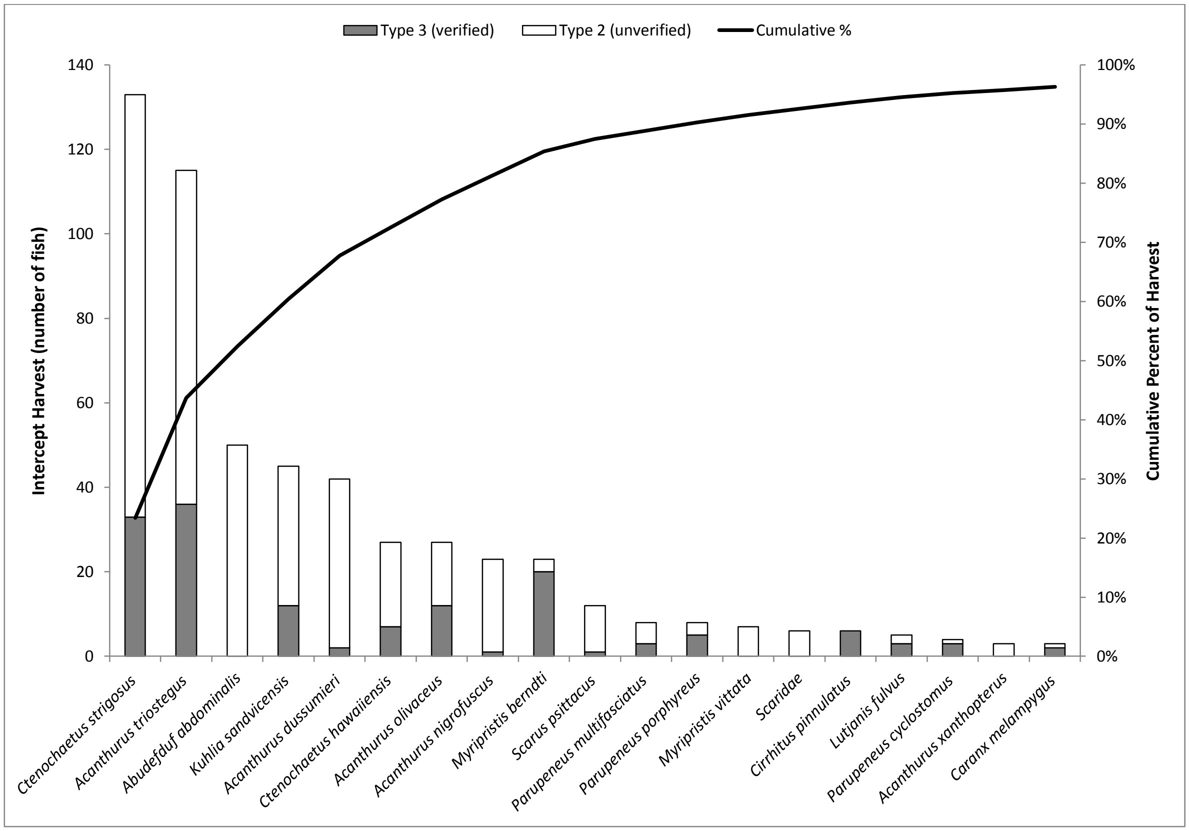

Figure 3.i.7: 2010 spear intercept harvest (number of fish) of the top 20 coral reef taxa in the Hawai'i non-commercial fishery.

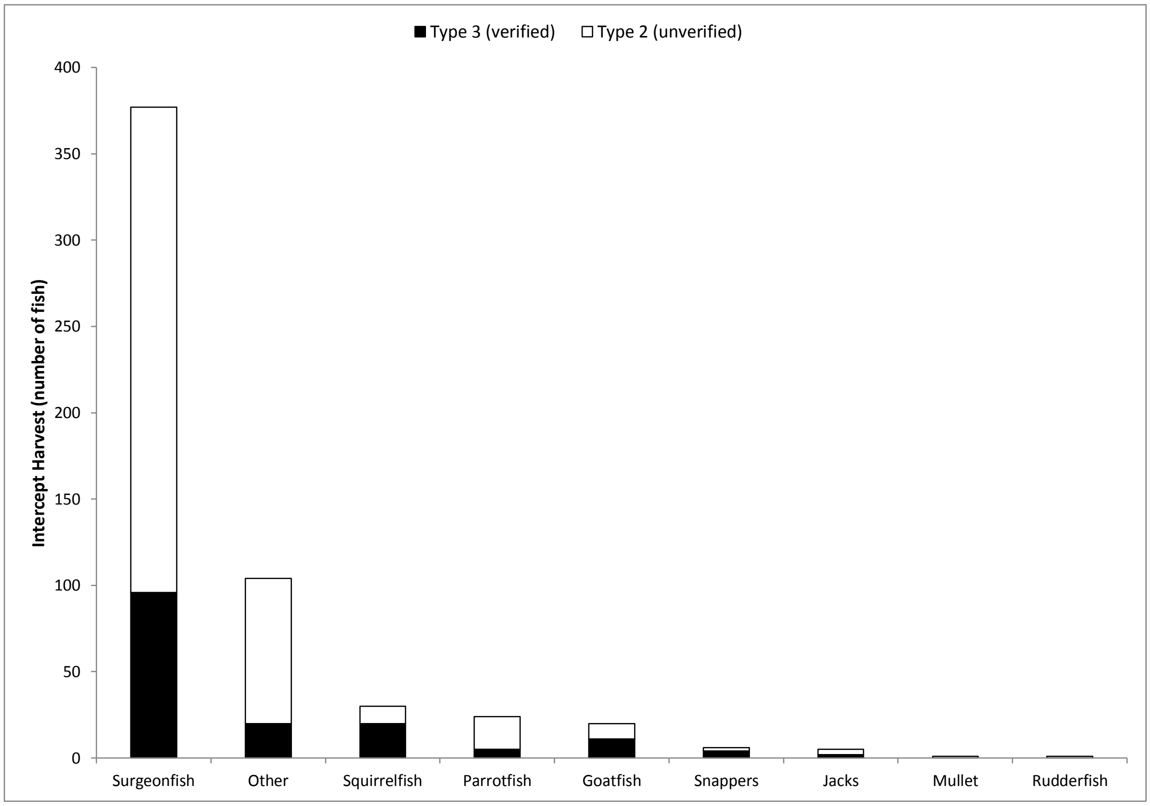

Figure 3.i.8: 2010 spear intercept harvest (number of fish) of all coral reef species groups in the Hawai'i non-commercial fishery.

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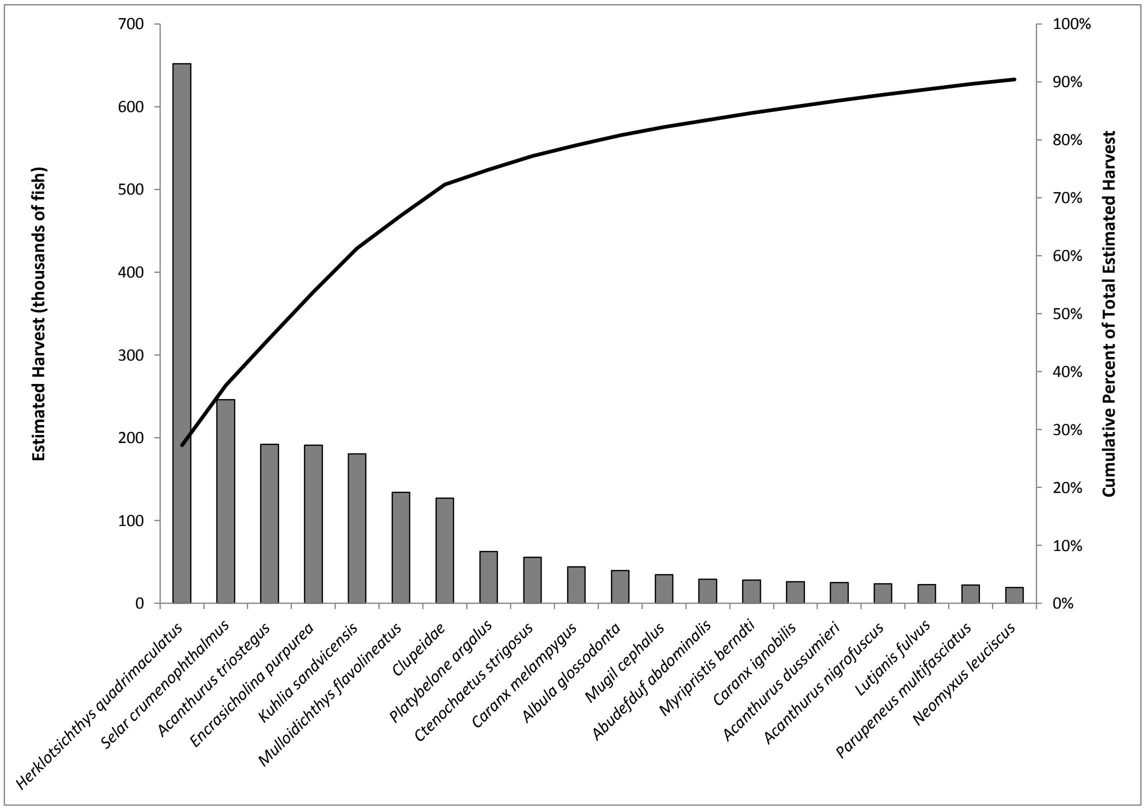

Figure 3.i.9: 2010 shore-based estimated harvest (number of fish) of the top 20 coral reef taxa in the Hawai'i non-commercial fishery.

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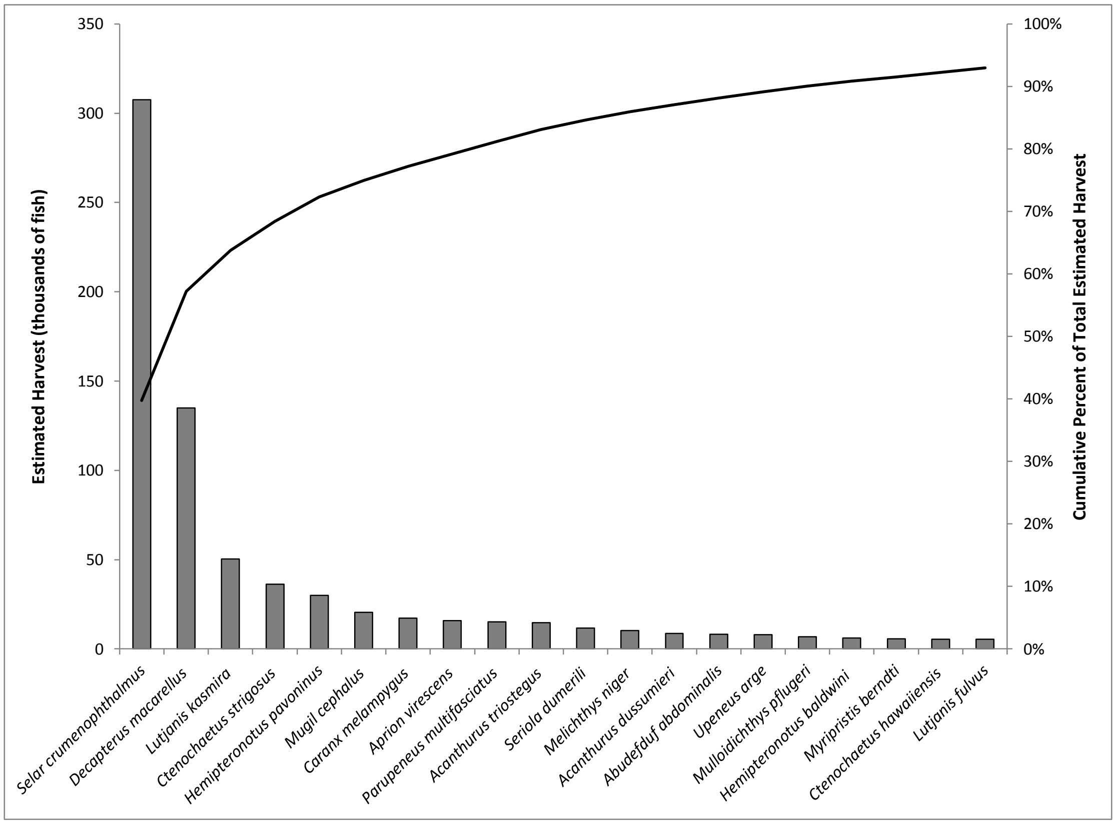

Figure 3.i.10: 2010 boat-based estimated harvest (number of fish) of the top 20 coral reef species in the Hawaiʻi non-commercial fishery.

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Table 4: Sums of expanded landings of coral reef species from species composition files and sums of estimated expanded landings of coral reef species from the non-commercial algorithm and associated percentage errors. The weight from the species composition file was used as the exact value in the percentage error calculation.

Creel Survey	Exact Coral Reef Landings (lbs)	Estimated Coral Reef Landings (lbs)	Percentage Error
CNMI Shore-Based	129,730	128,909	0.63%
Guam Shore-Based	282,026	278,895	1.11%
CNMI Boat-Based	320,135	251,850	21.33%
Guam Boat-Based	2,369,484	2,085,235	12.00%

Evaluation of Creel Survey Program in the Western Pacific Region (Guam, CNMI, and American Samoa)

A Report to the Western Pacific Regional Fishery Management Council

By

Sunny Bak

Info Design Hawaii

February 2012

Executive Summary

The fishery data collection programs in the Western Pacific region including Guam, Saipan and American Samoa were evaluated. The objective of the study was to identify issues of the existing data collection programs and how they relate to producing statistically valid estimates of total catch and effort for the implementation of Annual Catch Limit (ACL) requirements.

Three fishery data collection programs were evaluated as requested by the Western Pacific Regional Fishery Management Council, and they are the Commercial Purchase System, Tournament data collection program, and the Creel Survey Programs (boat-based, and shore-based). Due to its complexity and reliance from management the Creel Survey Program was the primary focus of this evaluation.

The creel survey was designed to collect fishery information by intercepting fishers or fishing trips from public access sites on survey days using available resources. The collected data are used to understand the trend of fisheries for monitoring purposes. In this report, evaluated areas of the Creel Survey Programs include sampling design, survey implementation and the estimation methods.

In short, the evaluation concludes that the currently implemented fishery data collection programs may not be adequate to provide statistically valid estimates for the ACL implementation

1) The survey design and strategy of the creel survey programs do not extend to all fishery sectors
2) The operational procedure and protocols of the creel survey programs are unclear, in practice, thus producing unknown errors in the data and estimates
3) The *Expansion Algorithm* uses unverified assumptions and imputation methods that introduce unknown level of uncertainty in the estimates.

Other survey methods and strategies are needed for the fishery sectors that the creel survey design does not adequately cover. While there are other existing data collection systems such as the Commercial Purchase System and Tournament data collection, they need significant improvement in their survey design, strategy, and implementation efforts. Data collected from the Commercial Purchase System may be biased and inaccurate for its low response rates due, in part, to the sensitivity of the requested data, and unreliable quality from its self-reported nature. The Tournament data collection program is not currently well developed and not implemented in Guam and Saipan.

<u>Survey design</u>
Implementation of Federal Annual Catch Limit (ACL) measures requires statistically reliable estimates that are representative of the entire fisheries of each region. To achieve this, the survey design and strategies must be selected based on the regional characteristics of the fisheries in order to target the population of interest. The existing creel survey design is used to target fishers who can be intercepted in access sites. Errors are introduced and issues of implementation arise when the creel survey is used for obtaining fishery information that is beyond the survey design and sampling frame, and thus complicates the expansion process by requiring numerous assumptions to produce estimates. Alternative survey designs and strategies must be explored to target fisheries that are not adequately captured by the current creel survey. As long as the alternative survey forms request consistent information, using different survey methods should not cause incompatible data series.

- Explicit data requirements for precise stock assessment, federal (ACLs) and local monitoring must be identified and prioritized.

- A rigorous quantitative analysis of the existing creel survey data needs to be conducted to understand current data gaps and identify deficiencies from the current sampling design.
- Alternative survey methods and strategies must be explored for fishery sectors that are not adequately sampled by the creel survey; survey instruments using new technologies may be explored for more effective and efficient data collection.
- Minimum sample sizes must be determined to obtain estimates of required precision.

<u>Sampling design</u>
For all regions, the sample frame for the Creel Survey Program does not include all possible sites which may introduce bias and uncertainty in the estimates.

- Fishing activities at excluded sites need to be assessed to determine if better methods of distributing sampling effort are required. This would ensure that the survey is including all sites of significant fishing activities or substantially different catch rates.
- If the existing Creel Survey Program is not adequate for the excluded areas, alternative survey design may be pursued.

<u>Survey Implementation and data collection</u>
The survey must be implemented as designed, although changes of survey protocols may occasionally occur at the local level or by WPacFIN staff in an effort to more efficiently allocate resources. However, changes of survey design must be properly assessed to avoid introducing bias or jeopardizing efficiency.

There is currently no operational procedures manual written for field agents to reference. This promotes the appearance of flexibility in survey implementation and data collection in the field, which introduces uncertainty in the estimates. In addition, the existing questionnaires may be ambiguous, resulting in misunderstandings from fishers, leading to the potential for inaccurate information.

The creel survey interview involves asking fishing trip-related questions, counting fish by species or family level, and measuring length or weight of each fish. The characteristics of fishing trips and the amount of catch from each trip clearly can be quite variable, and so does the time allowed for interviews. Clear instructions or procedures must be determined for various situations to ensure consistent responses from field staff and accurate estimates. Moreover, training must be provided for proper execution of the survey. Often, methods are discussed and determined verbally, but not documented which leads to inconsistent implementation across survey agents.

The motivation level of survey agents and the fishing community is a crucial factor affecting data quality. Survey agents collect data, and fishers provide information, but often both survey agents and fishers do not know why the data are collected or how the data are used.

- Survey and sampling design need to be clearly documented by WPacFIN.
- Clear operational procedures for each survey need be defined and documented based on the sampling design.
- Changes of survey protocols without proper assessment should be discouraged. If changes of survey protocol occur, they need be documented and later evaluated.
- Education of sampling design and best practice for managers is recommended.
- A pilot study is recommended to find effective ways of collecting accurate data for various situations.

- Training materials and operational manuals for survey agents of various technical levels are recommended. Training materials and training session may include:
  - Proper operational procedures of conducting surveys
  - Accurate identification of fish
  - Methods of estimating fish counts in various situations
  - Importance of accurate measurements and impact of poor data collection in management
  - The value of their work
- Outreach effort such as brochures to introduce survey programs and to provide survey results to the fishing community may be implemented. Moreover, survey results can motivate the survey agents by showing the result and value of their work.
- An incentive program is recommended for positive participation and more time allowance for interviews. Examples could include ice for catch or raffle tickets for fishing gear, amongst others.

Estimation and *Expansion Algorithm*

As mentioned above, the estimation becomes complex and difficult when estimates needed for management are beyond the sampling design of the creel survey. Moreover, computing estimates of the incomplete sampling frame introduces bias and uncertainty.

Numerous assumptions and rules are built into different stages of the *Expansion Algorithm (Algorithm).* All assumptions used in estimation need to be verified and properly corrected, where necessary. When estimating catch and effort from a group with small sample size, the *Algorithm* attempts to borrow data. This method may under- or over-estimate the variance and the estimates of catch information. The effect of the borrowing method in the estimates is unknown.

An aerial survey on Guam is conducted, and the estimates from the aerial survey may be more efficient than that of the ground survey. However, the aerial survey data have not yet been analyzed. Currently, it is used to adjust shore-based fishing effort for a region that has a low level of fishing activity. Considering the cost of an aerial survey procedure, it would be advised to explore the validity and efficacy of data from this survey method.

- Each assumption and rule used in the *Expansion Algorithms* must be evaluated to verify if they are appropriate.
- Sample selection must be randomized and standardized.
- Other statistically valid borrowing methods must be explored.
- Aerial survey data need to be analyzed and find more effective way of using the data.
- Assessment of cost effectiveness of the aerial survey is recommended.

Maintaining a robust survey design and sampling strategy for fishery information in the midst of dynamic fisheries and management requirements is challenging. High quality survey data and estimates may be produced with a proper assessment of the fisheries and management requirements, appropriate survey designs, accurate execution and efficient estimators. Each component may involve different agencies, and require clear communication and understanding of the program across the agencies.

Well crafted documentation is crucial, and a review of programs on a regular basis (i.e. every two years) is strongly recommended to assess the efficiency of the design and strategy for the level of quality desired and meeting the management need.

Contents

Introduction

Since the early 1970's, creel surveys have provided the basis for our understanding of fish identification, levels of fishing activity, and local fisheries trends in the Western Pacific region (including Guam, the CNMI and American Samoa). The passage of the Magnuson Stevens Fishery Conservation and Management Act in 1976 mandated monitoring of domestic fisheries. The Western Pacific Fisheries Information Network (WPacFIN) was formed in 1981 to provide technical and statistical support to local agencies for more systematic creel survey procedures and data processing through the standardization of creel survey sampling design [1] and implementation. While standardized, the sampling design and implementation of creel surveys in the Western Pacific Region have changed over time due to the dynamics of local fisheries, resource availability and shifting management needs and focus. The creel survey has been conducted with a sample frame that could be supported by local capacity and conditions.

The creel surveys are designed to capture catch and effort information for all fisheries in Western Pacific Region including commercial, recreational, and subsistence fisheries. These survey data are used to provide basic fisheries statistics for local agencies and to generate various reports for the ecosystem plan teams of the Western Pacific Regional Fisheries Management Council and the *Fisheries Statistics of the Western Pacific* series published by WPacFIN.

The Magnuson Stevens Reauthorization Act (MSRA) of 2006 established mandates to implement annual catch limits (ACLs) for federally managed stocks. This requires accurate estimates of total catch and effort at the species level expanded to the island level. To this day, these creel surveys are the primary (and arguably the sole) source of data for fisheries monitoring and management in the Western Pacific region. Realizing the potential use of these creel survey data to satisfy ACL requirements, the program needed to be assessed and evaluated for statistical validity in the context of the current sampling design, data collection procedures and estimation of parameters at the level of accuracy and scale needed for ACLs.

Collecting high quality fishery data and estimating at population level are challenging using voluntary data collection programs. Several potential issues surrounding the existing structure of the survey program were brought up by the Mariana Island Fishery Ecosystem Plan (FEP) Team in 2011 when considering the use of creel survey data in setting ACLs, and the FEP team recommended examining the validity of the creel survey data and, where necessary, finding feasible solutions to improve the program.

Evaluation methods, recommendation and report organization

To address the need for statistically valid total catch and effort estimates, fishery data collection programs in the Western Pacific region were evaluated in a statistical framework. The programs reviewed in this document include the small-scale Commercial Purchase and Tournament data collection programs, as well as the more developed Creel Survey Programs.

[1] Sampling design is the method chosen to select a sample from the target population.

The Commercial Purchase System and Tournament data collection programs do not employ sampling designs or estimation methods, and therefore were evaluated for statistical and operational validity by simply assessing their operational procedures and the quality of data collected.

The Creel Survey Program is the most complex data collection program in the Western Pacific region and serves as the primary source of information for fishery management, and thus, is the main focus of this evaluation.

The creel survey programs were evaluated for statistical, technical and operational validity by assessing the following areas:

- Sampling design
- Survey implementation
- Database structure
- Estimation and expansion algorithm

The evaluation methods include:

1. Review of existing creel survey documentation
2. Interviews with WPacFIN staff
3. Observations of the current survey procedures and implementation in each region including Guam, Saipan and American Samoa
4. Interviews with survey agents, program managers, fishers, and relevant stakeholders in each region
5. Review of the survey instrument and database structure and algorithms used in estimation and expansion

Documentation of the creel survey program was recently drafted by WPacFIN (Oram et al., 2010a-f); however, it does not provide sufficient details needed to evaluate the sampling design and operational procedures. The description of survey methods, design, and operational procedures was obtained by observing the creel surveys at each site and personal interviews with agency personnel and WPacFIN staff.

Raw computer codes for the expansion algorithms and flowcharts created by WPacFIN were used for documentation and evaluation of the estimation methods.

Organization and operation of the data collection programs

The Creel Survey and Commercial Purchase System program in Western Pacific region were designed by the WPacFIN and are administered by local agencies in the Western Pacific region with the assistance of WPacFIN. The local agencies include:

- Guam Division of Aquatic and Wildlife Resources (DAWR)
- CNMI Department of Land and Natural Resources Division of Fish & Wildlife (DFW)
- American Samoa Department of Marine and Wildlife Resources (DMWR)

Each agency is responsible for collecting data and entering these data into the database system provided by WPacFIN. The Tournament data collection program has been developed and implemented only for American Samoa and it is administered by American Samoa DMWR. Currently, no tournament data are collected on Guam and CNMI.

Small scale data collection programs in the Western Pacific

Commercial Purchase System

The Commercial Purchase System collects commercial catch and market information from vendors who buy fish from fishers. It is administered by local agencies with technical support from WPacFIN, and descriptive statistics are generated for reports. The Commercial Purchase System is a voluntary, self-reported data collection program on Guam and Saipan, and a mandatory program in American Samoa. Due to the voluntary nature of the program on Guam and Saipan, the response rate is very low. Most vendors are not willing to share the details of their business activities with government agencies. Moreover, the vendors do not participate because there is no incentive to do the additional work of filling out the receipt book at species level. On Guam, only the Guam Fishermen's Cooperative Association participates consistently in the Commercial Purchase System, and on Saipan, one or two vendors inconsistently participate in the program. Data collected consistently from one particular subgroup or vendor may result in biased output. Even in American Samoa, where the Commercial Purchase System is mandatory, vendor participation is problematic. Another issue with the system is unreliable data quality from self-reporting. The receipt book may be filled out by a vendor to meet the mandatory reporting requirement, however, it is unknown if the information is accurate.

- More outreach efforts are recommended to increase participation rates. Brochures may be created to introduce the program and show results of the survey. If there is a significant number of vendors who are non-native English speakers, outreach materials may be translated into different languages.
- In order to improve data quality and lower the burden of additional work from the vendors, local agencies may assist in data collection efforts.
- A survey sampling design may be employed to select a representative random sample instead of attempting to obtain information from all vendors; and an incentive program could be developed to encourage participation from vendors.
- Making the Commercial Purchase System a mandatory reporting system may increase participation, although data quality controls will need to be implemented to ensure and measure response accuracy.

Tournament Data Collection

A Tournament data collection program was developed and implemented in American Samoa, although other island areas (Guam and Saipan) do not have comparable programs. The program consists simply of local agency staff recording the number of participants and fish caught at tournament events.

- To improve this program, standardized survey methods and design may be developed.
- Outreach efforts may also be helpful in receiving positive participation and support from the community. Examples of outreach effort could include; sponsoring events, providing operational assistance, and supplying equipment for tournament events.

Evaluation of Creel Survey Program

Information collected from Creel Survey

Fishing activities are categorized as boat-based and shore-based in the Creel Survey Program, and they are defined by where a fishing activity is initiated by a fisher (Oram et al., 2010a-f). The boat-based creel survey collects fishery information by recording fishing activities (trips), interviewing fishers and recording catch-related information such as fish counts, species composition and measurement. Other trip-specific information such as fishing method, fishing activities (charter, non-charter), locations and other metadata (weather, tides, etc.) are recorded. Fishing effort in boat-based fisheries is defined as a fishing trip per fishing method. Catch is defined as total number of fish caught per fishing effort.

Similar to the boat-based survey, the shore-based survey intends to capture fishery information of the shore-based fishing activities. Shore-based fishing effort is defined as fishing hours used by a fishing method (gear), and catch is defined as a number of fish caught per fishing effort.

More detailed information about survey data collection can be found in WPacFIN boat-based and shore-based creel survey documentation (Oram et al., 2010a-f).

Commonly used survey methods and WPacFIN survey methods

Creel surveys have traditionally been used to collect fisheries information to better understand trends in fisheries and to estimate angler effort and catch information (Pollock et al. 1994). A summary table of some commonly used survey methods for creel surveys is provided in Table 1.

Table 1

Commonly used survey methods to collect catch and effort information in creel survey

Survey methods	Survey procedure	Description	Survey data
Access survey	Survey agents stationed at one location	Fishers are sampled on completion of fishing activity by survey agents	Catch and effort
Roving survey	Survey agents travel to each location	Fishers are sampled while engaged in fishing activity by survey agents	Catch and effort
Bus route type access survey	Survey agents travel to each location and stationed for a set period of time	Fishers are sampled while fishing or on completion of fishing activity	Catch and effort
Aerial survey	Survey agents fly along the coastline	Fishers are sampled while engaged in fishing activity by survey agents	Effort

Survey methods may be selected based on the characteristics of fisheries and geographical features of a particular region. In a larger area with more access sites, a type of roving survey that is analogous to a "bus route" survey may be more suitable than an access survey (Robson and Jones, 1989; Jones et al., 1990; Jones and Robson, 1991). In a *bus route access* survey, survey agents follow a strict time schedule to visit each site for a specific period of time to wait to interview fishers, and then proceed to the next one. An *aerial* survey may be a practical choice for an area of which access sites have low level of fishing activities and are difficult to reach from the ground (Pollock et al., 1997). This survey allows more comprehensive coverage of a large area in a short period of time.

Complemented surveys are often used to obtain different parameters such as catch and effort information by different survey methods (Hoenig et al., 1993; Pollock et al., 1994; Hoenig et al., 1997; Pollock et al., 1997). Various combinations of survey methods have been proposed in the literature to improve efficiency of the survey implementation and survey data quality for specific characteristics of fisheries or survey areas (see Table 2).

Table 2.
Complemented survey methods and suitable survey area conditions

Complemented surveys	Condition of survey areas
• Access • Roving	Smaller areas with few distinct access sites
• Access • Roving • Bus-route	Larger areas with more access sites
• Access • Roving • Aerial	Larger areas with many access sites of low fishing activities, and are difficult to reach

WPacFIN creel survey method and sampling design

The Creel Survey Program uses a complemented method of access and roving surveys. For the boat-based survey, field agents are stationed at a designated access site during survey hours and record boat activities, this is the access survey portion of the program. In addition, field agents drive around the island to visit each access site and record boat activities, a roving method. These two types of surveys collect fishing effort data. Catch data and trip related information are obtained as survey agents interview fishers who are returning to the access site.

In the shore-based survey program, a roving method is used to collect both catch and effort data. The survey is conducted as field agents drive along the coastline of a designated survey site. Similar to the boat-based survey, effort and catch data are collected as recording information and interviewing fishers while fishers are still engaged in fishing activities, or on completion of fishing. Complemented survey methods used in each region are described in Table 3.

In addition to access and roving survey methods, WPacFIN uses an *opportunistic sampling* method where at any time survey agents may intercept and interview fishers who are found to be using rarely encountered fishing methods (such as spearfishing or surround net).

Table 3.
Complemented survey methods and types used in Western Pacific Creel Survey Programs

Guam		
Boat-based	Access survey Interview (catch) Boat-log (effort)	Roving survey Participation count (effort) Aerial survey (effort)
Shore-based	Roving survey Interview (catch)	Roving survey Participation count (effort)
Saipan		
Boat-based	Access survey Interview (catch) Boat-log (effort)	Roving survey Participation count (effort)
Shore-based	Roving survey Interview (catch)	Roving survey Participation count (effort)
American Samoa		
Boat-based	Access survey Interview (catch)	Roving survey Participation count (effort)
Shore-based	Roving survey Interview (catch)	Roving survey Participation count (effort)

The sampling frame [2] of creel survey consists of a list of public access sites (regions) and a list of available days to survey and is stratified by day type (weekday and weekend) and port (or region), and month (or quarter). Within each stratum, survey days are randomly selected with certain restrictions. The completeness of lists of sites and days for survey varies by region based on accessibility and resource availability.

Evaluation

Survey Design
The boat-based access survey design appears to be sufficient to collect fishing effort data on a specific access site with few assumptions; the survey hours are assumed to be aligned with the hours of the highest boat activities, and the sample frame is complete. For catch data on the other hand, the efficiency of design appears to be limited to small scale fishing trips. The current design makes it difficult to collect accurate information from trips with large amount of catch especially when various species are involved. The survey design does not seem to be adequate for certain trip types such as a charter trip. A charter trip may carry multiple fishers on a trip, and the survey method or protocols used to collect catch data does not capture sufficient information later needed for estimation of total catch. Hence, some charter trips are ignored and not surveyed.

The shore-based survey design is limited to fishers using certain fishing gears for both catch and effort data. For example, spearfishers or night-time fishers targeting specific species are difficult to intercept with the existing survey design. *Opportunistic sampling* may be useful to understand the CPUE. However, opportunistic sampling is not a scheduled task and is highly dependent on a level of

[2] A sampling frame is the list of target population members from which the sample will be drawn

motivation of field agents. Any sample data collected through opportunistic sampling methods cannot be used in the expansion of total effort since the sample is not randomly selected.

Sampling design
The creel survey employs stratified systematic sampling with certain selection rules. The rules include 1) no consecutive survey days for an individual survey site. There needs to be at least one day separating survey days at an individual site; 2) Access survey days are limited to one site. One cannot visit multiple ports on an access survey day.

Systematic sampling may be ideal when there exists “a natural ordering” in the target population members, and the sample may be drawn in a systematic way from the ordered population for unbiased sampling. Systematic sampling design may be a suitable choice since catch and effort often are tied to seasonality, and selecting the survey days in a systematic manner can lead to unbiased sample selection.

The current sampling technique, however, is non-standardized systematic sampling due to the selection rules applied. Survey days are selected at random but if consecutive days are selected, the sample is redrawn. The non-standardized sampling may complicate estimation process since it is difficult to compute selection probability.

Sample size (survey days)
Fishery data are heavily dependent on environmental factors such as weather and tides, and a small number of survey days, it is difficult to obtain accurate estimates of quarterly or annual catch and effort due to highly variable fishing conditions within the period of time. The survey days (sample size) that are assigned to each stratum seem too small, although a comprehensive data analysis would be required to properly (statistically) address this issue. The expansion algorithm requires 3 interviews per stratum in order to estimate catch and effort without borrowing data from other stratum. Somewhat counter-intuitively, a large number of interviews do not necessarily produce more accurate estimates if the interviews are from one survey day, and the catch rate of the day is consistent. Variability in catch and effort information may be larger between days than within days, therefore allocating a large enough number of survey days to obtain samples from different days is recommended to obtain valid fishery data.

Recommendations

Identify data requirements and explore additional or alternative survey designs
Explicit data requirements for federal and regional fishery management need to be identified and prioritized by NMFS and the Council. The survey design including survey methods, implementation strategies, and survey instrument were developed and implemented in early 1980s. An analysis of historic survey data and the current survey design may be conducted to identify deficiencies of the existing survey design. Alternative survey design and strategies may be determined appropriate for more reliable data collection. For some fisheries or regions, a creel survey may not be suitable. Instead of conducting on-going creel surveys, more focused data collection efforts could be done for a specific period of time and one could properly target the fisheries of interest on a regular basis (i.e., every two years). Another option may be to utilize model-assisted estimation method for fisheries that are highly dependent on environmental and social variables.

Standardized sampling design
The sample (survey day) selection needs to be randomized, and the sampling design needs to be standardized. To determine an optimal sampling design and allocation of sampling effort, sampling design principles may be employed.

Complete sampling frame
The sampling frame needs to be complete for unbiased sample selection unless the impact of the excluded subpopulation is shown to be negligible. Currently, the catch and effort estimates of the excluded ports are computed based on assumptions that are not verified. A study needs to be conducted on the excluded sites to verify existing assumptions. If substantially different levels of catch and effort are found at the excluded sites, sampling methods need be determined to obtain information from those sites. The characteristics of the excluded areas and available resources need be taken into consideration when selecting an appropriate sampling method. Options available include:

- Including all sites in the sampling frame with different selection probabilities proportional to the level of fishing activity or catch rates.
- Employing alternative, less costly, survey methods if no additional resources are available. For example, the bus route survey method may be used to cover multiple sites on a given survey day instead of dedicating one full survey day to one access site.

Determine sample size (survey days)
Quantitative data analysis may be conducted to determine minimum sample sizes needed for desired precision of the estimates of catch and effort.

Guam

On Guam**,** surveys are conducted between approximately 05:30 – 24:00 and a list of available days to survey includes Monday-Sunday except for holidays. The sampling frames and survey schedule for Guam surveys are described in Table 4a and Table 4b for boat-based and shore-based surveys, respectively. More detailed information can be found in WPacFIN creel survey program documentation (see Oram et al., 2010a-f).

Table 4a.
Sample frame for Guam boat-based creel survey program

ID	Site	Interview, Boat Log	Interview Survey days Day type = {weekend, weekday}	Participation Count**
1	Agana Boat Basin	X	Twice per month/day type	X
2	Agat Marina	X	Once per month/day type	X
3	Merizo Pier	X	Once per month/day type	X
4	Pago Bay			X
5	YLig Bay			X
6	Umatac Bay			X
7	Agat Bay			X
8	Seaplane Ramp			X

*** Boat-based and shore-based participation count survey are conducted simultaneously for the entire island, twice (morning and evening) on a given survey day, twice per month*

Table 4b.
Sample frame for Guam shore-based creel survey program

ID	Site	Interview	Interview Survey days	Participation Count**
1	Region I: Gun Beach to Adelup	X	1 day per month (weekday or weekend day)	X
2	Region II: Adelup to Agat	X	1 day per month (weekday or weekend day)	X
3	Region III: Pago Bay to Merizo	X	2 days per month (one weekday and one weekend day)	X

*** Boat-based and shore-based participation count survey are conducted simultaneously for the entire island, twice (morning and evening) on a given survey day, twice per month*

An aerial participation count survey is conducted around the island on one weekday and one weekend day per month, and is scheduled on the same day of the ground participation count survey day. It begins at a random time between 08:00 and 12:00, and is conducted for approximately 2 hours. During survey hours, survey agents count the number of fishers and their fishing methods.

There are approximately 9 DAWR employees involved in the creel survey programs; some are also involved in other projects leaving only a few as full-time creel survey agents.

Evaluation (Guam)

Incomplete sampling frame with restricted access

After the events of 9/11, military base access has been restricted, and in recent years survey agents are no longer able to access the military areas. Local experts suggest that there is a fair amount of fishing activity in military areas. In an effort to collect fishery information from the military areas, the DAWR had developed an opportunistic creel survey program in 2007 and the survey was to be conducted by military personnel. However, the data collection and quality have been inconsistent.

Duration of ground roving survey

Participation counts for shore-based and boat-based activities are conducted simultaneously in the morning and in the afternoon on a given survey day. The instantaneous or progressive count is conducted along the accessible coastline of the entire island except for private access areas and military bases, and it takes approximately 7 hours on each shift. The duration of the roving survey suggests that the ground coverage may be too large for a ground roving method. While the Aerial survey is conducted, it is not used for estimation of total effort.

Recommendations

Alternative survey designs for military bases

Since the creel survey currently cannot be conducted on military bases, alternative survey designs and strategies need to be explored and determined for reliable data collection.

- A catch and effort reporting system may be implemented for all boats that utilize boat ramps located on military bases. A combination of internet and mail surveys may be an option to collect these data. A boat registry may be developed and could potentially be used as a list frame. Since self-reporting systems may suffer from low response rate and unreliable data, careful design of surveys and outreach materials are crucial for successful data collection.
- Seasonal studies may be conducted on military bases to collect catch and effort data during the study period and use them to construct a sampling distribution. Prior to fielding of the survey, the survey specification (such as survey duration, names of survey agents, etc.) may be determined to be authorized by the military authorities. This approach may be less intrusive since access is granted for specific personnel for a specific period of time.
- The opportunistic survey program currently implemented in the Anderson Air Force base needs to be improved if it will be continued.

Options are suggested for each area of evaluation to provide examples of alternative methods. However, a proper assessment and analysis are recommended in order to optimize resources.

Analysis of aerial survey data

The aerial survey has been conducted to count the number of fishers engaged in shore-based fishing activities. The Aerial survey data need to be analyzed to verify if aerial survey methods produce more precise estimates, relative to ground participation counts.

Commonwealth of the Northern Mariana Islands (CNMI)

The CNMI creel survey sampling sample frame consists of a list of public access sites (regions) and a list of available days to survey. Available days include Monday-Sunday except for holidays. Surveys are conducted approximately 24 hours on a given survey day. The sample frames of boat-based and shore-based creel surveys are described in Table 5a and 5b, respectively. The current sample frame includes only the island of Saipan. There are 8 full time creel survey agents involved in the creel survey programs.

The shore-based participation and interview surveys are conducted on the same selected survey day; survey agents drive one way conducting one survey, and on the way back in the opposite direction, the other survey is conducted. Usually one survey shift consists of three one-way segments (surveys). The order of survey methods used is randomly selected.

On the island of Saipan, the creel survey sampling frame includes only the western side of the island because a majority of fishing activity occurs on the western side and the eastern coastline is primarily cliffs. Cliff fishing occurs on the eastern side, but the scale of fishing activity is very low. Currently, a pilot study is being conducted on the southern side of the island to assess the scale of fishing activities.

Table 5a.
Sample frame for Saipan boat-based creel survey program

ID	Site	Interview Boat log	Participation Count	Survey days Per Quarter (3 months)
1	Sugar Dock	X	X	9 survey days in each stratum
2	Fishing Base	X	X	9 survey days in each stratum
3	Smiling Cove	X	X	9 survey days in each stratum
4	Tanapag Camalin		X	9 survey days in each stratum (for each survey)
5	DFW Ramp		X	9 survey days in each stratum (for each survey)

Table 5b.
Sample frame for Saipan shore-based creel survey program

ID	Site	Interview	Participation Count **	Survey days Per Quarter (3 months)
1	Western side of Saipan	X	X	4 survey days in each stratum (both surveys conducted on a same day)

** The shore-based participation count survey and interview are conducted on the same survey day.

Evaluation (CNMI)

Incomplete sample frame
The total catch and effort estimates are needed for the CNMI, however, the sampling effort is applied only to Saipan, excluding other islands such as Tinian and Rota. There has not been an effort to collect

fishery information from other islands of CNMI besides Saipan. On Saipan, catch data are collected from 3 major sites although the sampling frame for effort includes more sites.

Distribution of sampling effort
Both boat-based and shore-based creel surveys are conducted for approximately 24 hours on a given survey day. Despite the high sampling effort invested, the number of interviews or participation counts is highly variable and inconsistent. This is particularly an issue on night surveys, as survey agents have a difficult time identifying fishers. For example, night time spearfishing is difficult to spot since the fishing activities occur in water and even using a high voltage flashlight, survey agents can easily miss fishers in the water. This results in inaccurate data collection and questionable effort information.

Recommendations

Complete sampling frame
The federal and regional (CNMI) management requirements need to be identified. There is no fishery related data from Tinian and Rota for use in estimating catch and effort. The sampling design and strategy must be determined to collect accurate catch and effort data for these islands. Alternative options may be to collect auxiliary data which can be used to derive estimates of catch and effort for Tinian and Rota.

Efficient allocation of sampling effort
It is suggested that the sampling effort may not be appropriately assigned to the sampling frame to target the population of interest. The existing survey data need to be analyzed in order to assess if the sampling hours are effectively allocated to obtain the fishery information needed for management. In addition, any possible factors that may cause high variability in the number of interviews should be investigated. Based on the result of this data analysis, sampling effort may be redistributed to improve data collection efficiency.

American Samoa

The American Samoa creel survey sampling frame consists of a list of accessible regions along the coastline and a list of available days to survey which includes Monday through Saturday excluding Sundays and holidays. On a given survey day, surveys are conducted between 6:00 and 24:00. The sample frames and schedule of the surveys are described in Table 6a and 6b.

There are 7 full time and 1 part time survey agents involved in the creel survey programs in Tutuila, and two part-time survey agents on the islands of Manu'a.

Table 6a.
Sample frame for American Samoa boat-based creel survey program

ID	Site	Interview	Survey days (sample size)	Participation Count
1	Pago Pago	X	At least 12 weekdays per month	X
2	Fagatogo	X	2 weekend days per month	X
3	Utulei	X		X
4	Faga'alu	X	06:00 ~ 24:00	X
5	Fagasa Bay	X		X
6	Manu'a islands	X	Inconsistent	X

Table 6b.
Sample frame for American Samoa shore-based creel survey program

ID	Site	Interview	Survey days (sample size)	Participation Count
1	West : Amanave to Vaiola	X	At least 12 weekdays per month	X
2	Central: Nu'uuli to Aua	X	2 weekend days per month	X
3	East: Lauli'I to Tula	X	06:00 ~ 24:00	X
4	Northern villages	none	none	none

Evaluation (American Samoa)

Incomplete sample frame (exclusion of other islands)
Currently, the sample frame includes the island of Tutuila and the islands of Manu'a (Ta'u, Ofu and Olosenga). The survey on Manu'a islands is limited to opportunistic sampling under no supervision, resulting in inconsistent data collection and quality. The sampling frame does not include Aunu'u Island on which the level of fishing activity needs to be examined.

On the island of Tutuila, the sample frame for shore-based fisheries covers only the south side of the island. There are a few fishing villages on the northern side which may need to be included in the sampling frame.

Recommendations

Alternative survey design for Manu'a and Aunu'u

The current creel survey design may not be suitable for the islands of Manu'a and the island of Aunu'u since it is difficult to supervise or manage survey agents remotely. A pilot study may be conducted to understand the fisheries characteristics on the islands of Manu'a and Aunu'u, for determining an adequate survey design and estimation method and effective data collection. One potential option may be seasonal data collection by well-trained survey agents. The study results may be used to identify auxiliary information for model-assisted estimation for catch and effort.

Alternative survey design for the northern villages on Tutuila

A pilot study is recommended to understand the characteristics of fishing activities in the northern villages, and determine an appropriate method for collecting fishery information. Possible options for survey methods may include a panel survey where a fisher may be randomly selected to keep a fishing log or diary. A panel survey is suitable when logistics may be problematic for survey agents to travel to the northern part of the island, and fishers are willing to participate. Participants can be compensated for the duration of data collection. Another option may be to use auxiliary information related to catch and effort that is less costly and easier to obtain. Model assisted estimation method may be used in computing catch and effort estimates.

Improving efficacy of current creel survey design

Data analysis may be conducted to assess the percentage of boats survey agents intercept for interview while survey agents are not stationed at access sites. If the number of missing boats is significant, alternative survey strategies may to be pursued for improved performance.

Currently, American Samoa invests a great amount of sampling effort by conducting creel surveys everyday during weekdays and two weekend days per month. Data analysis may be conducted to more effectively utilize the sampling effort to achieve accurate estimates and use resources more efficiently.

Implementation of the Creel Survey Program

The sampling design is selected to obtain a sample that is representative of a target population by attempting to minimize mean squared error (MSE) – which consists of variance and bias. Adjustments to survey operations may occur at the regional level as resource availability and budgetary situations fluctuate. Some adjustments are made because operational procedures of the sampling design or survey methods are not clearly documented which creates an apparent flexibility in survey implementation. Changes made without consideration of statistical validity may affect estimation by introducing bias, variance and uncertainty.

Scheduling
For random selection of the survey days, the schedulers are instructed to draw survey days from a box of numbers (days) ranging from 1-31, and the selected days are assigned to survey sites. This procedure is performed a few months prior to the given month of field work being scheduled. Some surveys are scheduled one year in advance. The current method of selecting survey days is not practical and realistic in the field. It is unknown how often the practice of choosing random days from the box of numbers is actually used. Moreover, some surveys have a fixed schedule for convenience. For example, in American Samoa weekend surveys are scheduled on the last Saturday of each pay period every month, and if there is any correlation between days selected (for example, weekend after pay day) and a level of fishing activity, it introduces bias in the estimates.

As days are selected (scheduled) for surveys, they are entered in the data system and later used to compute daily averages of fishing effort. While the survey days are scheduled a few months in advance, it is possible that some days may be cancelled. Cancellation of scheduled survey days is problematic since the existing estimation procedure does not compute the average based on the days surveyed but days scheduled (See *Estimation Method section for more information*).

Training
New hires are trained on site as they observe senior survey agents conducting surveys in the field. There is minimal to no supervision of survey implementation and data collection in the field once survey agents are allowed to conduct surveys alone. A structured training program is not currently provided, and a performance evaluation considering proper execution of the survey is not in place.

Data Collection
During interview surveys, the survey agents face numerous varying factors as they conduct interviews. There are different trip types (charter, non-charter), varying number of fishers on a fishing trip, amount of catch to measure and count at the species level, all in the context of the limited amount of time a fisher may allow for an interview. Without proper operational procedures to conduct interviews that address the various situations an interviewer may face in the field, it can be challenging to obtain accurate and consistent information. Apparently, there is a lack of clear instruction on conducting interviews for various situations. Although survey agents are trained onsite by observing senior agents, instructions are often told verbally. There is no operations manual or reference that is available to survey agents. This allows the appearance of flexibility in execution of survey, thus introducing uncertainty in the estimation.

Some operational procedures of survey methods are misunderstood by survey agents. Instructions are given verbally during on-site trainings by different survey agents, thus the procedures may not be consistent, and it creates the potential for variability in how surveys are conducted. For example, during a participation count, a survey agent did not count a spearfisher who was exiting the water because the agent is allowed to count fishers who are engaged in a fishing activity, and the spearfisher had technically completed fishing activity. Other survey agents, however, consider an exiting fisher for an interview. Another example is the waiting time at each access site during participation counts. Some agents were told that there is a specific period of time they need to wait before proceeding to the next site, some were told otherwise. There is no clear instruction therefore this procedure has the potential to vary by field agent.

Some regions use local fish names for interview surveys since survey agents are more familiar with the local names, and it minimizes the training time. This may be problematic if the relationship of the local fish names and scientific names of species is not unique.

Participation

The success of the Creel Survey Program is heavily dependent on the support from the local fishing community. Many fishers have experiences with the creel surveys over the years and seem to be cooperative as survey agents approach them. However, there are some who do not provide accurate information or choose not to participate mainly because 1) it is voluntary data collection, 2) they are unaware of how the data are used or they feel that the data will be used against fishers.

There is a lack of outreach to provide information about the creel survey program such as an introduction to the survey programs or basic survey statistics and results. Even within an agency, many survey agents do not know how the creel survey data are used and the impact of inaccurate data collection on the management of their fisheries. Survey agents and those whom do participate do not ever see any results from their time and efforts, which can foster mistrust from the community and complacency amongst agency staff.

There has been some outreach effort in each region. Currently, Guam DAWR gives out outreach materials (tide calendars and other information), and American Samoa DMWR is in the process of incorporating an incentive program to encourage participation. Saipan DWR attempts to build positive relationship with the fishing community by providing services such as support for fishing tournaments.

Success of the creel survey also relies on the level of motivation from survey field agents. The response rate will likely vary based on how the survey agents interact with fishers. Creel survey agents, at times, face unfriendly fishers, long hours of driving in traffic, and waiting hours at a site to intercept fishers. Conducting the survey on a regular basis can be a mundane routine, and it is difficult to sustain a high level of motivation. There is no supervision or incentive for survey agents' performance whether or not they do their job honestly and effectively. Despite the effort invested by the agencies, there has been some criticism by the fishing community surrounding the performance of some survey agents. Ensuring positive motivation for the survey agents is imperative to ensure that they follow the operations properly.

Recommendations

Automation of creel survey sample selection (scheduling)
To enforce randomization of sample selection and to minimize human errors, automation of scheduling is recommended. A web-based scheduling application may be an option since it is accessible from any web browser and each local office has a high speed internet connection. Furthermore, the web based application does not require on-site installation of software. The automated scheduler will take the burden of random scheduling off the managers and reduce non-sampling errors or biased scheduling.

Documentation of the current procedures and future changes
The creel survey program uses survey methodologies that are well established in fisheries literature, and the techniques associated with the survey design are well defined. Implementation of sampling design of the creel survey program must be clearly defined and thoroughly documented based on the survey design. Any changes made in sampling design or estimation must be documented, reviewed and validated by survey experts to ensure statistical validity of the changed sampling design.

Training or workshop of sampling design for program managers
It is crucial that the program managers understand the importance of the proper operation of creel survey procedures in accordance with the sampling design, and the effect of incorrect implementation in estimation. Training or workshops to address such topics is recommended for managers who are responsible for making decisions on operations of the survey programs in the field. The training session can be utilized for discussions on other issues of creel survey procedures to assess efficiency and practicality of the existing methods.

Methods of collecting consistent data
To avoid inconsistent data collection due to the various situations survey agents face during interviews, a list of approved alternative methods of obtaining information must be determined and clearly documented. A pilot study involving fishers, survey agents and researchers may be conducted to find practical and statistically valid ways of obtaining consistent information. During the study, methods can be pre-tested for logistical practicality.

Training session and training materials for survey agents
Training must be provided to survey agents for consistent and accurate execution of data collection. In addition, the reference materials and operations manual must be written for survey agents of various technical levels. Moreover, the training may emphasize the importance of their role in the fishing community and fishery management. In addition, an incentive program for survey agents based on their performance may be helpful to increase and maintain motivation levels.

Supervision
In addition to providing training sessions, supervisors or survey experts may accompany the survey agents on a regular basis to ensure proper execution of the survey and to assess the logistics and the existing survey methods for capturing the current dynamics of the fisheries.

(cont.)

Recommendations (*cont.*)

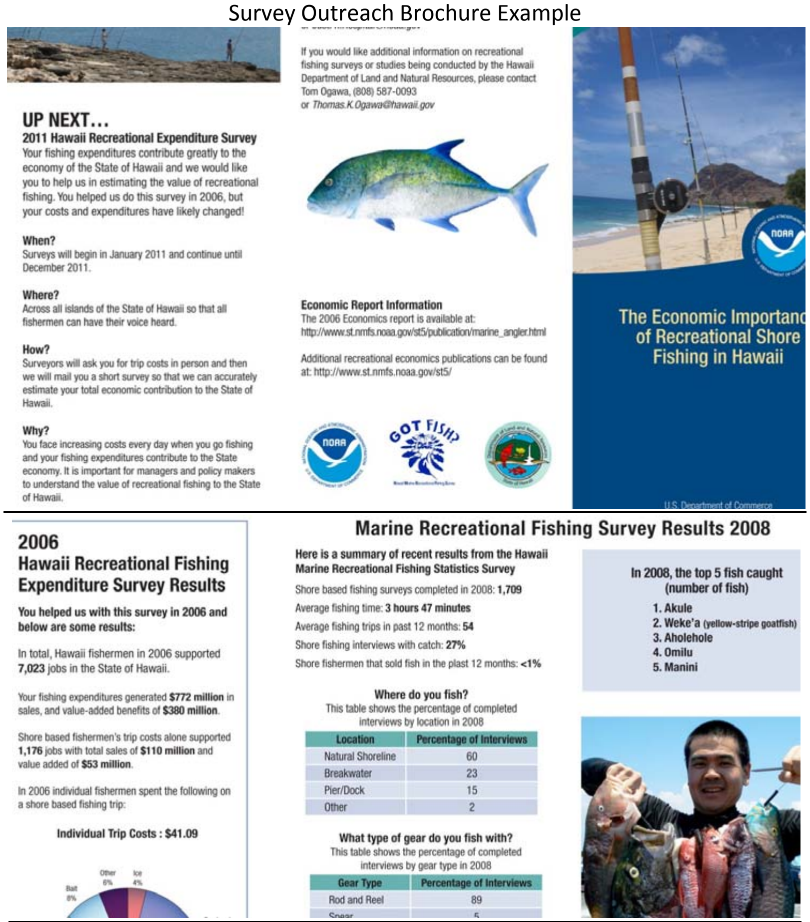
<u>Outreach effort and incentive system</u>

Outreach efforts are recommended to encourage the fishing community to participate in the creel survey. Brochures may be an effective method to introduce the survey program and describe the importance of their participation. They are affordable and can be easily distributed at tackle shops or tournaments, or as survey agents approach fishers for interviews.

An incentive system may be an option not only to encourage participants of the surveys, but also to gain more time for accurate measurement or count of the catch. Some inexpensive incentive options may be quarterly raffle tickets for a prize such as fishing gear, or providing ice for their catch while conducting interviews.

Provided below is a modified sample of a brochure used to support a recent NOAA recreational expenditure survey in Hawaii. The complete brochure can be found in Appendix E.

Figure 1.
Survey Outreach Brochure Example



WPacFIN Estimation methods for Catch and Effort

Boat-based Catch and Effort Estimation

The creel survey data are used to compute annual and quarterly estimates of total catch, effort and catch per unit effort (CPUE) as well as species composition of total catch. For boat-based estimation, fishing effort is defined as a fishing trip, and catch is defined as a total number of fish caught per fishing effort. All parameters are estimated as group estimates at each stratum level; group being fishing method or trip type (charter or non-charter), and strata being location (ports or access site), day type (weekend and week day). In other words, total effort and catch estimates are computed for each fishing method, location, and trip types. However, some trip types are not applicable in all island areas (for example, the charter and non-charter distinction is not made in American Samoa).

Total Effort Estimation

In total effort estimation, the value of total sample effort is computed by adding the number of all observed fishing trips during a specific year (or quarter). In expansion of the sample total effort to annual (or quarterly) effort, two temporal adjustment factors are used. The first adjustment factor of *within a day* expansion (a_1) is determined by local experts, and the second adjustment factor (a_2) of annual (or quarterly) expansion is computed as a ratio of a number of days in a year (or a quarter) to a total scheduled survey days.

$$\textbf{Estimated Annual Fishing Effort} = a_1 a_2 \textbf{Sample Fishing Effort}$$

Some interviews may contain incomplete information. In an effort to impute missing information, various methods are used and these methods vary by regions.

Catch per unit effort (CPUE) Estimation

CPUE is computed as a ratio of total weight of observed catch to total number of observed fishing trips within a year (or a quarter); this estimator of CPUE is also known as a ratio-of-means estimator (Pollock et al., 1997). Similar to total catch estimates, CPUE is also estimated as a group estimate at stratum level.

$$\textbf{Estimated CPUE} = \textbf{Sample CPUE}$$

When the number of observed fishing trips is fewer than 3, the CPUE is estimated using borrowed data from other group or stratum, or by aggregating at stratum or group level. Some ports are not included in the sampling frame to collect catch information. For those ports, CPUE is estimated using data from other surveyed ports.

Total Catch Estimation

Total catch estimation for each group and stratum is obtained by multiplying the estimated total effort and the estimated CPUE.

$$\textbf{Estimated Total Catch} = \textbf{Sample CPUE} \times \textbf{Estimated Total Effort}$$

Species Composition

Species composition is obtained by multiplying the sample species composition ratio to the estimated total catch.

$$\textbf{Estimated Species A} = \frac{\textbf{Total Weight of Species A}_{\textbf{Sample}}}{\textbf{Total Weight of All Species}_{\textbf{Sample}}} \times \textbf{Estimated Total Catch}$$

Shore-based Catch and Effort Estimation

The creel survey data are used to compute annual and quarterly estimates of total catch, effort and catch per unit effort (CPUE) as well as species composition of total catch. For shore-based estimation, effort is defined as a fishing hour, and catch is defined as total number of fish caught per fishing effort. All parameters are estimated as a group estimate at each stratum level; group being fishing gear type and strata being region, day type (weekend and week day) and survey shift (morning and evening). In other words, total effort and catch estimates are computed for each fishing gear type, region and day type (weekend and week day) and survey shift (morning and evening).

Total Effort Estimation

In total effort estimation, the value of total sample effort is computed by adding the number of all observed fishing hours during a specific year (or a quarter). To expand the sample effort estimate temporally to an annual (or a quarterly) level, two temporal adjustment factors are applied to the sample effort estimate. The first adjustment factor (b_1) is a ratio of a number of days in a year (or a quarter) to a total scheduled survey days. The second adjustment factor is the number of available fishing hours in each shift on a survey day (b_2) for example on Guam, values of b_2 for morning and evening shifts are 12 hours and 8 hours respectively.

$$\textbf{Estimated Annual Fishing Effort} = \boldsymbol{b_1 b_2}\textbf{Total Number of Fishing Gear}_{\textbf{Sample}}$$

A total effort estimate is computed for a region excluded from the spatial sampling frame by using data from surveyed regions or data from other survey methods.

Catch per unit effort (CPUE) Estimation

CPUE is computed as a ratio of total weight of the observed catch to the total “observed” fishing hours within a year (or a quarter). When the number of interviews is fewer than 3, a pre-calculated CPUE in the database is used. CPUE is also estimated as a group estimate at stratum level. The CPUE of an excluded region from survey is estimated using CPUE of other regions and an effort ratio of other regions and the excluded region.

$$\textbf{Estimated CPUE} = \textbf{Sample CPUE} = \frac{\textbf{Total Weight of Catch}_{\textbf{Sample}}}{\textbf{Total Fishing Hours}_{\textbf{Sample}}}$$

Total Catch Estimation
Total catch estimation for each group and stratum is obtained by multiplying the estimated total effort and estimated CPUE. The total catch is estimated as a group estimate at stratum level.

$$\textbf{Estimated Total Catch} = \textbf{Sample CPUE} \times \textbf{Estimated Total Effort}$$

Species Composition
Species composition is obtained by multiplying the sample species composition to the estimated total catch.

$$\textbf{Estimated Species A} = \frac{\textbf{Total Weight of Species A}_{\textbf{Sample}}}{\textbf{Total Weight of All Species}_{\textbf{Sample}}} \times \textbf{Estimated Total Catch}$$

More detailed information about boat-based and shore-based estimation methods and expansion algorithms can be found in Appendices C and D, respectively.

Evaluation

Assumptions
Estimates of boat-based catch and effort are computed per access site using the survey data. The estimates of the non-sampled sites are computed based on some assumptions which are not verified. For example, the total effort of the non-sampled ports on Guam is assumed to be same as the total effort of Merizo and Agat harbor.

The *Expansion Algorithms* for Guam and American Samoa use temporal and spatial adjustment factors that are computed as the inverse of some ratios, known as *p1* and *p2;* the values of the ratios are determined by local experts based on their assumptions of the survey coverage although these assumptions are not verified.

The errors produced from unverified assumptions may be negligible; however, they need to be properly verified.

Expansion
The *Expansion Algorithm* expands catch and effort information for a period of time (quarterly or annual) without taking other fishery related factors such as weather or seasonality into consideration. When quarterly estimates are computed using quarterly data, it may reflect seasonality characteristics although the sample size (survey days) are too small, however, when data are expanded annually with a small number of survey days and number of interviews, the annual catch and effort may be significantly under or over-estimated.

Data borrowing method
The interview data are post-stratified and the catch and effort are estimated at stratum level, and often result in a small number of data for estimation at stratum level. When the number of interviews is too small (fewer than 3) to compute a catch estimate, the *Algorithm* borrows survey data from other

stratum or group in order to increase the number of interviews. The *Algorithm* looks for other survey data points as it goes down the priority list created by WPacFIN until the number of interviews reaches 3. The current method of borrowing survey data is solely dependent on the priority list, and it is unidentified where the data are borrowed from, thus the effect of the borrowed data in estimates is unknown.

For Guam shore-based estimation, there are values for pre-computed CPUEs from historic data for each region, day and fishing gear, and the values are stored in database as CPUEs before 1989 and CPUEs from 1990. When a number of interviews are fewer than 3 in estimation of CPUE, the *Algorithm* does not use the survey data; instead, it uses a pre-computed CPUE value. The update of the pre-computed CPUEs occurs inconsistently. For Saipan, a *pooling method* is used to borrow survey data within or between stratum or group based on a priority list. It is difficult to compute the effect of these methods in estimation.

<u>Biased in estimation</u>

The scheduling of the survey is not truly random and the selection probability is not used in the estimation which results in biased estimates.

<u>Other estimation issues</u>

In estimation, if a scheduled survey day is not observed by survey agents, the fishing activity of the day is considered zero, assuming that the survey was cancelled due to a bad weather. This assumption is observed to be inconsistent, and thus has the potential to underestimate the catch and effort.

<u>Complete interview vs. Incomplete interview</u>

In the literature, different estimation methods are applied to compute CPUE and total effort from complete and incomplete survey. A complete survey is defined as one when fishers are interviewed upon completing their fishing activity. Incomplete survey is when fishers are interviewed while engaged in their fishing activity. In the *Expansion Algorithm*, incomplete interviews are treated as complete ones. By treating the complete and incomplete interviews equally, total effort and total catch may be underestimated.

<u>Guam Aerial Survey</u>

The current use of the aerial survey is to determine fishing effort ratios for un-sampled areas relative to sampled areas, and the ratio ranges from approximately 0.06-0.16 which is low. Aerial surveys are becoming a more widely used and accepted method since the it is often found to be more effective for areas that are too large for ground roving survey, however, the Guam aerial survey data are not utilized in estimation.

Conclusion

The fishery data collection programs in the Western Pacific region including Guam, Saipan and American Samoa were evaluated.

In short, the evaluation concludes that the currently implemented fishery data collection programs are not sufficient to provide statistically valid estimates for the ACL implementation because 1) the survey design and strategy of the creel survey programs do not extend to all fishery sectors 2) the operational procedure and protocols of the creel survey programs are unclear, in practice, thus producing unknown errors in the data and estimates, and the 3) *Expansion Algorithm* uses unverified assumptions and imputation methods that introduce unknown level of uncertainty in the estimates.

The new management demands brought on by ACL requirements need statistically reliable catch and effort estimates that are representative of all fisheries in each region to inform management decisions. Increased effort in developing more concrete survey and sampling designs to target populations of interest, documenting clear operational procedures and extensive community outreach are recommended.

Finding survey designs and strategies to collect fishery information in the midst of dynamic fisheries and management requirements is challenging, and it takes iterations of assessment and modification of all aspects of survey design to obtain the quality data including types of information being collected through the survey programs. Periodic reviews of all components of data collection programs including quantitative data analysis of survey data are recommended to ensure that overall quality standards and goals of the data collection programs are met and to identify and address required changes.

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Appendix A: Survey Forms

There are three survey forms and boat presence/absence maps used for the boat-based creel survey. The boat presence/absence maps are used to aid survey agents to identify boats berthed in their usual locations. The survey forms include:

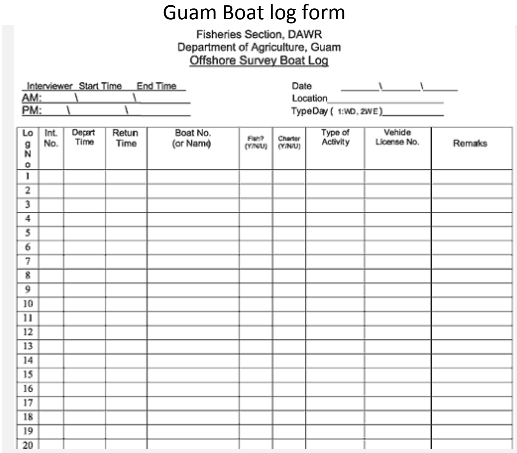
- Boat log form
- Interview form
- Participation count form

The Boat log form is used by survey agents to record boating activities at a given launching site or marina by indicating the boats out fishing and those currently berthed. A boat presence/absence map is used as a guide to identify boats that are usually berthed at the same spot. The Interview form is used by survey agents during contact with a fisher and covers various aspects of the fishing trip including, gear usage, catch composition, and efforts are made to measure the catch[3]. The Participation count form is completed by survey agents as they visit each port in a survey region, and is used to determine the scale of fishing activity on a given survey day. The interview and participation count forms of the shore-based survey are similar to those of the boat-based survey. In this section, the sample forms presented are of the boat-based survey.

Guam

Boat-based creel survey forms are provided below. In addition to the boat presence/absence map, Guam uses a Boat log form, Interview form, and Participation count form. Shore-based survey program forms are limited to the Interview form and the Participation count form. The boat-based survey forms are shown in the figures A1-A3.

FigureA1.
Guam Boat log form



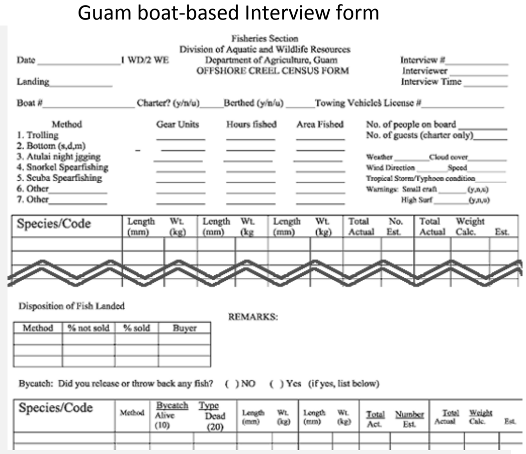
Fisheries Section, DAWR
Department of Agriculture, Guam
Offshore Survey Boat Log

Interviewer Start Time End Time
AM: \ \
PM: \ \

Date \ \
Location
TypeDay (1:WD, 2WE)

Log No	Int. No.	Depart Time	Retun Time	Boat No. (or Name)	Fish? (Y/N/U)	Charter (Y/N/U)	Type of Activity	Vehicle License No.	Remarks
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

Figure A2.
Guam boat-based Interview form



Fisheries Section
Division of Aquatic and Wildlife Resources
Department of Agriculture, Guam
OFFSHORE CREEL CENSUS FORM

Date 1 WD/2 WE
Landing
Interview #
Interviewer
Interview Time

Boat # Charter? (y/n/u) Berthed (y/n/u) Towing Vehicle's License #

Method	Gear Units	Hours fished	Area Fished
1. Trolling			
2. Bottom (s,d,m)			
3. Atulai night jgging			
4. Snorkel Spearfishing			
5. Scuba Spearfishing			
6. Other			
7. Other			

No. of people on board
No. of guests (charter only)
Weather Cloud cover
Wind Direction Speed
Tropical Storm/Typhoon condition
Warnings: Small craft (y,n,u)
High Surf (y,n,u)

Species/Code	Length (mm)	Wt. (kg)	Length (mm)	Wt. (kg	Length (mm)	Wt. (kg)	Total Actual	No. Est.	Total Actual	Weight Calc.	Est.

Disposition of Fish Landed

Method	% not sold	% sold	Buyer

REMARKS:

Bycatch: Did you release or throw back any fish? ( ) NO ( ) Yes (if yes, list below)

Species/Code	Method	Bycatch Alive (10)	Type Dead (20)	Length (mm)	Wt. (kg)	Length (mm)	Wt. (kg)	Total Act.	Number Est.	Total Actual	Weight Calc.	Est.

[3] In the past survey agents made efforts to weigh a portion, or all, of the catch - where practical.

Figure A3.
Guam boat-based Participation count form

DEPARTMENT OF AGRICULTURE
FISHERIES SECTION, DIVISION OF AQUATIC AND WILDLIFE RESOURCES
OFFSHORE VEHICLE-TRAILER PARTICIPATION CENSUS

DATE______________ WD WE/H

DAY SURVEY: STAFF____________

Port Number	Port	No. Vehicle-Trailers	Time
1	AGANA BOAT BASIN		
2	AGAT MARINA		
3	MERIZO PIER		
4	PAGO BAY		
5	YLIG BAY		
6	UMATAC BAY		
7	AGAT BAY		
8	SEAPLANE RAMP		
9 (Other)			
9 (Other)			
9 (Other)			

Saipan

In addition to boat presence/absence maps, Saipan uses a Boat log form, Interview form, and Participation count form. On the Participation count form, charter boat trips are recorded separately since the characteristics of their fishing trips are different than others. Examples of the forms are presented in Figure A4-A6.

Figure A4.
Saipan Boat log form

Saipan Boat-based Boat Log Form

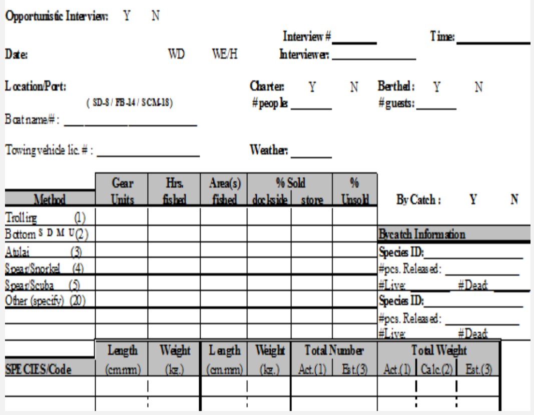
Date: ____________ WD WE/H

Interviewer	Time Start	Time End

PORTS	
Sugar Dock (8)	
Fishing Base (14)	
Smiling Cove (18)	

Log #	Int. #	Depart time	Return time	Boat # / Name	Charter Y / N	Type of Activity	Fish Y / N	Remarks
1.				CM				
2.				CM				
3.				CM				

Figure A5.
Saipan boat-based Interview form

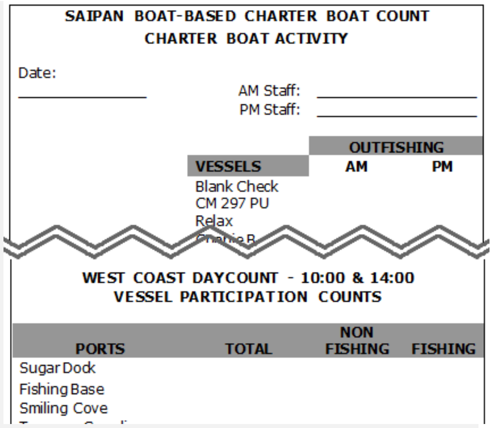

Opportunistic Interview: Y N
Interview # ______ Time: ________
Date: WD WE/H Interviewer: ________
Location/Port: (SD-8 / FB-14 / SCM-18) Charter: Y N #people ______ Berthed: Y N #guests: ______
Boat name#: ________
Towing vehicle lic. #: ________ Weather: ______

Method	Gear Units	Hrs. fished	Area(s) fished	% Sold dockside	% Sold store	% Unsold
Trolling (1)						
Bottom S D M U (2)						
Atulai (3)						
Spear/Snorkel (4)						
Spear/Scuba (5)						
Other (specify) (20)						

By Catch: Y N
Bycatch Information
Species ID: ________
#pcs. Released: ________
#Live ______ #Dead ______
Species ID: ________
#pcs. Released: ________
#Live ______ #Dead ______

SPECIES/Code	Length (cm.mm)	Weight (kg.)	Length (cm.mm)	Weight (kg.)	Total Number Act.(1)	Total Number Est.(3)	Total Weight Act.(1)	Total Weight Calc.(2)	Total Weight Est.(3)

Figure A6.
Saipan boat-based Participation count form


SAIPAN BOAT-BASED CHARTER BOAT COUNT
CHARTER BOAT ACTIVITY
Date: ________
AM Staff: ________
PM Staff: ________

VESSELS	OUTFISHING AM	OUTFISHING PM
Blank Check		
CM 297 PU		
Relax		

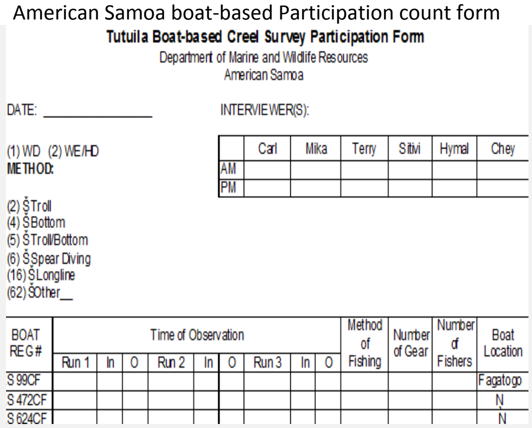
WEST COAST DAYCOUNT - 10:00 & 14:00
VESSEL PARTICIPATION COUNTS

PORTS	TOTAL	NON FISHING	FISHING
Sugar Dock			
Fishing Base			
Smiling Cove			

American Samoa

In American Samoa, only a Participation count form and Interview form are used. Unlike Guam and Saipan, there is no separate Boat log form or presence/absence map. The Participation count form includes boat log information as well. Examples of forms used in American Samoa are presented below:

Figure A7.
American Samoa boat-based Participation count form

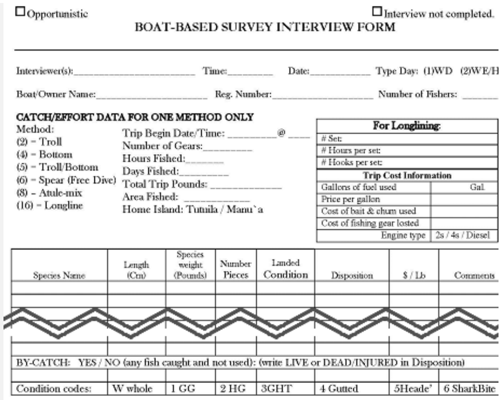

Tutuila Boat-based Creel Survey Participation Form
Department of Marine and Wildlife Resources
American Samoa
DATE: ________ INTERVIEWER(S):

	Carl	Mika	Terry	Sitivi	Hymal	Chey
AM						
PM						

(1) WD (2) WE/HD
METHOD:
(2) Troll
(4) Bottom
(5) Troll/Bottom
(6) Spear Diving
(16) Longline
(62) Other__

BOAT REG#	Run 1	In	O	Run 2	In	O	Run 3	In	O	Method of Fishing	Number of Gear	Number of Fishers	Boat Location
S 99CF													Fagatogo
S 472CF													N
S 624CF													N

Figure A8.
American Samoa boat-based Interview form


☐Opportunistic ☐Interview not completed.
BOAT-BASED SURVEY INTERVIEW FORM
Interviewer(s):________ Time:________ Date:________ Type Day: (1)WD (2)WE/H
Boat/Owner Name:________ Reg. Number:________ Number of Fishers: ______
CATCH/EFFORT DATA FOR ONE METHOD ONLY
Method:
(2) - Troll
(4) - Bottom
(5) - Troll/Bottom
(6) - Spear (Free Dive)
(8) - Atule-mix
(16) - Longline
Trip Begin Date/Time: ________@ ____
Number of Gears:________
Hours Fished:________
Days Fished:________
Total Trip Pounds: ________
Area Fished: ________
Home Island: Tutuila / Manu`a

For Longlining:	
# Set:	
# Hours per set:	
# Hooks per set:	
Trip Cost Information	
Gallons of fuel used	Gal
Price per gallon	
Cost of bait & chum used	
Cost of fishing gear losted	
Engine type	2s / 4s / Diesel

Species Name	Length (Cm)	Species weight (Pounds)	Number Pieces	Landed Condition	Disposition	$ / Lb	Comments
BY-CATCH: YES / NO (any fish caught and not used): (write LIVE or DEAD/INJURED in Disposition)							
Condition codes:	W whole	1 GG	2 HG	3GHT	4 Gutted	5Heade'	6 SharkBite

The Interview survey form collects information about the fishing trip including catch and effort data, as well as fishing-related information such as weather, tides, etc. (Oram et al., 2010a-f). Currently, efforts are also made to measure the fork length of each fish caught, but fish are no longer weighed by survey agents during interviews.

There are various ways to collect and record catch information from fishing trips depending on how much time is allotted for survey agents and amount of catch to estimate. The current form provides a guideline for data collection that is suitable for small fish counts (i.e., one row per fish), but does not provide for alternative methods of counting or estimating catch by survey agents.

The interview form may be re-designed to reflect the information currently being collected (eliminate data fields that are no longer collected).

Guidelines for various methods must be established and documented, and a means on survey forms need to be included to provide survey agents flexibility in using alternative methods to better estimate catch during interviews with significant amount of catch. It also may be helpful to always keep copies of waterproof forms in the survey binder in case of bad weather.

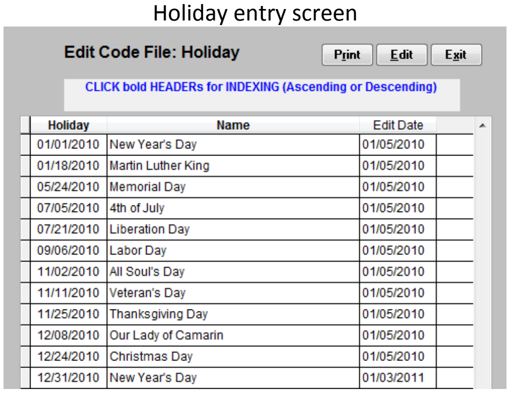
Appendix B: Data Entry and Database Structure

The creel survey data system is developed in Visual Fox Pro 9.0 SP2 and maintained by WPacFIN staff to support data entry, data management, estimation, and report generation.

<u>Data entry</u>

The data entry is performed at local agencies either by a survey agent, program manager or a data entry technician. Prior to entering survey data, other support information needs to be entered in the data system, namely, holidays and sample days (examples are shown in Figure B1 and B2). It is part of the data quality effort to ensure survey days are properly entered, and that holidays are excluded from the sample days.

Figure B1.
Holiday entry screen



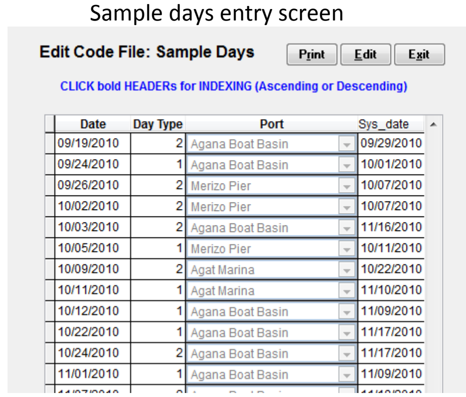
Edit Code File: Holiday

Print | Edit | Exit

CLICK bold HEADERs for INDEXING (Ascending or Descending)

Holiday	Name	Edit Date
01/01/2010	New Year's Day	01/05/2010
01/18/2010	Martin Luther King	01/05/2010
05/24/2010	Memorial Day	01/05/2010
07/05/2010	4th of July	01/05/2010
07/21/2010	Liberation Day	01/05/2010
09/06/2010	Labor Day	01/05/2010
11/02/2010	All Soul's Day	01/05/2010
11/11/2010	Veteran's Day	01/05/2010
11/25/2010	Thanksgiving Day	01/05/2010
12/08/2010	Our Lady of Camarin	01/05/2010
12/24/2010	Christmas Day	01/05/2010
12/31/2010	New Year's Day	01/03/2011

Figure B2.
Sample days entry screen



Edit Code File: Sample Days

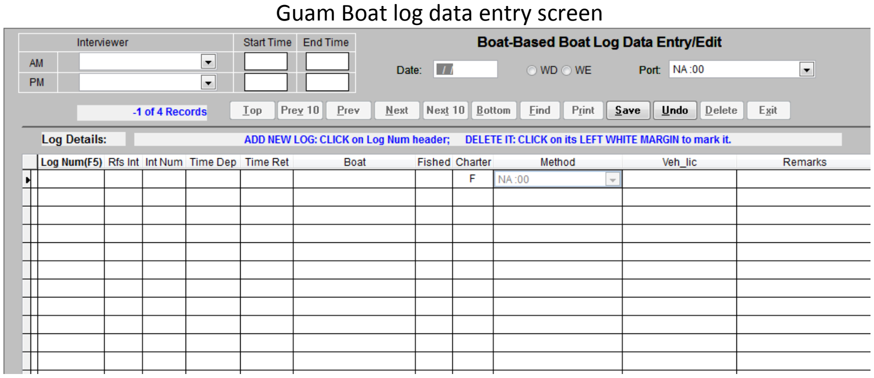
Print | Edit | Exit

CLICK bold HEADERs for INDEXING (Ascending or Descending)

Date	Day Type	Port	Sys_date
09/19/2010	2	Agana Boat Basin	09/29/2010
09/24/2010	1	Agana Boat Basin	10/01/2010
09/26/2010	2	Merizo Pier	10/07/2010
10/02/2010	2	Merizo Pier	10/07/2010
10/03/2010	2	Agana Boat Basin	11/16/2010
10/05/2010	1	Merizo Pier	10/11/2010
10/09/2010	2	Agat Marina	10/22/2010
10/11/2010	1	Agat Marina	11/10/2010
10/12/2010	1	Agana Boat Basin	11/09/2010
10/22/2010	1	Agana Boat Basin	11/17/2010
10/24/2010	2	Agana Boat Basin	11/17/2010
11/01/2010	1	Agana Boat Basin	11/09/2010

Once the support data are in the system, the survey data may be entered. Boat log data need to be entered prior to the interview data. Participation count data may be entered independently. Data entry screens were designed to resemble the forms used in the field. The Guam data entry screens are shown in Figures B3 – B5 as an example.

Figure B3.
Guam Boat log data entry screen



Boat-Based Boat Log Data Entry/Edit

	Interviewer	Start Time	End Time
AM			
PM			

Date: / / ○ WD ○ WE Port: NA :00

-1 of 4 Records

Top | Prev 10 | Prev | Next | Next 10 | Bottom | Find | Print | Save | Undo | Delete | Exit

Log Details: ADD NEW LOG: CLICK on Log Num header; DELETE IT: CLICK on its LEFT WHITE MARGIN to mark it.

Log Num(F5)	Rfs Int	Int Num	Time Dep	Time Ret	Boat	Fished	Charter	Method	Veh_lic	Remarks
							F	NA :00		

Figure B4.
Guam boat-based interview data entry screen

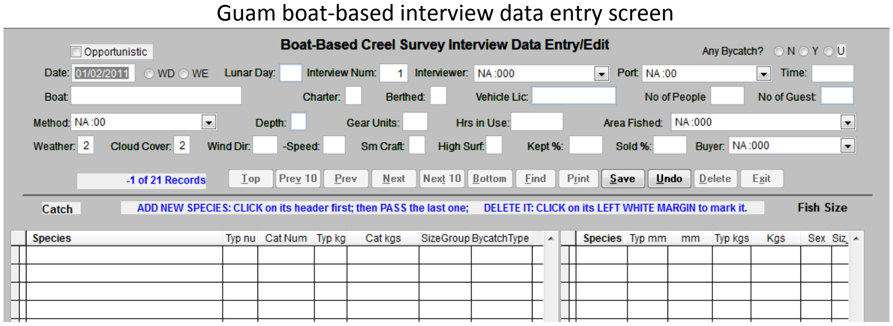
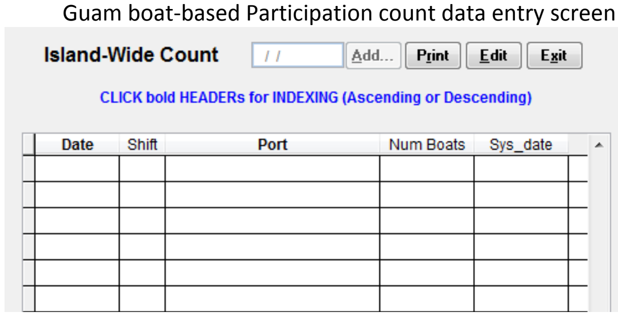


Figure B5.
Guam boat-based Participation count data entry screen



The creel survey data system provides a user-friendly data entry screen. Layers of strict data control modules are implemented in the data entry system in order to prevent entry errors and to collect data in a consistent format.

The data entry has a functionality that computes values for missing data. For example, the weight of a fish is estimated by the data system and is available as an input value for interview data entry since weight is no longer obtained during the interview survey. However, the formulae used in these data processes need to be clearly documented.

Data quality control

There are multiple layers of data quality control protocols implemented in the system.

1. Rules: Each data box has a rule or rules for valid data entry. If the entered information is out of range or is identified as an invalid data entry, the system prompts a warning message and requires a change.
2. Auto-fill: Forms have auto-fill capability for consistent information and reduces potential errors between forms when similar information is collected across multiple forms. For example, as mentioned above, sample days are already entered in the system with scheduled port id and date. In boat log data entry, as the date is typed, the port id is automatically filled out.
3. Drop-down selection: for data entry values that are frequently used or are from a known selection, the data box provides drop-down selection for a user to choose from. This prevents

spelling errors and eliminates different ways of entering the same information. Some of the entry boxes with drop down selection are listed below:

- List of locations fished
- Names of buyers if catch to be sold
- Cloud conditions
- Disposition
- Names of interviewers
- List of fishing methods
- List of ports
- Other weather conditions

Creel survey data entry-level quality control rules are strict and if they are not met, the system does not allow the user to proceed to next entry box unless the current box is filled with a value in a correct range. Data entry technicians seem to feel comfortable using the system. While some strict rules reduce efficiency, they greatly reduce the chance of simple data entry errors.

However, some rules may need to be examined. One example is that the system does not allow further data entry unless a required box is filled. The quality control may be implemented at the end of the entry screen so the user would not submit without missing values instead of being stopped at each box. During testing of the data entry, the author was caught in one box and made the system crash as she was trying to get out or to find values for the box.

Due to recent changes in the menu structure for the American Samoa data entry system, the system users seem to be confused and are having trouble understanding the new structure. The users assumed that some of the functionalities have disappeared while they were simply relocated in the new structure. It is recommended that improved documentation be developed and that a user manual must also be drafted and must include any updates for the users of the data system.

<u>Database structure</u>

The creel survey data are stored in a relational database in Visual FoxPro 9.0. The survey data and support information are stored in relational database tables (see Figures B6-B8). There are temporary tables that are used during the expansion process. Once the process is completed, the temporarily tables are emptied.

Figure B6.
Guam creel survey relational database structure

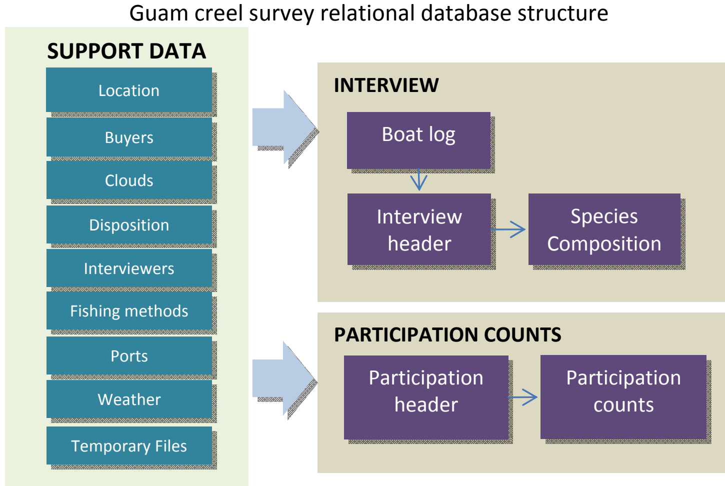


Figure B7.
Saipan creel survey relational database structure

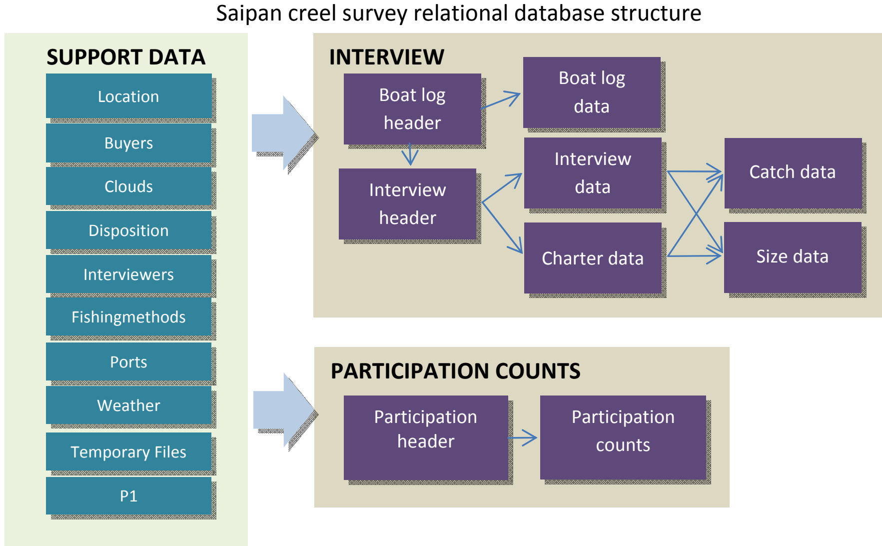
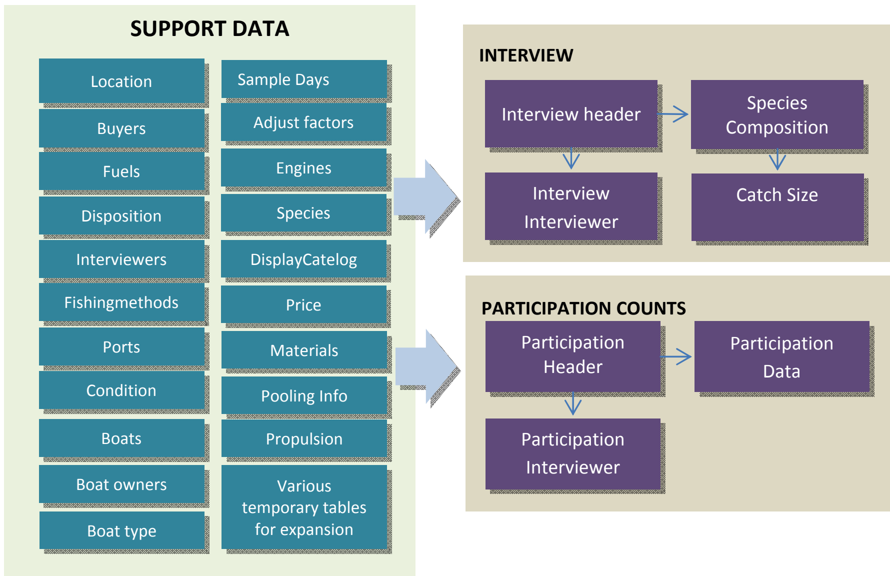


Figure B8.
American Samoa creel survey relational database structure



For the shore-based surveys, the database structure looks similar. The only difference is the set of support files and there are no boat log related tables.

Visual FoxPro 9.0 is the last version of FoxPro that Microsoft has developed and support for the current version will expire in 2015. While still updating and maintaining the current FoxPro data system, WPacFIN is in the process of developing creel survey data programs in an alternative system to replace FoxPro.

The Guam and Saipan data systems and American Samoa system were created and are maintained by different developers. The database structure and design are slightly different among each island. A master database and consistent structures across regions may be developed to account for potential changes in sampling design and could incorporate additional databases or structure to support the different aspects of data collection at each region.

Data reporting

Summary reports are produced from the data entered in the database of the WPacFIN data system. Generally, quarterly and annual reports are generated for various plan teams, and the reports include total catch and effort of species by fishing method, and species composition information. The sample reports are shown in Tables B1-B2.

Table B1.

Sample summary report of annual catch and effort estimates generated from the WPacFIN data system

Division of Aquatic & Wildlife Resources
Department of Agriculture
Government of Guam

May 23, 2011 11:14 AM — Page: 1 — Weight Unit: kg

Boat-Based Creel Survey Expansion Summary

For January to December, 2010

Based on Expanding Full Time-Period Data

Method	Type of Day	Num of Int	kg/hr	kg/gr-hr	kg/trip	Expanded Data (CV %) Trip	Catch(kg)	Hour	Person	Prsn-hr	Gear-hr
	Weekday										
TROLLING		269	6.10	1.90	30.48 (52.4)	6,044 (12.4)	184,204 (12.4)	30,219	16,368	74,642	96,848
BOTTOM		40	1.06	0.33	4.29 (82.1)	1,657 (5.7)	7,104 (17.4)	6,693	4,706	18,465	21,776
ATULAI NIGHT LIGHT		3	3.54	1.59	21.06 (88.9)	85 (51.5)	1,781 (72.4)	502	167	997	1,118
SPEAR/SNORKEL		12	3.88	1.34	10.87 (53.6)	1,057 (8.0)	11,482 (13.9)	2,958	3,102	8,712	8,567
	Weekend/Holiday										
TROLLING		397	6.56	1.90	31.07 (70.4)	4,670 (13.2)	145,098 (12.6)	22,115	14,133	61,197	76,374
BOTTOM		119	1.69	0.61	8.43 (59.7)	2,119 (12.4)	17,871 (3.0)	10,558	5,348	26,238	29,533
ATULAI NIGHT LIGHT		7	3.30	1.25	21.72 (89.6)	123 (28.8)	2,673 (45.7)	809	246	1,624	2,133
SPEAR/SNORKEL		11	3.64	1.38	10.80	356 (6.2)	3,847 (38.6)	1,056	1,129	3,527	2,783
SPEAR/SCUBA			22.87	7.47	36.60	31 (51.3)	1,134 (51.3)	50	124	186	152
JIGGING			3.11	1.10	10.90	5 (98.2)	53 (98.2)	17	19	73	48
	Combined Day-Type										
TROLLING		666	6.29	1.90	30.73 (88.1)	10,714 (9.1)	329,302 (8.9)	52,333	30,502	135,839	173,222
BOTTOM		159	1.45	0.49	6.61 (92.9)	3,776 (7.4)	24,975 (4.5)	17,250	10,054	44,703	51,309
ATULAI NIGHT LIGHT		10	3.39	1.37	21.45	208 (27.0)	4,453 (39.9)	1,312	413	2,620	3,250
SPEAR/SNORKEL		23	3.82	1.35	10.85	1,413 (5.8)	15,330 (14.2)	4,014	4,231	12,239	11,350

Table B2.

Sample summary report of species composition of annual catch generated from the WPacFIN data system

Division of Aquatic & Wildlife Resources
Department of Agriculture
Government of Guam

May 23, 2011 11:19 AM — Page: 6 — Weight Unit: kg

Boat-Based Creel Survey Species Composition

For January to December, 2010

Based on Expanding Full Time-Period Data

All Species	TOTAL	Trolling	Bottom	Atulai	Mix Spear		ɔa	Others
Sargocentron diadema	6		6					
Group %	*<0.01*		*0.03*					
Gymnocranius microdon	4		4					
Group %	*<0.01*		*0.02*					
Pontinus macrocephalus	3		3					
Group %	*<0.01*		*0.01*					
Balistidae	1		1					
Group %	*<0.01*		*<0.01*					
TOTAL (kg):	383,100	329,302	24,980	4,452		15,327	805	8,231
Method %	*100.00*	*85.95*	*6.51*	*1.16*		*4.00*	*0.21*	*2.14*

In summary, the current WPacFIN data system performs the following tasks:

- providing data entry screen and controls data entry errors
- storing data in a relational database structure
- computing estimates of total catch and fishing effort using the data entered
- generating summary reports of the computed estimates and statistical properties such as coefficient of variation of the estimates

The data system is designed for data entry, estimation, and reporting. It flags and controls errors caused by data entry. The system may be utilized not only for data reporting, but also reporting of efficiency of estimators to better understand the performance of the survey design and identify the data gap. Modules may be developed in the system to derive statistical properties of the estimates to determine statistical validity of estimates. Currently, coefficient of variation (CV) is computed as part of a summary report, however, the non-standardized sampling and survey design may make computation difficult, thus the current estimation of variance needs to be evaluated and alternative methods may be pursued.

Appendix C: Expansion Algorithms: Boat-based Survey

Guam

In WPacFIN boat-based creel survey estimation, total catch (C) is estimated as a function of catch per unit effort (CPUE) and total effort (T), where the measure of effort is the number of trips taken for each fishing method, and CPUE is catch per trip.

The estimated total catch ($\hat{C}_D$) in a given period of time (*D*) is computed as the product of the estimated total effort ($\hat{T}$) and the estimated catch per unit effort ($\widehat{CPUE}$):

$$\hat{C}_D = \widehat{CPUE}_D \times \hat{T}_D$$

The algorithm used in the estimation of $C, CPUE \text{ and } T$, known as the *Expansion Algorithm (Algorithm),* was developed and implemented in Microsoft Fox Pro by WPacFIN to deliver automated expansion of the parameters using creel survey data and to generate reports.

The creel survey utilizes stratified sampling where the target population is stratified by day type, month and site ($h = 1, \ldots H$). In the *Algorithm,* survey data are grouped by trip type (charter, non-charter) and fishing method ($g = 1, \ldots, G$), and group estimates of each stratum are computed.

The Guam boat-based creel survey utilizes access-roving survey methods. The sample catch is obtained by interviewing fishers as survey agents are stationed at a scheduled access site and wait for fishers to return from their fishing trips; the sample effort is obtained by agents recording fishing effort in the boat log during survey hours. The Participation count survey is conducted to collect effort data as survey agents travel to each access site around the island.

Estimation of Total Effort ($\hat{\mathrm{T}}$)

The total effort estimation of the boat-based fisheries involves boat log and participation count data.

For the access surveys (interview and boat log), only three ports are sampled (Agat, Agana, and Merizo). The *Algorithm* attempts to compute effort estimates of the un-sampled ports with some assumptions. The estimated total effort for a given period of time *D,* is a product of an averaged total effort per day and the number of days in *D* period:

(Estimated total effort) $$\hat{T}_{Dhg} = D_h \times \bar{T}_{hg}$$

To compute the total effort estimate, the survey data are retrieved from the survey database. How the *Expansion Algorithm* retrieves the data and uses them in estimation, as well as the data source are described in Table C1.

Table C1.
Variables and equations used in *Algorithm* to estimate total effort

Variables	Description	Data source
M_{hg}	Total number of scheduled sample days randomly selected by staff	SampleDay table [Database]
m_{hg}	Total number of observed sample days	Boat log header table [Database]
t_{hgi}	Observed total number of trips on the *ith* day	Boat log header table [Database]
$p1_{hg}$	Averaged temporal adjustment factor over a given period of time ***Note:*** *The values of **p1** range between 0 and 1, and determined by local staff*	P1 Support table [Database]
b_{hg}	Observed total number of fishing trips	Participation counts [Database]
T_{hg}	Observed total number of fishing trips ***Note:*** *total effort is estimated at stratum level. Total effort of ports not surveyed are estimated using data from other ports.* ***Assumptions***: *Port 90 is defined as all un-sampled ports combined) and Total effort of other un-sampled ports is equal to sum of port 2 (Agat) and port 3 (Merizo)*	$T_{hg} = \begin{cases} \sum_{i=1}^{m_{hg}} t_{hgi}, & surveyed\ ports \\ \sum_{i=1,\ g:port \ni \{2,3\}}^{m_{hg}} t_{hgi}, & not\ surveyed\ ports \end{cases}$
a_{1hg}	Ratio of number of observed fishing trips to number of observed non-fishing trips ***Note:*** *the ratio is used to determine ratio of fishing trips to non-fishing trips of survey data with missing information about fishing trips*	$a_{1_{gh}} = 1 + \frac{\sum_{fished=Unknown} t_{hgi}}{\sum_{fished=\{Y\ and\ N\}} t_{hgi}}$
a_{2hg}	Unknown fishing method	$a_{2_{gh}} = 1 + \frac{\sum_{method=unknown} t_{hgi}}{\sum_{method=known} t_{hgi}}$
a_{3hg}	Spatial adjustment factor for ports not surveyed ***Assumption***: *total effort of not surveyed is same as total effort of Agat and Merizo combined*	$a_{3_{hg}} = \begin{cases} \frac{\sum_{g:port>3} b_{hg}}{\sum_{g:port \ni \{2,3\}} b_{hg}}, & not\ surveyed\ ports \\ 1, & surveyed\ ports \end{cases}$
$\hat{T}_{hg}$	Adjusted total number of fishing trips	$\hat{T}_{hg} = (1/p1_{hg})\, a_{1_{gh}} a_2 a_{3_{gh}} T_{hg}$
$\bar{T}_{hg}$	Average number of fishing trips ***Assumption:*** *fishing effort was zero on unobserved days of scheduled sample day assuming survey was cancelled due to bad weather*	$\bar{T}_{hg} = \frac{T_{hg}}{M_{hg}}$
D_h	Number of days within a given period of time	

$\hat{\boldsymbol{T}}_{\boldsymbol{Dhg}}$	Estimated total number of fishing trips of group population	$\hat{T}_{Dhg} = D_h \times \bar{T}_{hg}$

Estimation of CPUE ($\widehat{CPUE}$) and Total Catch ($\hat{C}$)

The catch per unit effort (CPUE) is estimated as a ratio of the observed total catch from the sampled fishing trips to the total number of sampled fishing trips. Total catch (C) is then estimated as a product of estimated CPUE and the estimated total effort.

In estimation of CPUE, the survey data are stratified by day type and site ($h = 1, \ldots, H$). Similar to the effort estimation, survey data are grouped by trip type and fishing method ($g = 1, \ldots, G$) within a stratum, and group estimates of each stratum are computed.

When the number of interviews in a group is fewer than 3, data are borrowed from other stratum or group based on the priority list predetermined by island agency staff in consultation with WPacFIN staff.

(Estimator for CPUE)

$$\widehat{CPUE}_{hg} = \frac{weight\ of\ total\ sample\ catch_{hg}}{total\ sample\ trips_{hg}}$$

(Estimator for Total Catch)

$$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$$

To compute the estimates, the survey data are retrieved from the survey database. How the *Expansion Algorithm* retrieves the data and uses them in estimation of CPUE and total catch, as well as the data source are described in Table C2.

Table C2.

Variables and equations used in *Algorithm* to estimate CPUE and total catch

Variables	Description	Data source
$\boldsymbol{n_{hg}}$	Number of interviews on the *ith* day	Boat-based Interviews [Database]
$\boldsymbol{x_{hgi}}$	Total weight (kg) of catch on the *ith* day ***Note:*** *if number of h,g interviews is less than 3, pooling method applies*	Boat-based Interviews [Database]
$\widehat{\boldsymbol{CPUE}}_{\boldsymbol{hg}}$	Trip CPUE	$\widehat{CPUE}_{hg} = \begin{cases} \frac{\sum_{m_{hg}} x_{hgi}}{\sum_{m_{hg}} n_{hgi}}, & surveyed\ ports \\ \frac{\sum_{port\in\{2,3\}} \sum_{m_{hg}} x_{hgi}}{\sum_{port\in\{2,3\}} \sum_{m_{hg}} n_{hgi}}, & not\ surveyed \end{cases}$
$\hat{\boldsymbol{C}}_{\boldsymbol{hg}}$	Estimated total catch	$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$
$\widehat{\boldsymbol{Csp}}_{\boldsymbol{hg}}$	Estimated total catch of *sp* species $x_{sp_{hgi}}$ = total catch of sp species on ith day	$\widehat{Csp}_{hg} = \hat{C}_{hg} \times \frac{\sum_{m_{hg}} x_{sp_{hgi}}}{\sum_{m_{hg}} x_{hgi}}$

Saipan

In WPacFIN boat-based creel survey estimation, total catch (C) is estimated as a function of catch per unit effort (CPUE) and total effort (T), where the measure of effort is the number of trips taken for each fishing method, and CPUE is catch per trip.

The estimated total catch ($\hat{C}_D$) in a given period of time (*D*) is computed as the product of the estimated total effort ($\hat{T}$) and the estimated catch per unit effort ($\widehat{CPUE}$):

$$\hat{C}_D = \widehat{CPUE}_D \times \hat{T}_D$$

The algorithm used in the estimation of $C, CPUE$ and T, known as the *Expansion Algorithm (Algorithm),* was developed and implemented in Microsoft Fox Pro by WPacFIN to deliver automated expansion of the parameters using creel survey data and to generate reports.

The creel survey utilizes stratified sampling where the target population is stratified by day type, month and site ($h = 1, \ldots H$). In the *Algorithm,* survey data are grouped by trip type (charter, non-charter) and fishing method ($g = 1, .., G$). Due to unique characteristics between charter trips, survey data within each group and stratum were also grouped by charter type (head boat charter and *6-Pack* boat), and group estimates of each stratum are computed.

The Saipan boat-based creel survey utilizes access-roving survey methods. The sample catch is obtained by interviewing fishers as survey agents are stationed at a scheduled access site and wait for fishers to return from their fishing trips. Boat log is used to collect effort data during survey hours. The Participation count survey is conducted to collect effort data as survey agents travel to each access site around the island. For Saipan, Participation count survey data are used to compute effort estimates.

Estimation of Total Effort ($\hat{T}$)

The total effort estimation of the Saipan boat-based effort involves the boat log and the participation count data.
Estimated total effort for a given period of time *D,* is a product of an averaged total effort per day and the number of days in *D* period:

(Estimated total effort) $$\hat{T}_{hg} = D_h \times \bar{T}_{hg}$$

To compute the estimates, the survey data are retrieved from the survey database. The data are then assigned to variables described below, or used for computation of a value in estimation process. How the *Expansion Algorithm* retrieves the data and uses them in estimation, as well as the data sources are described in Table C3.

Table C3.
Variables and equations used in Algorithm to estimate total effort

Variables	Description	Data source
M_{hg}	Total number of scheduled sample days	SampleDay table [Database]
m_{hg}	Total number of sample days	Participation header table [Database]
t_{hgi}	Observed total number of trips on the *ith* day	Charter Participation Count [Database] Non-charter Participation Count [Database]
D_h	Number of days within a given period of time	
T_{hg}	Observed total number of fishing trips	$T_{hg} = \sum_{i=1}^{m_{hg}} t_{hgi}$
$\sum_{methods} T_{hg}$	Observed total number of fishing trips	$\sum_{methods} T_{hg} = \sum_{method} \sum_{i=1}^{m_{hg}} t_{hgi}$
$a_{1_{hg}}$	Fishing method adjustment factor	$a_{1_{hg}} = \frac{T_{hg}}{\sum_{methods} T_{hg}}$
$T_{\substack{method=bot,\\ charter=Y\\ deptime>1200}}$	Total number of bottomfish charter trips departed at noon or later	Boat Log
$T_{\substack{hg:port=92\\ shift:PM}}$	Total number of bottomfish head boat charter trips during evening survey shift	Participation count
$a_{2\ hg}$	Evening fishing adjustment	$\frac{\left(\max\left(T_{\substack{method=bot\\ charter=Y,\\ deptime>1200}}, T_{\substack{hg:g=headboat\\ shift:PM}}\right) + T_{\substack{hg:g=headboat\\ shift:AM}}\right)}{T_{hg:port=92}}$ $T_{\substack{method=bottomfish\\ charter=Y,\\ deptime>1200}}$ (from boat log) $T_{\substack{hg:port=headboat\\ shift:PM}}$ (from participation count form)
$\hat{T}_{hg}$	Adjusted total number of fishing trips within a given period of time ***Note:*** *where port 91 = 6-Pack charter, part 92= Head boats*	$\hat{T}_{hg} = \begin{cases} a_{1_{hg}} T_{hg}, & 6\ pack\ charter \\ a_{2_{hg}} T_{hg}, & headboats \\ a_{1_{hg}} a_{2_{hg}} T_{hg}, & otherwise \end{cases}$
$\bar{T}_{hg}$	Average number of fishing trips	$\bar{T}_{hg} = \frac{\hat{T}_{hg}}{M_{hg}}$
$\hat{T}_{Dhg}$	Estimated total number of fishing trips	$\hat{T}_{Dhg} = D_h \times \bar{T}_{hg}$

Estimation of CPUE ($\widehat{CPUE}_{hg}$) and Total Catch ($\hat{C}_{hg}$)

The catch per unit effort (CPUE) is estimated as a ratio of the observed total catch from the sample fishing trips to the total number of observed fishing effort. Total catch is then estimated as a product of estimated CPUE and the estimated total effort.

Similar to the effort estimation, depending on the requirement of reports, data are either grouped by or post-stratified by fishing method and trip type within each stratum of day type and site. When the number of interviews in a group is smaller than 3, data are borrowed within or between stratum and group based on the priority list predetermined by WPacFIN staff.

(Estimator for CPUE)

$$\widehat{CPUE}_{hg} = \frac{weight\ of\ total\ sample\ catch_{hg}}{total\ sample\ trips_{hg}}$$

(Estimator for Total Catch)

$$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$$

Table C4 shows how *Expansion Algorithm* retrieves the data and uses them in estimation of CPUE and total catch, as well as the data sources.

Table C4.
Variables and equations used in *Algorithm* to estimate CPUE and total catch

Variables	Description	Data source
$\boldsymbol{n_{hg}}$	Number of interviews on the *ith* day	Boat-based Interviews [Database]
$\boldsymbol{x_{hgi}}$	Total weight (kg) of catch on the *ith* day ***Note:*** *if number of h,g interviews is less than 3, pooling method applies*	Boat-based Interviews [Database]
$\boldsymbol{\widehat{CPUE}_{hg}}$	Trip CPUE	$\widehat{CPUE}_{hg} = \frac{\sum_{m_{hg}} x_{hgi}}{\sum_{m_{hg}} n_{hgi}}$
$\boldsymbol{\hat{C}_{hg}}$	Estimated total catch	$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$
$\boldsymbol{\widehat{Csp}_{hg}}$	Estimated total catch of *sp* species $x_{sp_{hgi}} =$ total catch of sp species on *ith* day	$\widehat{Csp}_{hg} = \hat{C}_{hg} \times \frac{\sum_{m_{hg}} x_{sp_{hgi}}}{\sum_{m_{hg}} x_{hgi}}$

American Samoa

In WPacFIN boat-based creel survey estimation, total catch (C) is estimated as a function of catch per unit effort (CPUE) and total effort (T), where the measure of effort is the number of trips taken for each fishing method, and CPUE is catch per trip.

The estimated total catch ($\hat{C}_D$) in a given period of time (*D*) is computed as the product of the estimated total effort ($\hat{T}$) and the estimated catch per unit effort ($\widehat{CPUE}$):

$$\hat{C}_D = \widehat{CPUE}_D \times \hat{T}_D$$

The algorithm used in the estimation of $C, CPUE$ and T, known as the *Expansion Algorithm (Algorithm),* was developed and implemented in Microsoft Fox Pro by WPacFIN to deliver automated expansion of the parameters using creel survey data and to generate reports.

The creel survey utilizes stratified sampling where the target population is stratified by day type, month and site ($h = 1, \ldots H$). In the *Algorithm,* survey data are grouped by fishing method ($g = 1, .., G$) and group estimates of each stratum are computed.

The American Samoa boat-based creel survey utilizes access-roving survey approach although the survey agents are not physically stationed at an access site to interview fishers. The Participation count survey is conducted to collect effort data as survey agents travel to each access site around the island.

Estimation of Total Effort ($\hat{\mathrm{T}}$)

The total effort estimation of the boat-based catch and effort involves participation count data which is analogous to boat log of Guam and Saipan. Estimated total effort for a given period of time *D,* is a product of an averaged total effort per day and the number of days in *D* period:

(Estimated total effort) $$\hat{T}_{hg} = D_h \times \bar{T}_{hg}$$

To compute the estimates, the survey data are retrieved from the survey database. How the *Expansion Algorithm* retrieves the data and uses them in estimation, as well as the data sources are described in Table C5.

Table C5.
Variables and equations used in *Algorithm* to estimate total effort

Variables	Description	Data source
M_{hg}	Total number of scheduled sample days scheduled	SampleDay table [Database]
m_{hg}	Total number of observed sample days	Boat log header table [Database]
t_{hgi}	Observed total number of trips on the *ith* day	Boat log header table [Database]
D_h	Number of days within a given period of time	
$p1_h$	Averaged temporal percent coverage over time *D* ***Note****: the value ranges from 0 to 100, and the range is determined by local staff*	Support table [Database]
$p2_h$	Averaged spatial percent coverage over time *D* ***Note****: the value ranges from 0 to 100, and the range is determined by local staff*	Support table [Database]
T_{hg}	Observed total number of fishing trips	$T_{hg} = \sum_{i=1}^{m_{hg}} t_{hgi}$
a_{1_h}	Spatial adjustment factor (%)	$a_{1_h} = 1/p1_{hg}$
a_{2_h}	Temporal adjustment factor (%)	$a_{2_h} = 1/p2_{hg}$
$a_{3_{hg}}$	Unknown fishing method adjustment factor ***Assumption****: ratio of fishing methods of unknown sample is similar to that of the known sample*	$a_{3_{hg}} = \frac{\sum_{g:method=unknown} t_{hgi}}{T_{hg}}$
$\hat{T}_{hg}$	Adjusted total number of fishing trips within a given period of time ***Note: 10000 are applied since a_{1_h} and a_{2_h} are percentages***	$\hat{T}_{hg} = 10000 \times a_{1_h} a_{2_h} T_{hg:method=known} + a_{3_h} T_{hg:method=known}$
$\bar{T}_{hg}$	Average number of fishing trips with each group ***Assumption:*** *fishing effort was zero on unobserved days of scheduled sample day assuming survey was cancelled due to bad weather*	$\bar{T}_{hg} = \frac{\hat{T}_{hg}}{M_{hg}}$
$\hat{T}_{Dhg}$	Estimated total number of fishing trips of group population	$\hat{T}_{Dhg} = D_h \times \bar{T}_{hg}$

Estimation of CPUE ($\widehat{CPUE}$) and Total Catch ($\hat{C}$)

The catch per unit effort (CPUE) is estimated as a ratio of the observed total catch from the sampled fishing trips to the total number of fishing effort. Total catch is then estimated as a product of estimated CPUE and the estimated total effort.

In estimation of CPUE, the sample frame is stratified by day type and site ($h = 1, \ldots, H$). Similar to the effort estimation, data are either grouped by or post-stratified by fishing method ($g = 1, \ldots, G$). When the number of interviews in a group is smaller than 3, data are borrowed within or between stratum and group based on the priority list predetermined by WPacFIN staff.

(Estimator for CPUE)

$$\widehat{CPUE}_{hg} = \frac{weight\ of\ total\ sample\ catch_{hg}}{total\ sample\ trips_{hg}}$$

(Estimator for Total Catch)

$$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$$

Table C6 shows how *Expansion Algorithm* retrieves the data and uses them in estimation of CPUE and total catch, as well as the data sources.

Table C6.
Variables and equations used in *Algorithm* to estimate CPUE and total catch

Variables	Description	Data source
n_{hg}	Number of interviews on the *ith* day	Boat-based Interviews [Database]
x_{hgi}	Total weight (kg) of catch on the *ith* day ***Note:*** *if number of h,g interviews is less than 3, pooling method applies*	Boat-based Interviews [Database]
$\widehat{CPUE}_{hg}$	Trip CPUE	$\frac{\sum_{m_{hg}} x_{hgi}}{\sum_{m_{hg}} n_{hgi}}$
$\hat{C}_{hg}$	Estimated total catch	$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$
$\widehat{Csp}_{hg}$	Estimated total catch of *sp* species $x_{sp_{hgi}} =$ total catch of sp species on ith day	$\widehat{Csp}_{hg} = \hat{C}_{hg} \times \frac{\sum_{m_{hg}} x_{sp_{hgi}}}{\sum_{m_{hg}} x_{hgi}}$

Appendix D: Expansion Algorithms: Shore-Based Survey

Guam

In WPacFIN shore-based creel survey estimation, total catch (C) is estimated as a function of catch per unit effort (CPUE) and total effort (T), where the measure of effort is the number of fishing hours taken for each fishing gear, and CPUE is catch per effort. Shore-based creel survey utilizes roving-roving survey methods.

For survey purposes, the shoreline of Guam is divided into four regions. Catch information is collected as survey agents drive along the coastline of a selected survey region on a given survey day, and intercept fishers for interview.

The effort information is obtained by participation count surveys as field staff drive along the coastline and count effort. Both boat-based and shore-based participation count surveys are conducted for 3 regions (one region is not accessible) on a given survey day. Aerial survey data cover the entire island and is used to correct for the region that is not covered by the shore-based creel survey.

Estimation of Total Effort ($\hat{T}$)

The total effort estimation of the shore-based fisheries involves participation count data. In estimation, it is stratified by day type (weekday and weekend), region (4 regions) and shift (morning and evening) ($h = 1, \ldots, h$), and grouped by fishing method ($g = 1, \ldots, G$). Due to the small number of samples collected, it is difficult to estimate effort by fishing method. For fishing methods other than *hook-and-line* (the most frequently encountered fishing method), group region is ignored.

Estimated total effort for a given period of time *D,* is a product of an averaged total effort per day and the number of days in *D* period:

(Estimated total effort) $$\hat{T}_{hg} = \hat{K}_h \times \bar{T}_{hg}$$

To compute the estimates, the survey data are retrieved from the survey database. The data are then assigned to variables described below, or used for computation of a value in estimation process. How the *Expansion Algorithm* retrieves the data and uses them in estimation, as well as the source of the data are described in Table D1.

Table D1.
Variables and equations used in *Algorithm* to estimate total effort of the shore-based fisheries

Variables	Description	Data source
$\boldsymbol{M_{hg}}$	Total number of scheduled sample days randomly selected by staff	SampleDay table [Database]
$\boldsymbol{m_{hg}}$	Total number of observed sample days	Participation counts [Database]
$\boldsymbol{b_{hgi}}$	Observed total number of fishers on the ith day	Participation counts [Database]
$\boldsymbol{B_{hg}}$	Observed total number of fishers	$B_{hg} = \sum_{i=1}^{m_{hg}} b_{hgi}$
$\boldsymbol{t_{hgi}}$	Observed total number of fishing gear on the ith day	Participation counts [Database]
$\boldsymbol{T_{hg}}$	Observed total number of fishing gears	$T_{hg} = \begin{cases} \sum_{i=1}^{m_{hg}} t_{hgi} \;, & \text{method} = \text{hook and line} \\ \sum_{\text{g:regions}} \sum_{i=1}^{m_{hg}} t_{hgi} \;, & \text{method} = \text{others} \end{cases}$
$\boldsymbol{A_{hg}}$	Total observed effort from aerial survey	Aerial Survey [Database]
$\boldsymbol{p2_{hg}}$	Spatial adjustment factor Group (g) = fishing method	$p2_{hg} = \frac{A_{hg:region=4}}{\sum_{g:region\ni\{1,2,3\}} A_{hg}}$
$\boldsymbol{\bar{T}_{hg}}$	Average number of fishing gears ***Assumption****: On a cancelled scheduled survey days, fishing effort is considered zero assuming that survey was cancelled due to bad weather*	$\bar{T}_{hg} = \frac{T_{hg}}{M_{hg}}$
$\boldsymbol{\bar{B}_{hg}}$	Average number of fishers ***Assumption****: On a cancelled scheduled survey days, fishing effort is considered zero assuming that survey was cancelled due to bad weather*	$\bar{B}_{hg} = \frac{B_{hg}}{M_{hg}}$
$\boldsymbol{D_h}$	Number of days within a given period of time	Simple math
$\boldsymbol{\hat{K}_h}$	Estimated total fishing hours	$\hat{K}_h = \begin{cases} \mathrm{D_h} \times 12, & \text{for day} \\ \mathrm{D_h} \times 8, & \text{for night} \end{cases}$
$\boldsymbol{\hat{B}_{hg}}$	Estimated total angler fishing hours	$\hat{K}_h \times \bar{B}_{hg}$
$\boldsymbol{\hat{T}_{hg}}$	Estimated total gear hours	$\hat{K}_h \times \bar{T}_{hg}$

Estimation of CPUE ($\widehat{CPUE}$) and Total Catch ($\hat{C}$)

The catch per unit effort (CPUE) is estimated per gear type as a ratio of the observed total catch to the total number of fishing hours for a given gear type. Total catch is then estimated as a product of estimated CPUE (catch/gear hour) and the estimated total effort (gear hours).

It is stratified by day type, region, and shift (morning/evening), and grouped by fishing method. Similar to effort estimation, the *Algorithm* ignores grouping by regions for fishing methods except for *hook-and-line* and then computes the catch estimate. When the number of interviews in a group is smaller than 3, it uses pre-calculated CPUE from historic data stored in the database instead of using the survey data.

(Estimator for CPUE) $$\widehat{CPUE}_{hg} = \frac{\text{total weight of catch}}{\text{total fishing gear hours}}$$

(Estimator for Total Catch) $$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$$

Table D2 shows how the *Expansion Algorithm* retrieves the data and uses them in estimation of CPUE and catch, as well as the data sources.

Table D2.
Variables and equations used in *Algorithm* to estimate CPUE and total catch

Variables	Description	Data source
$\boldsymbol{r_{hgi}}$	Total number of observed sample days	Interviews [Database]
$\boldsymbol{n_{hgi}}$	Number of interviews on the *ith* day	Interviews [Database]
$\boldsymbol{x_{hgi}}$	Total weight (kg) of catch on the *ith* day	Interviews [Database]
$\boldsymbol{tc_{hgi}}$	Observed total number of fishing gear on the *ith* day	Interviews[Database]
$\boldsymbol{bc_{hgi}}$	Total number of fishers on the *ith* day	Interviews[Database]
$\boldsymbol{s_{hgi}}$	Total number of hours fishing on the *ith* day ***Note:** hour of fishing until intercepted for interview*	Interviews [Database]
$\boldsymbol{\widehat{tc}_{hgi}}$	Estimated gear hours	$s_{hgi} \times tc_{hgi}$
$\boldsymbol{\widehat{CPUE}_{hg}}$	CPUE	$\widehat{CPUE}_{hg} = \begin{cases} \frac{\sum_{r_{hg}} x_{hgi}}{\sum_{r_{hg}} \widehat{tc}_{hgi}}, & \sum_{m_{hg}} n_{hgi} \geq 3 \\ \text{Precomputed CPUE}_{\text{hg}}, & otherwise \end{cases}$ $Precomputed\ CPUE_{hg}$ [Database]
$\boldsymbol{\hat{C}_{hg}}$	Estimated total catch	$\hat{C}_{hg} = \begin{cases} \widehat{CPUE}_{hg} \times \hat{T}_{hg}, & g: region \ni \{1,2,3\} \\ p2_{hg} \times \widehat{CPUE}_{hg} \times \hat{T}_{hg}, & g: region = 4 \end{cases}$
$\boldsymbol{\widehat{Csp}_{hg}}$	Estimated total catch of *sp* species $x_{sp_{hgi}} =$ total catch of sp species on ith day	$\widehat{Csp}_{hg} = \hat{C}_{hg} \times \frac{\sum_{r_{hg}} x_{sp_{hgi}}}{\sum_{r_{hg}} x_{hgi}}$

Saipan

In WPacFIN shore-based creel survey estimation, total catch (C) is estimated as a function of catch per unit effort (CPUE) and total effort (T), where the measure of effort is the number of fishing hours taken for each fishing gear, and CPUE is catch per effort. Shore-based creel survey utilizes roving-roving survey methods. Catch information is collected as survey agents drive along a coastline of a selected survey region on a given survey day, and intercept fishers for interview. The Effort information is obtained by participation count surveys as survey field agents drive along the coastline and count effort.

Estimation of Total Effort ($\hat{\mathrm{T}}$)

The total effort estimation of the shore-based fisheries involves participation count data. In estimation, it is stratified by day type (weekday and weekend), and shift (morning and evening) ($h = 1, \dots, H$), and grouped by fishing method ($g = 1, \dots, G$). Estimated total effort for a given period of time *D,* is a product of an averaged total effort per day and the estimated total fishing hours in *D* period.

(Estimated total effort) $$\hat{T}_{hg} = \hat{K}_h \times \bar{T}_{hg}$$

To compute the estimates, the survey data are retrieved from the survey database. The data are then assigned to variables described below, or used for computation of a value in estimation process. How the *Expansion Algorithm* retrieves the data and uses them in estimation, as well as the data sources are described in Table D3.

Table D3.
Variables and equations used in *Algorithm* to estimate total effort of the shore-based fisheries

Variables	Description	Data source
$\boldsymbol{M_{hg}}$	Total number of scheduled sample days randomly selected by staff	SampleDay table [Database]
$\boldsymbol{m_{hg}}$	Total number of observed sample days	Participation counts [Database]
$\boldsymbol{b_{hgi}}$	Observed total number of fishers on the *ith* day ** averaged count if there are more than one runs in a shift*	Participation counts [Database]
$\boldsymbol{B_{hg}}$	Observed total number of fishers	$B_{hg} = \sum_{i=1}^{m_{hg}} b_{hgi}$
$\boldsymbol{t_{hgi}}$	Observed total number of fishing gear on the *ith* day ** averaged count if there are more than one runs in a shift*	Participation counts [Database]
$\boldsymbol{T_{hg}}$	Observed total number of fishing gear	$T_{hg} = \begin{cases} \sum_{i=1}^{m_{hg}} t_{hgi}, & \text{method} = \text{hook and line} \\ \sum_{\text{g:methods} \neq 1} \sum_{i=1}^{m_{hg}} t_{hgi}, & \text{method} = \text{others} \end{cases}$
$\boldsymbol{\bar{T}_{hg}}$	Daily average number of fishing gears	$\bar{T}_{hg} = \frac{T_{hg}}{m_{hg}}$
$\boldsymbol{\bar{B}_{hg}}$	Average number of fishers	$\bar{B}_{hg} = \frac{B_{hg}}{m_{hg}}$
$\boldsymbol{D_h}$	Number of days within a given period of time	
$\boldsymbol{\hat{K}_{hg}}$	Estimated total fishing hours within $\mathrm{D_h}$ period of time	$\hat{K}_{hg} = \mathrm{D_h} \times 6$
$\boldsymbol{\hat{T}_{hg}}$	Estimated total gear hours	$\hat{K}_{hg} \times \bar{T}_{hg}$

Estimation of CPUE ($\widehat{CPUE}$) and Total Catch ($\hat{C}$)

The catch per unit effort (CPUE) is estimated per gear type as a ratio of the observed total catch to the total number of fishing hours for a given gear type. Total catch is then estimated as a product of estimated CPUE and the estimated total effort ($\hat{T}_{hg}$).

It is stratified by day type (weekday and weekend) and shift (morning evening), and grouped by fishing method. When the number of interviews in a group is smaller than 3, the *Algorithm* borrows survey data within or outside of stratum or group based on a priority list compiled by island agency staff in consultation with WPacFIN.

(Estimator for CPUE) $$\widehat{CPUE}_{hg} = \frac{\text{total weight of catch}}{\text{total fishing gear hours}}$$

(Estimator for Total Catch) $$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$$

Table D4 shows how *Expansion Algorithm* retrieves the data and uses them in estimation of CPUE and total catch.

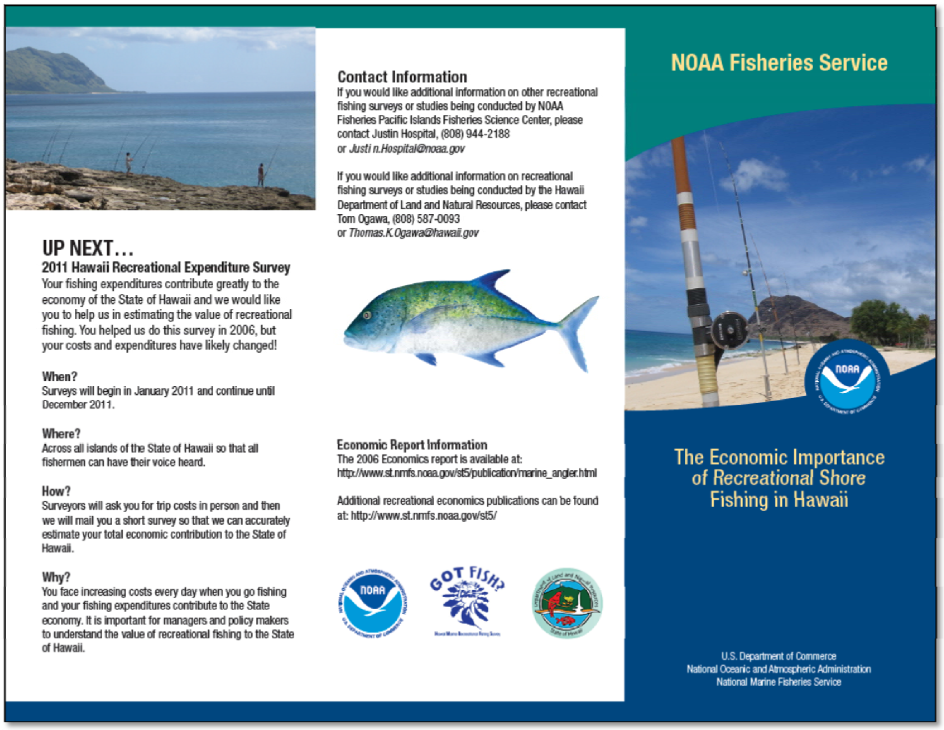
Table D4.
Variables and equations used in *Algorithm* to estimate CPUE and total catch

Variables	Description	Data source
n_{hgi}	Number of interviews on the *ith* day	Interviews [Database]
x_{hgi}	Total weight (kg) of catch on the *ith* day	Interviews [Database]
tc_{hgi}	Observed total number of fishing gear on the *ith* day	Interviews[Database]
bc_{hgi}	Total number of fishers on the *ith* day	Interviews[Database]
s_{hgi}	Total number of hours fishing on the *ith* day ***Note:** hour of fishing until intercepted for interview*	Interviews [Database]
$\hat{tc}_{hgi}$	Estimated gear hours	$s_{hgi} \times tc_{hgi}$
$\widehat{CPUE}_{hg}$	CPUE ***Note**: if number of interview is fewer than 3, data are borrowed from or outside of stratum or group*	$\widehat{CPUE}_{hg} = \frac{\sum_{m_{hg}} x_{hgi}}{\sum_{m_{hg}} \hat{tc}_{hgi}}$
$\hat{C}_{hg}$	Estimated total catch	$\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$
$\widehat{Csp}_{hg}$	Estimated total catch of *sp* species $x_{sp_{hgi}} =$ total catch of sp species on ith day	$\widehat{Csp}_{hg} = \hat{C}_{hg} \times \frac{\sum_{m_{hg}} x_{sp_{hgi}}}{\sum_{m_{hg}} x_{hgi}}$
$\widehat{Csp}$	Estimated total catch	$\sum_{g} \widehat{Csp}_{hg}$

American Samoa

Due to technical difficulties in accessing the computer codes of the Expansion Algorithm, the American Samoa shore-based Expansion Algorithm was not documented in this report.

Appendix E: Sample Outreach Brochure



UP NEXT…

2011 Hawaii Recreational Expenditure Survey

Your fishing expenditures contribute greatly to the economy of the State of Hawaii and we would like you to help us in estimating the value of recreational fishing. You helped us do this survey in 2006, but your costs and expenditures have likely changed!

When?

Surveys will begin in January 2011 and continue until December 2011.

Where?

Across all islands of the State of Hawaii so that all fishermen can have their voice heard.

How?

Surveyors will ask you for trip costs in person and then we will mail you a short survey so that we can accurately estimate your total economic contribution to the State of Hawaii.

Why?

You face increasing costs every day when you go fishing and your fishing expenditures contribute to the State economy. It is important for managers and policy makers to understand the value of recreational fishing to the State of Hawaii.

Contact Information

If you would like additional information on other recreational fishing surveys or studies being conducted by NOAA Fisheries Pacific Islands Fisheries Science Center, please contact Justin Hospital, (808) 944-2188 or *Justi n.Hospital@noaa.gov*

If you would like additional information on recreational fishing surveys or studies being conducted by the Hawaii Department of Land and Natural Resources, please contact Tom Ogawa, (808) 587-0093 or *Thomas.K.Ogawa@hawaii.gov*

Economic Report Information

The 2006 Economics report is available at: http://www.st.nmfs.noaa.gov/st5/publication/marine_angler.html

Additional recreational economics publications can be found at: http://www.st.nmfs.noaa.gov/st5/

GOT FISH?

NOAA Fisheries Service

The Economic Importance of Recreational Shore Fishing in Hawaii

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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"Evaluation of Creel Survey Program in the Western Pacific Region", page 59

2006
Hawaii Recreational Fishing Expenditure Survey Results

You helped us with this survey in 2006 and below are some results:

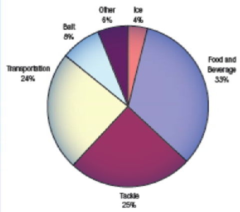
In total, Hawaii fishermen in 2006 supported **7,023** jobs in the State of Hawaii.

Your fishing expenditures generated **$772 million** in sales, and value-added benefits of **$380 million.**

Shore based fishermen's trip costs alone supported **1,176** jobs with total sales of **$110 million** and value added of **$53 million.**

In 2006 individual fishermen spent the following on a shore based fishing trip:

Individual Trip Costs : $41.09



Marine Recreational Fishing Survey Results 2008

Here is a summary of recent results from the Hawaii Marine Recreational Fishing Statistics Survey

Shore based fishing surveys completed in 2008: **1,709**

Average fishing time: **3 hours 47 minutes**

Average fishing trips in past 12 months: **54**

Shore fishing interviews with catch: **27%**

Shore fishermen that sold fish in the plast 12 months: **<1%**

In 2008, the top 5 fish caught (number of fish)

1. Akule
2. Weke'a (yellow-stripe goatfish)
3. Aholehole
4. Omilu
5. *Manini*

Where do you fish?
This table shows the percentage of completed interviews by location in 2008

Location	Percentage of Interviews
Natural Shoreline	60
Breakwater	23
Pier/Dock	15
Other	2

What type of gear do you fish with?
This table shows the percentage of completed interviews by gear type in 2008

Gear Type	Percentage of Interviews
Rod and Reel	89
Spear	5
Hand Pole	3
Throw Net	2
Other	1

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