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

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# 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.

Sampling design

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.

Survey Implementation and data collection

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.

# 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<br>• Roving | Smaller areas with few distinct access sites |
| • Access<br>• Roving<br>• Bus-route | Larger areas with more access sites |
| • Access<br>• Roving<br>• 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<br>Interview (catch)<br>Boat-log (effort) | Roving survey<br>Participation count (effort)<br>Aerial survey (effort) |
| **Shore-based** | Roving survey<br>Interview (catch) | Roving survey<br>Participation count (effort) |
| **Saipan** | | |
| **Boat-based** | Access survey<br>Interview (catch)<br>Boat-log (effort) | Roving survey<br>Participation count (effort) |
| **Shore-based** | Roving survey<br>Interview (catch) | Roving survey<br>Participation count (effort) |
| **American Samoa** | | |
| **Boat-based** | Access survey<br>Interview (catch) | Roving survey<br>Participation count (effort) |
| **Shore-based** | Roving survey<br>Interview (catch) | Roving survey<br>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.*)

Outreach effort and incentive system

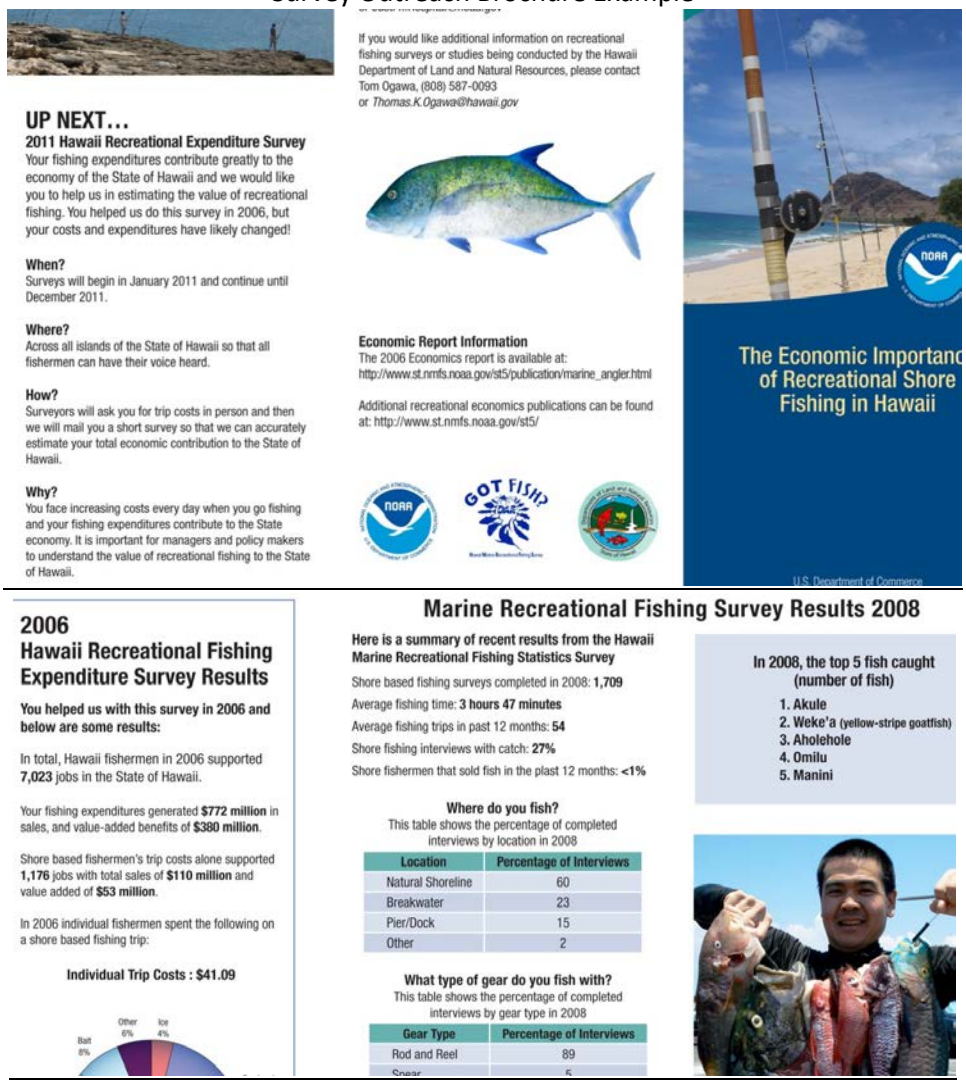
Outreach efforts are recommended to encourage the fishing community to participate in the creel survey. Brochures may be an effective method to introduce the survey program and describe the importance of their participation. They are affordable and can be easily distributed at tackle shops or tournaments, 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 and trip type (charter or non-charter), and strata being location (ports or access site) and day type (weekend and week day). In other words, total effort and catch estimates are computed for each fishing method, location, day type and trip type. However, some groups or strate 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 by 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 by 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 group estimates 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, 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.

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

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 by 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 by 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.

Biased in estimation

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

Other estimation issues

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.

Complete interview vs. Incomplete interview

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.

Guam Aerial Survey

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

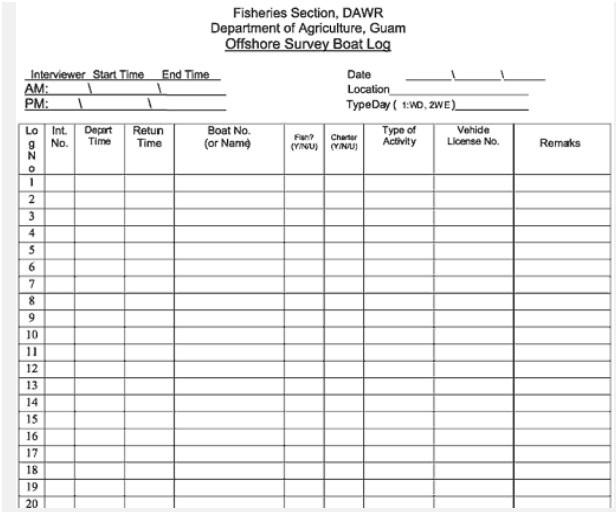
The Boat log form is used by survey agents to record boating activities at a given launching site or marina by indicating the boats out fishing and those currently berthed. A boat presence/absence map is used as a guide to identify boats that are usually berthed at the same spot. The Interview form is 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.

<u>Guam</u>

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 | Return 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 | | | | | | | | | |
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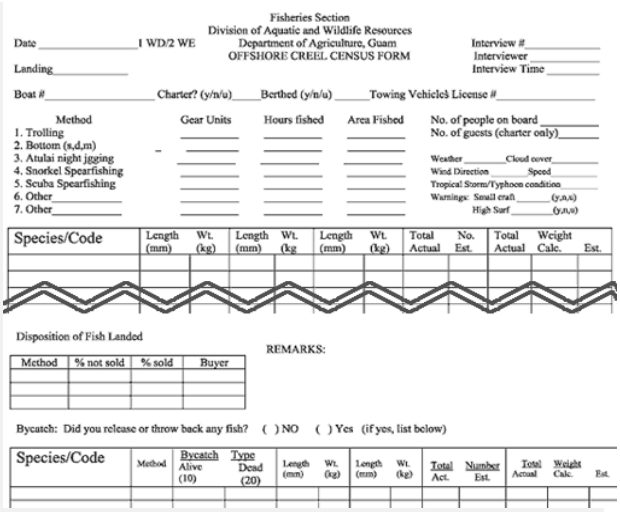
| 19 | | | | | | | | | |
| 20 | | | | | | | | | |

**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\ License #_____

Method
1. Trolling
2. Bottom (s,d,m)
3. Atulai night jigging
4. Snorkel Spearfishing
5. Scuba Spearfishing
6. Other_____
7. Other_____

Gear Units | Hours fished | Area Fished

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**

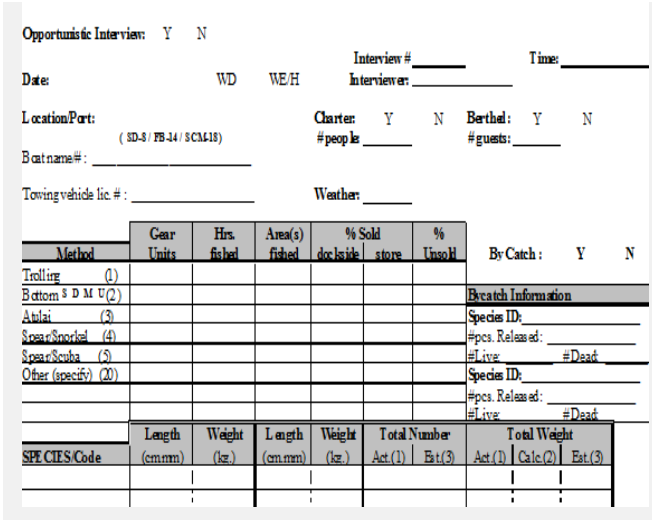
Date: _____ WD WE/H

| | Time | |
|---|---|---|
| Interviewer | Start | 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: Charter: Y N Berthed: Y N

( SD-S / FB-14 / SCM-18) #people _____ #guests:_____

Boat name#: _____

Towing vehicle lic.# : _____ Weather: _____

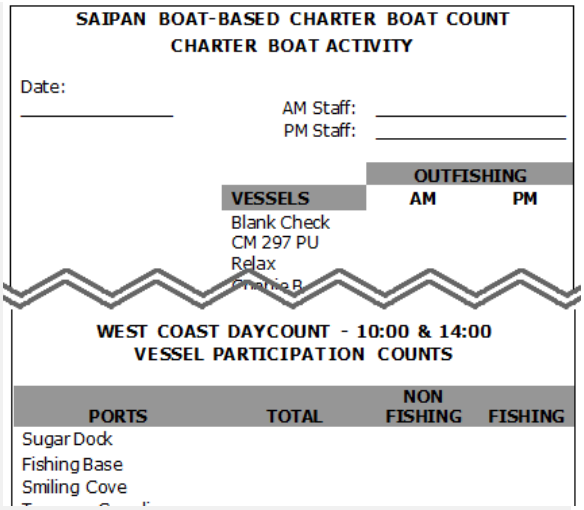
| Method | Gear Units | Hrs. fished | Area(s) fished | % Sold dockside | % Sold store | % Unsold |
|---|---|---|---|---|---|---|
| Trolling (1) | | | | | | |
| Bottom S D M U (2) | | | | | | |
| Atulai (3) | | | | | | |
| Spear/Snorkel (4) | | | | | | |
| Spear/Scuba (5) | | | | | | |
| Other (specify) (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 | PM |
|---|---|---|
| Blank Check | | |
| CM 297 PU | | |
| Relax | | |
| Charlie B | | |

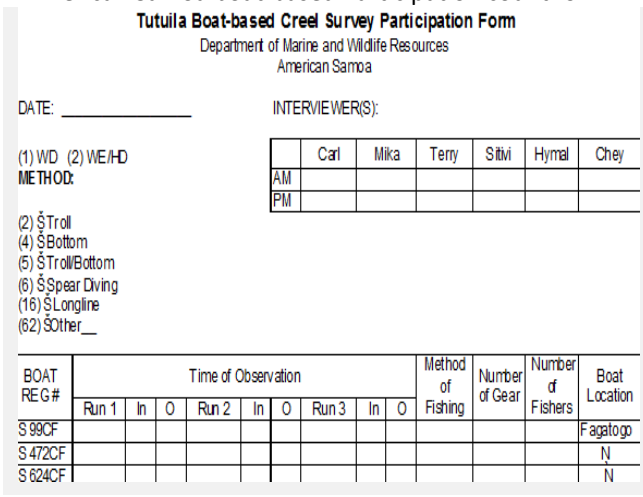
WEST COAST DAYCOUNT - 10:00 & 14:00
VESSEL PARTICIPATION COUNTS

| 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):

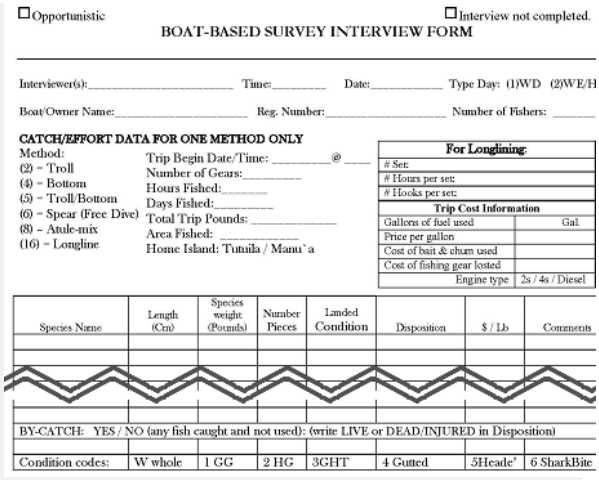
| | Carl | Mika | Terry | Sitivi | Hymal | Chey |
|---|---|---|---|---|---|---|
| AM | | | | | | |
| PM | | | | | | |

(1) WD (2) WE/HD
METHOD:

(2) ŠTroll
(4) ŠBottom
(5) ŠTroll/Bottom
(6) ŠSpear Diving
(16) ŠLongline
(62) ŠOther__

| BOAT REG# | Time of Observation 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.

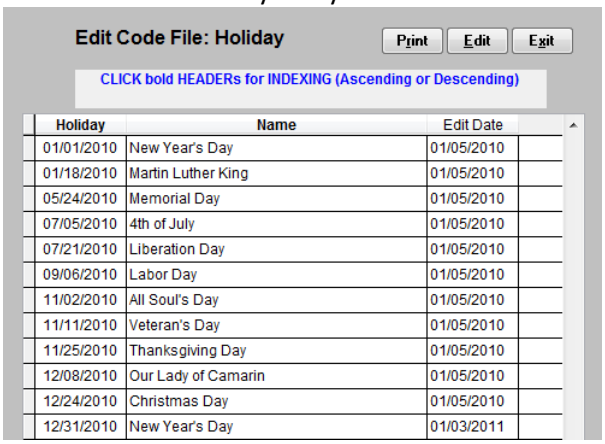
# Appendix B: Data Entry and Database Structure

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.

Data entry

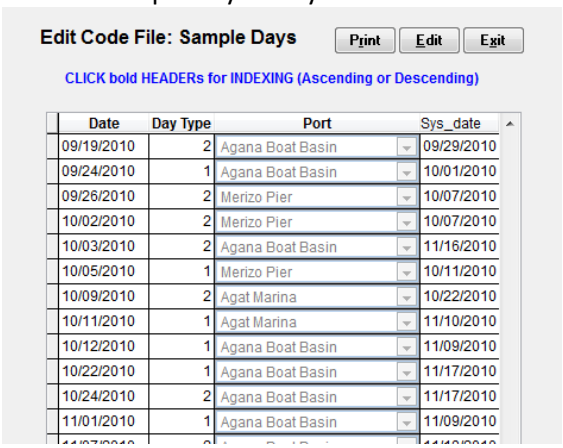
The data entry is performed at local agencies either by a survey agent, program manager or a data entry technician. Prior to entering survey data, other support information needs to be entered in the data system, namely, holidays and sample days (examples are shown in Figure B1 and B2). It is part of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




| 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




| 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

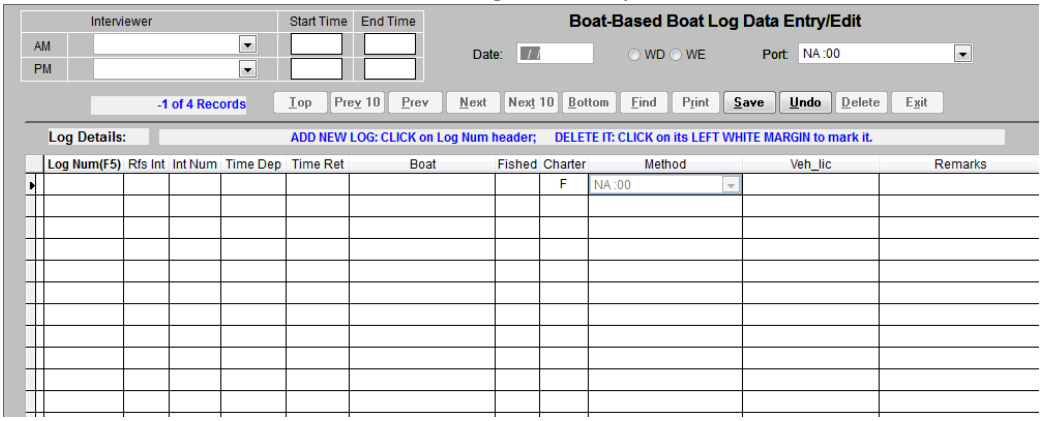


**Figure B4.**
Guam boat-based interview data entry screen

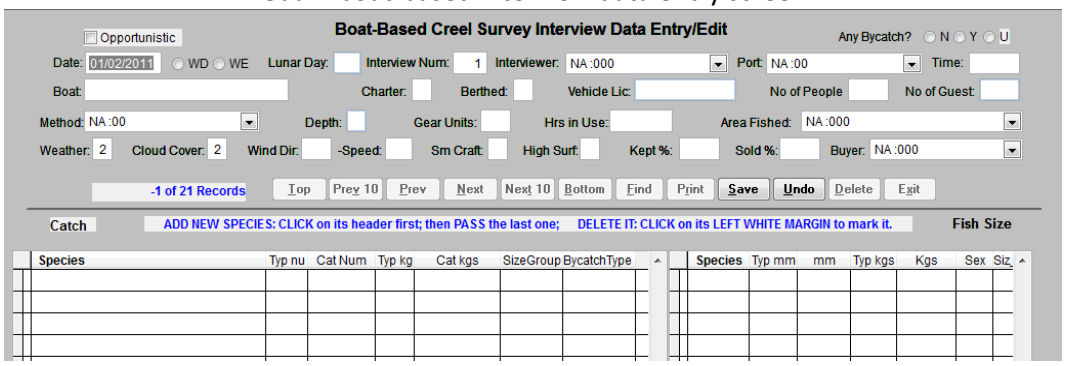
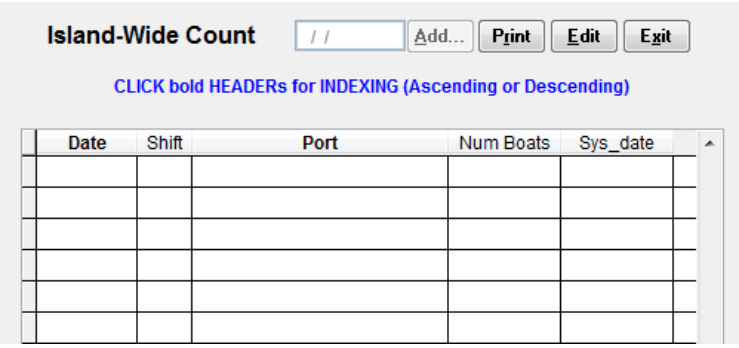



**Figure B5.**
Guam boat-based Participation count data entry screen




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.

Database structure

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

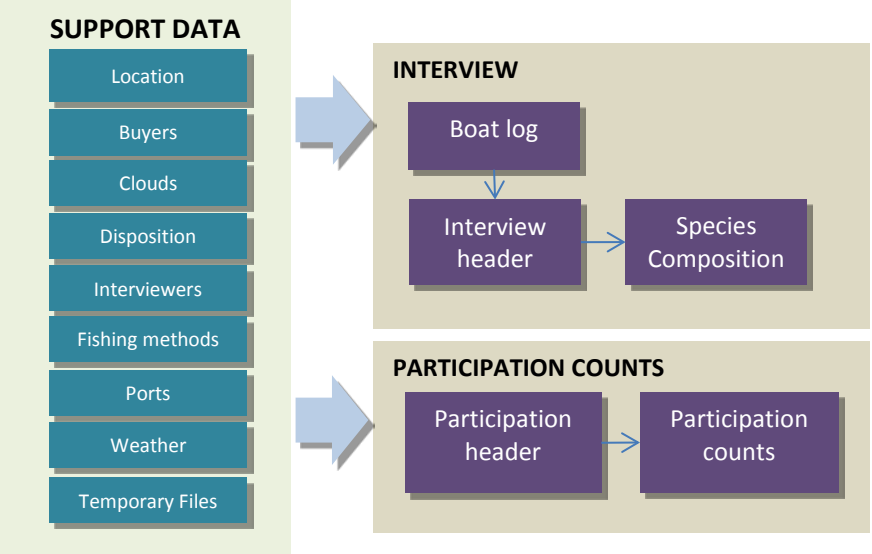



**Figure B7.**
Saipan creel survey relational database structure

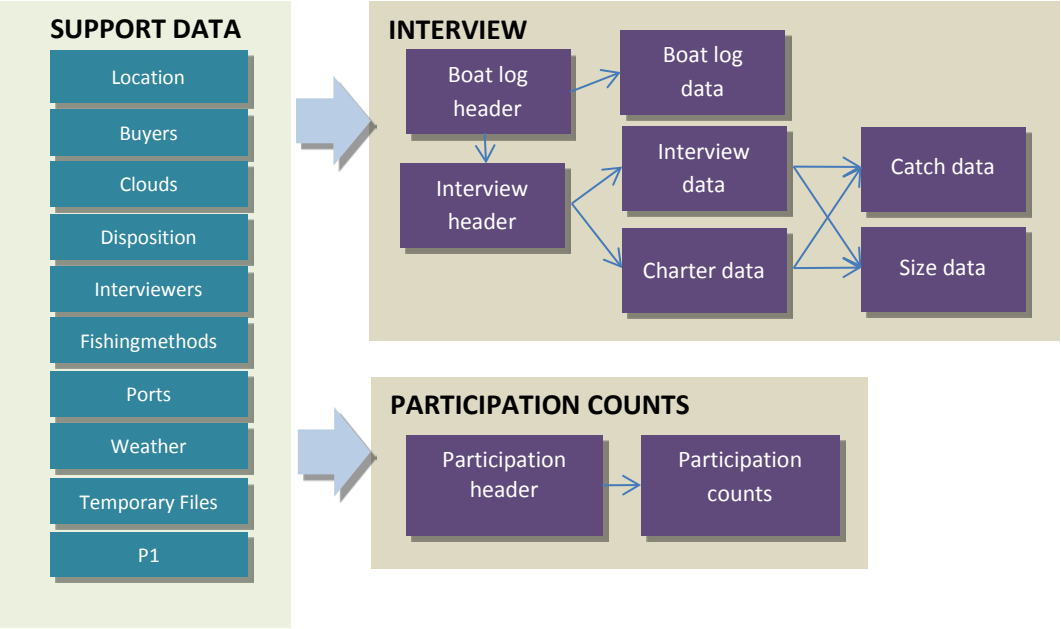
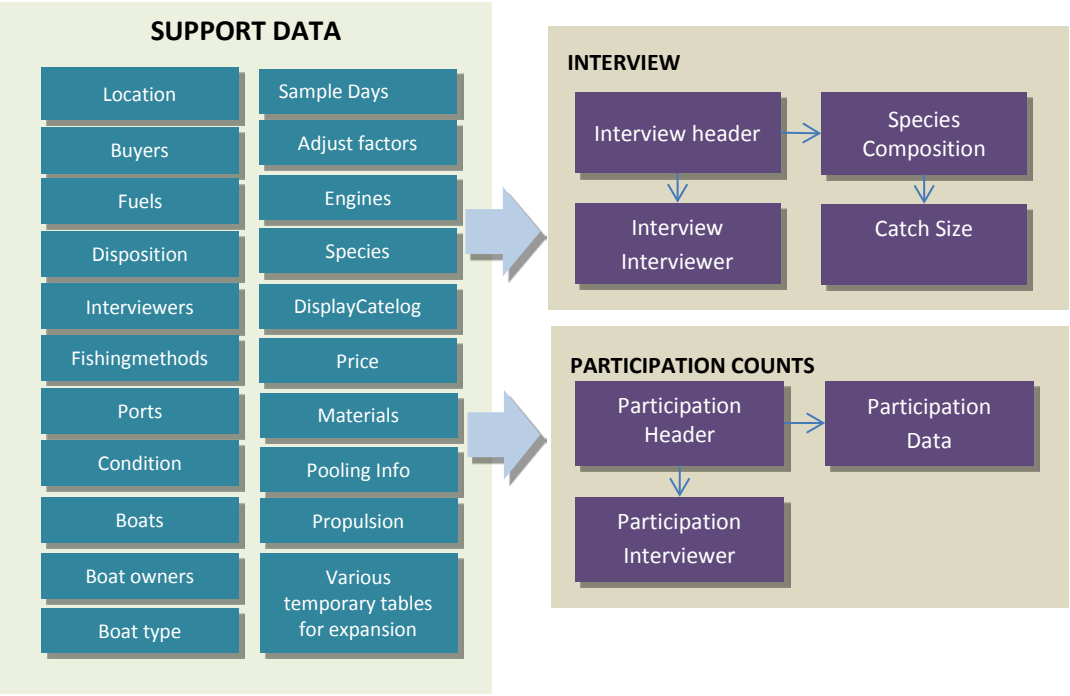


**Figure B8.**
American Samoa creel survey relational database structure




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 — Page: 1
11:14 AM — 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 | Expanded Data (CV %) kg/hr | kg/gr-hr | kg/trip | 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 — Page: 6
11:19 AM — 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 $C, CPUE$ 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 ($g = 1, .., G$), 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* ($\hat{T}$)

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<br>***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<br>***Note:*** *total effort is estimated at stratum level. Total effort of ports not surveyed are estimated using data from other ports.*<br>***Assumptions****:*<br>*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)* | $T_{hg} = \begin{cases} \sum_{i=1}^{m_{hg}} t_{hgi} \ , & surveyed\ ports \\ \sum_{i=1,\ \text{g:port} \ni \{2,3\}}^{m_{hg}} t_{hgi} \ , & not\ surveyed\ ports \end{cases}$ |
| $a_{1_{hg}}$ | Ratio of number of observed fishing trips to number of observed non-fishing trips<br>***Note:*** *the ratio is used to determine ratio of fishing trips to non-fishing trips of survey data with missing information about fishing trips* | $a_{1_{gh}} = 1 + \frac{\sum_{fished=Unknown} t_{hgi}}{\sum_{fished=\{Y\ and\ N\}} t_{hgi}}$ |
| $a_{2_{hg}}$ | Unknown fishing method | $a_{2_{gh}} = 1 + \frac{\sum_{method=unknown} t_{hgi}}{\sum_{method=known} t_{hgi}}$ |
| $a_{3_{hg}}$ | Spatial adjustment factor for ports not surveyed<br>***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<br>***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 | |

| | | |
|---|---|---|
| $\widehat{T}_{Dhg}$ | 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 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 ($h = 1, \dots, H$). Similar to the effort estimation, survey data are grouped by trip type and fishing method ($g = 1, \dots, G$) 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 |
|---|---|---|
| $n_{hg}$ | Number of interviews on the *ith* day | Boat-based Interviews [Database] |
| $x_{hgi}$ | Total weight (kg) of catch on the *ith* day<br>***Note:*** *if number of h,g interviews is less than 3, pooling method applies* | Boat-based Interviews [Database] |
| $\widehat{CPUE}_{hg}$ | Trip CPUE | $\widehat{CPUE}_{hg} = \begin{cases} \frac{\sum_{m_{hg}} x_{hgi}}{\sum_{m_{hg}} n_{hgi}}, & surveyed\ ports \\ \frac{\sum_{port \in \{2,3\}} \sum_{m_{hg}} x_{hgi}}{\sum_{port \in \{2,3\}} \sum_{m_{hg}} n_{hgi}}, & not\ surveyed \end{cases}$ |
| $\hat{C}_{hg}$ | Estimated total catch | $\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$ |
| $\widehat{Csp}_{hg}$ | Estimated total catch of *sp* species<br>$x_{sp_{hgi}}$ = 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<br>***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<br>***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<br>$x_{sp_{hgi}} =$ 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* ($\hat{T}$)

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*<br>***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*<br>***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<br>***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<br>***Note: 10000 are applied since $a_{1_h}$ and $a_{2_h}$ are percentages*** | $\hat{T}_{hg} = 10000 \times a_{1_h} a_{2_h} T_{hg:method=known} + a_{3_h} T_{hg:method=known}$ |
| $\overline{T}_{hg}$ | Average number of fishing trips with each group<br>***Assumption:** fishing effort was zero on unobserved days of scheduled sample day assuming survey was cancelled due to bad weather* | $\overline{T}_{hg} = \frac{\hat{T}_{hg}}{M_{hg}}$ |
| $\hat{T}_{Dhg}$ | Estimated total number of fishing trips of group population | $\hat{T}_{Dhg} = D_h \times \overline{T}_{hg}$ |

*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 ($h = 1, \dots, H$). Similar to the effort estimation, data are either grouped by or post-stratified by fishing method ($g = 1, \dots, G$). 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 |
|---|---|---|
| $\boldsymbol{n_{hg}}$ | Number of interviews on the *ith* day | Boat-based Interviews [Database] |
| $\boldsymbol{x_{hgi}}$ | Total weight (kg) of catch on the *ith* day<br>***Note:*** *if number of h,g interviews is less than 3, pooling method applies* | Boat-based Interviews [Database] |
| $\boldsymbol{\widehat{CPUE}_{hg}}$ | Trip CPUE | $\frac{\sum_{m_{hg}} x_{hgi}}{\sum_{m_{hg}} n_{hgi}}$ |
| $\boldsymbol{\hat{C}_{hg}}$ | Estimated total catch | $\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$ |
| $\boldsymbol{\widehat{Csp}_{hg}}$ | Estimated total catch of *sp* species<br>$x_{sp_{hgi}} =$ 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) ($h = 1, \dots, h$), and grouped by fishing method ($g = 1, \dots, G$). 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<br>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<br>***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<br>***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 |
|---|---|---|
| $r_{hgi}$ | Total number of observed sample days | Interviews [Database] |
| $n_{hgi}$ | 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] |
| $b\square_{hgi}$ | Total number of fishers on the *ith* day | Interviews[Database] |
| $s_{hgi}$ | Total number of hours fishing on the *ith* day<br>***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 | $\widehat{CPUE}_{hg} = \begin{cases} \frac{\sum_{r_{hg}} x_{hgi}}{\sum_{r_{hg}} \hat{tc}_{hgi}}, & \sum_{m_{hg}} n_{hgi} \geq 3 \\ \text{Precomputed CPUE}_{hg}, & otherwise \end{cases}$<br>$Precomputed\ CPUE_{hg}$ [Database] |
| $\hat{C}_{hg}$ | Estimated total catch | $\hat{C}_{hg} = \begin{cases} \widehat{CPUE}_{hg} \times \hat{T}_{hg}, & g{:}region \ni \{1,2,3\} \\ p2_{hg} \times \widehat{CPUE}_{hg} \times \hat{T}_{hg}, & g{:}region = 4 \end{cases}$ |
| $\widehat{Csp}_{hg}$ | Estimated total catch of *sp* species<br>$x_{sp_{hgi}}$ = 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* ($\widehat{\mathrm{T}}$)

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<br>** 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<br>** 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 |
|---|---|---|
| $\boldsymbol{n_{hgi}}$ | 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<br>***Note:*** *hour of fishing until intercepted for interview* | Interviews [Database] |
| $\boldsymbol{\hat{tc}_{hgi}}$ | Estimated gear hours | $s_{hgi} \times tc_{hgi}$ |
| $\boldsymbol{\widehat{CPUE}_{hg}}$ | CPUE<br>***Note****: if number of interview is fewer than 3, data are borrowed from or outside of stratum or group* | $\widehat{CPUE}_{hg} = \frac{\sum_{m_{hg}} x_{hgi}}{\sum_{m_{hg}} \hat{tc}_{hgi}}$ |
| $\boldsymbol{\hat{C}_{hg}}$ | Estimated total catch | $\hat{C}_{hg} = \widehat{CPUE}_{hg} \times \hat{T}_{hg}$ |
| $\boldsymbol{\widehat{Csp}_{hg}}$ | Estimated total catch of *sp* species<br>$x_{sp_{hgi}}$ = total catch of sp species on $ith$ day | $\widehat{Csp}_{hg} = \hat{C}_{hg} \times \frac{\sum_{m_{hg}} x_{sp_{hgi}}}{\sum_{m_{hg}} x_{hgi}}$ |
| $\boldsymbol{\widehat{Csp}}$ | Estimated total catch | $\sum_{g} \widehat{Csp}_{hg}$ |

## American Samoa Shore-based Creel survey *Expansion Algorithm*

The WPacFIN shore-based creel survey estimation utilizes two survey datasets: (1) Participation count survey data and (2) Interview data. The total effort (*B*) is estimated using the number of fishing gears used for each fishing gear type recorded in the participation count survey. The CPUE is computed as a ratio of the total observed catch and the total observed effort using interview data. The total catch estimate is then computed as a function of the two estimates: total effort and CPUE estimates.

Fishery parameters (total catch and effort, CPUE) are estimated per route (*r*), survey shift (*s*) and day type (*d*) for each gear type (*g)*. For simplicity, instead of writing out all 3 (*r,s,d,*) stratum levels, each stratum will have a single notation *h.* For example, the total catch of a stratum of a gear type *g* is denoted as $C_{h,g}$.

The effort information is obtained by participation count surveys as surveyors drive along the coastline and stop at designated areas to count effort. Catch information is collected as surveyors drive along a coastline of a selected survey region on a given survey day, and intercept fishers for interview. On a given survey day, both interview and participation count surveys are conducted and survey agents participate in multiple survey runs along the designated routes. The shore-based survey information, as recorded in 2011, is summarized below in Table 1.

**Table 1.** Sample frame for American Samoa shore-based creel survey program

| ID | Route | Survey days (sample size) |
|---|---|---|
| 1 | West : Amanave to Vaiola | At least 12 weekdays per month |
| 2 | Central: Nu'uuli to Aua | 2 weekend days per month |
| 3 | East: Lauli'i to Tula | |

The total effort estimation for shore-based fisheries involves participation count data. In estimation of total effort, it is stratified by day type (*d*: weekday and weekend), survey route (*r*: west, central, east) and day and night (*s*) and grouped by gear type ($g = 1, \dots, G$) to obtain the estimate for each gear type *g* for stratum (*h*). The observed fishing effort is then corrected with adjustment factor ***p1*** to compute the annual estimate of the total effort per stratum.

*Expansion Algorithm* utilizes data borrowing techniques (or pooling methods) when the sample size is too small to compute estimates of fishery parameters. When the number of interviews is fewer than 3 for a group, the algorithm looks for interview data outside of the group. There are several pooling methods used and they are executed in the order defined in the algorithm until the combined number of interview for the group becomes 3 or more.

*(Estimated total effort)* $$\widehat{\boldsymbol{B}}_{h,g} = \boldsymbol{p_1} \times \boldsymbol{observed\ total\ no.of\ gear\ hrs\ for\ gear\ g_h}$$

The CPUE is estimated using the sample data CPUE.

*(Estimated CPUE)* $$\widehat{\boldsymbol{CPUE}}_{\boldsymbol{h,g}} = \frac{\boldsymbol{observed\ total\ catch_{h,g}}}{\boldsymbol{observed\ gear\ hours_{h,g}}}$$

The total catch estimation for shore-based fisheries involves the estimated CPUE and the estimated total effort. Total catch estimates by species is computed using the estimated total catch and the proportion of species in the sample.

*(Estimated total catch)* $\widehat{C}_{h,g} = \widehat{CPUE}_{h,g} \times \widehat{B}_{h,g}$

*(Estimated total catch of species sp)* $\widehat{C}_{h,g,sp} = \left(\frac{\textbf{observed total catch of species sp}}{\textbf{observed total catch}}\right) \times \widehat{C}_{h,g}$

**Table 2.** Variables and equations used in *Algorithm* to estimate fisheries parameters

| Variables | Description | Data source |
|---|---|---|
| $m_{h,g}$ | Observed total number of interviews for *h* stratum and *g* gear type | [Interview data from Database] |
| $b_{h,g}$ | Observed total number of gears for *h* stratum and *g* gear type | [Interview data from Database] |
| $a_{h,g}$ | Observed total number of fishers for *h* stratum and *g* gear type | [Interview data from Database] |
| $p_{1_{h,g}}$ | Ratio of time segments that observed fishing activities (adjustment factor) in *h* stratum and *g* gear type | $\frac{\sum_{l\in\{1..6\}} I\{Z_{h,g,l} > 0\}}{6}$ *Where I is an indicator function that returns 1 if Z is greater than 0, else returns 0* |
| $K_{d_h}$ | Total number of days of day type *d* in *h* stratum | |
| $Z_h$ | Total number of Participation survey runs | [Participation data from Database] |
| $\widehat{B}_{h,g}$ | **Estimated total number of gear hours in *h* stratum and *g* gear type**<br><br>For expansion, there are twelve 2-hour time segments. Six of the time segments cover the hours of 6am-6pm (day) , and the remaining six cover the hours of 6pm- 6am (night). | $\frac{1}{p_{1,h,g}} \sum_{i\in\{1..6\}} \frac{2Kb_{h,g,i}}{Z_{h,g,i}}$ |
| $c_{h,g}$ | Observed total catch (lbs) in *h* stratum and *g* gear type | $\sum_{j=1}^{m_{hg}} c_{h,g,j}$ |
| $t_{h,g}$ | Observed total number of gear hours | $\sum_{j=1}^{m_{hg}} t_{h,g,j}$ |
| $\widehat{CPUE}_{h,g}$ | **Estimated CPUE** | $\frac{c_{h,g}}{t_{h,g}}$ |
| $\widehat{C}_{h,g}$ | **Estimated total catch (lbs)** | $\widehat{CPUE}_{h,g} \times \widehat{B}_{h,g}$ |
| $\widehat{C}_{h,g,sp}$ | **Estimated Total catch (lbs) for *sp*$^{th}$ species** | $\left(\frac{c_{h,g,sp}}{\sum_{sp\in\{all\ species\}} c_{h,g}}\right) \times \widehat{C}_{h,g,sp}$ |

# 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

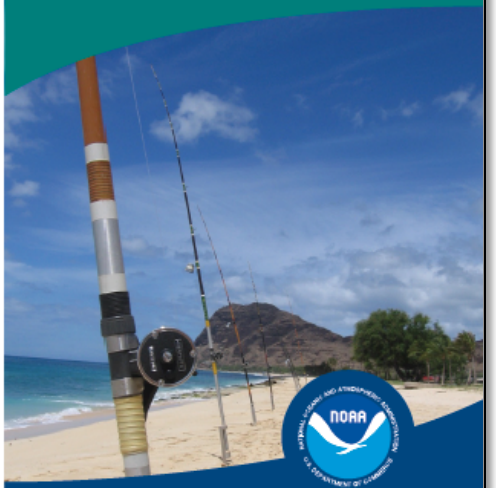
If you would like additional information on other recreational fishing surveys or studies being conducted by NOAA Fisheries Pacific Islands Fisheries Science Center, please contact Justin Hospital, (808) 944-2188
or *Justi n.Hospital@noaa.gov*

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/

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

## 2006
## Hawaii Recreational Fishing Expenditure Survey Results

**You helped us with this survey in 2006 and below are some results:**

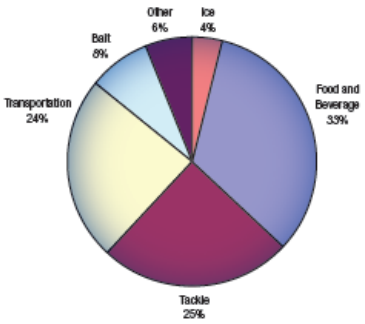
In total, Hawaii fishermen in 2006 supported **7,023** jobs in the State of Hawaii.

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 |