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A FISHERY DATA COLLECTION SYSTEM: SAIPAN

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A FISHERY DATA COLLECTION SYSTEM: SAIPAN

FINAL REPORT

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September 1983

PREFACE

This report was prepared under contract (No. 82-ABC-00224) by CIC Research, Inc. of San Diego, California. The objective of the contract was to develop and recommend a statistically sound fisheries data collection system for the Commonwealth of the Northern Mariana Islands, Division of Fish and Wildlife. To do this the contractor made an on-site visit to study the historical data and data collection methodologies used by the Division. Survey techniques and expansion algorithms were developed. Since this report was prepared under contract, the statements, findings, conclusions, and recommendations herein are those of the contractor and do not necessarily reflect the view of the National Marine Fisheries Service.

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Computer Systems Analyst

September 30, 1983

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INTRODUCTION

Since 1979, tourism in Saipan has increased by over 25 percent; an estimated 124,000 tourists visited the Island during 1982. The number of annual visitors to Saipan now exceeds eight times the size of the Island's resident population. This level of tourist activity, coupled with recently enacted regulations governing the purchasing of Island-produced commodities, subjects Saipan's fishing grounds to intense pressure. Not only do these fishing areas support an active commercial fleet, but a significant effort from subsistence and recreational fishermen as well.

At issue is determining the consequences that an increasingly significant fishing pressure will have upon the Island's fishing resources. In order to properly address this issue, a body of data describing the fishing activity on the Island must be compiled. The responsiblity for collecting fishing data falls on the Commonwealth of the Northern Mariana Islands' (CNMI) Division of Fish and Wildlife (DFW). It is the duty of the DFW to monitor all fishing activity on the Island in the hopes of identifying levels and trends in fishing participation, effort, and catch. To assist the DFW in their data collection role, this project will furnish the Division with the essential elements of a Fishery Data Collection System (FDCS) and indicate the procedures required to implement such a system.

The purpose of the FDCS is to generate a body of quality data on fishing activity on a continuous basis. Specifically, the major elements of the FDCS are as follows:

- Detailed description of FDCS objectives
- Specification of the general design components for the FDCS
- The required sampling designs
- Sampling activity procedures
- Processing methods for the system's data base
- Expansion algorithms and their reliability
- Quality assurance methods
- Presentation of FDCS data and results

In providing the framework for a FDCS, the study will assist the DFW in enacting a data collection program of its own.

The body of this report is divided into three sections: Section I briefly reviews the DFW's data collection activities. This review includes a look at past as well as current data gathering efforts. Section II describes the eight elements of an FDCS. This description involves a discussion of the range and type of activities which must be undertaken in order to satisfy the requirements for that particular element of the FDCS. Finally, Section III presents the recommendations on how to effectively implement the FDCS in Saipan.

This report is directed at Saipan and not the CNMI in general. However, the proposed system can be readily generalized to include the entire CNMI region. Throughout this report

possible alternatives or strategies for the FDCS will be discussed and assessed. The most feasible solution will always be identified. Again, the primary objective of this study is to serve as the cornerstone for the DFW's future data collection efforts.

SECTION I

REVIEW OF DATA COLLECTION ACTIVITIES

INTRODUCTION

Information describing Saipan's fishing activity has only recently been compiled. In fact, the DFW is now in the early stages of collecting fishing data. Primarily, the DFW's efforts have been directed to a single segment of the Island's fishing activity -- the commerical fishery. The DFW believes that 90 percent of the total Island-wide catch can be attributed to the commercial fishermen.

While the DFW's efforts in the field of collecting primary data may be relatively new, a review of these data gathering activities will be of value. The value of reviewing Saipan's past data collection efforts is twofold. First, such a review will assist during the specification stages of the FDCS's structure by reflecting the unique characteristics of the fishery. Second, by studying the data collection activities, previous pitfalls can be avoided when designing the FDCS. Therefore, this review will serve as the first step in developing a reliable and useful body of fishery statistics.

BRIEF HISTORICAL BACKGROUND OF DATA COLLECTION EFFORTS

The history of data collection efforts in Saipan shows a highly segmented and specialized approach to gathering fishing information. Beginning in the late 1970's, the DFW

entered the field of collecting fishing data. From the outset of these early survey efforts, the DFW has attempted to quantify the fishing activity of the offshore commerical fishery. These initial efforts were focused on the commerical fleet by developing vessel inventories. In addition, during this time, spotted effort was directed to obtaining catch information from the fleet. Most of the collection effort involved surveying retail outlets, thus providing information about only a portion of the commercial catch.

Unfortunately, due to a lack of procedural documentation, inconsistent surveying effort, and missing data, the past data collected is only of limited value. However, this information does provide a measure of commercial fleets' size. Basically, the size of the full-time commercial fleet over the past four years has been fairly stable, with only a slight increase. On the other hand, the part-time commercial fleet has grown over 40 percent since 1979. These figures indicate an overall growth in commercial fishing participation which can be attributed to the part-time fishermen.

CURRENT DATA COLLECTION SYSTEM

The DFW is now in the process of implementing a new data collection system. It is the goal of the DFW to establish a complete system which will accurately reflect the entire Island's fishing activity. During these initial developmental stages, the DFW has undertaken an ambitious survey program. However, before discussing the current program, a few

preparatory remarks are needed in order to place the current program in proper perspective.

Saipan is a relatively small island with 40 miles of beach coastline. The population of Saipan is approximately 15,000 residents. The DFW vessel log shows less than 150 fishing vessels and approximately 40 establishments buying local fish products. Together, each of these seemingly disjointed facts reveals a fishing activity level which is not numerically staggering and which may be suited to certain data collection procedures not normally feasible.

The DFW's personnel, primarily responsible for implementing the current system, possess unique and valuable knowledge about Saipan's fishing activity. Not only do these individuals have this knowledge base, but they personally know most of the Island's fishermen. These personal relationships represent a valuable asset to successfully implementing the current system.

Description of the Data Collection System

The DFW has chosen to develop its FDCS in a segmented manner by concentrating on a single type of fishing activity at a time. The focus of the current system is the commercial fishery. This fishing activity is the obvious choice because the bulk of past data collection efforts have been directed to commercial fishing. Essentially, the current system can be described as a census survey of the commercial fleet. The fleet includes full as well as part-time fishermen.

Two survey instruments have been developed and are being used to obtain the desired data. The first instrument is a fishing logbook. A logbook is provided to each fisherman. The fishermen are instructed on how to fill out the log information sheet. A sample information sheet is presented in Figure 1. At the conclusion of each fishing trip the fisherman is asked to fill out an information sheet completely. The DFW collects the information sheets on a monthly basis. Basically, the information collected from the commercial fishermen includes catch data, number of fishermen (participation), time fishing (effort), and fishing gear. The DFW meets regularly with the fishermen to ensure that the logbooks are kept current.

The second survey instrument is directed at another level in the marketing chain of fish -- the fish purchasing establishments. At the present time, the breakdown of these establishments is as follows:

- Hotels - 17%
- Retail Outlets - 40%
- Restaurants - 13%
- Government Programs - 3%
- Mobile Stands - 27%

Figure 1

Division of Fish and Wildlife

Department of Natural Resources

CNMI Government

Fish Landing data (88-309)

Boat owner _____ Date: _____

Boatname/Number _____

Time out: _____ Time in: _____

Fuel Consumed _____ gals. ( ) Gasoline
( ) Diesel

Number of fishermen on Board _____

Type of fishing:

( ) Trolling
( ) Bottom fishing
( ) Spear fishing
( ) Gill Net
( ) Trap
( ) Other (Specify)

Catch Report

Species	No. of Pieces	Total Weight	Areas Fished

Each establishment is supplied with a stack of commercial sales data forms. A copy of one of these forms is shown in Figure 2. Each form is to be filled out at the time of a fish purchase. The form primarily solicits catch information concerning the sale. The DFW works closely with these establishments to ensure that the sales information is properly recorded. Every two weeks or so, the DFW collects these forms. The DFW regularly updates the list of fish purchasing establishments and makes sure that all are well supplied with forms.

By providing survey instruments to all known commercial fishermen and fish-purchasing establishments, the DFW is censusing the commercial fishing activity. This data collection effort was begun in late 1982. By the beginning of 1983, the vast majority of fishermen had been given logbooks and all the fish buyers had been furnished with sales data sheets.

From the data compiled by the DFW, the following general information is known about the commercial fishing on the Island. Table 1 shows the breakdown of Saipan's boat population by the fishing activity in which the boats are primarily engaged.

Figure 2

DIVISION OF FISH & WILDLIFE
Department of Natural Resources
CNMI-Government

COMMERCIAL SALES DATA 550

BUYER: _____ DATE: _____

SELLER: _____

SPECIES PELAGIC	No. of Pieces	Price per Pound	Total Weight (lbs.)	Total Value
1.. Skipjack Tuna/Katsuo				
2. Yellowfin Tuna/Manguro				
3. Dogtooth/White Tuna				
4. Wahoo/Saowara				
5. Mahi Mahi/Dolphin				
6. Barracuda/Alu				
7. Rainbow Runner/Burri				
8. Marlin				
9. Other				
REEF FISH				
1. Big Eyed Scad/Atulai				
2. Goat fish/Satmonetti				
3. Squirrelfish/Sagamelon				
4. Mullet/Laiguan				
5. Rudderfish/Guili				
6. Rabbitfish/Hiting				
7. Surgeonfish/Hijok, Hugupao				
8. Parrotfish/Laggua				
9. Unicorn/Tataga				
10. Wrasse/Gaddas				
11. Other				
BOTTOM FISH				
1. Snapper/Mafuti				
2. Grouper/Gadao				
3. Onaga				
4. Opakapaka				
5. Gindai				
6. Other				
Lobster/Mahongan				

Table 1

PRIMARY FISHING ACTIVITY OF
SAIPAN'S BOAT POPULATION

Primary Fishing Activity	Percent Participating In Primary Activity
Full-time commercial fishing	23.4%
Part-time commercial fishing	68.8
Recreational fishing	7.1
No fishing	0.7

Source: CIC Research, Inc.
DFW

Ninety-nine percent of the boats in Saipan are used for fishing. The majority of these boats participate in part-time commercial fishing.

The primary fishing method for the commercial fleet is trolling, with spearfishing the most prevalent secondary method. Table 2 shows the distribution of fishing boats by fishing method, both primary and secondary. Principally, there are four fishing methods used: trolling, bottom, spear, and handline. Most of the fishing fleet is able to readily change fishing gear; this is especially true for the part-time fishermen.

Table 2

PERCENT DISTRIBUTION OF FISHING BOATS BY PRIMARY AND SECONDARY FISHING METHODS

Fishing Method	Percent of Boats	
	Primary Method	Secondary Method
Trolling	79.9%	-0-
Bottom	-0-	13.7%
Spear	11.9	45.3
Handline	7.5	35.2
Other	.7	5.8
	100.0%	100.0%

Source: CIC Research, Inc.
DFW

ASSESSMENT OF DATA COLLECTION ACTIVITIES

To assist the DFW in evaluating its data collection efforts, this concluding segment of Section I assesses the current programs. This assessment looks not only at the operational aspects of the program, but considers the theoretical approach as well. The comments contained in this section are not necessarily presented in order of their importance to the overall data collection program.

Feasibility of Voluntary Fishermen Logbooks

The current survey program rests upon the success of fishermen maintaining logbooks. From a historical perspective, a

voluntary logbook program in the fishing industry seldom yields the desired information. The reason is simple: fishermen fail to complete the logbook information requested. Therefore, the odds appear to be against the DFW making the logbook program workable. However, two factors are in the Division's favor, if they are properly implemented. First, DFW personnel know the fishermen on a personal level. These relationships will undoubtedly assist the DFW in obtaining the logbook information. Second, the number of fishermen on Saipan is small enough to make tracking each fisherman feasible. The DFW should be able to monitor the fishermen on a regular basis. If the DFW spends the necessary time and effort, the likelihood of having a successful voluntary logbook program will be greatly increased.

Census Survey Approach

Another element in the logbook program is the DFW's desire to census the Island's fishermen and fish-buying establishments. Two issues must be considered in this area of the survey program. First, for the census to succeed, each member of the census group must be identified. Therefore, the DFW must update the status of each fisherman and fish buyer on a continuing basis, as well as add any new member to the appropriate group. Also, the future feasibility of a census survey must be reviewed. As the fishing industry in Saipan grows, will it still be practical to census the entire industry? If not, the DFW must consider alternative sampling programs and determine the set of conditions that must exist in order to implement the new scheme.

Survey Instruments

Careful consideration should be given by the DFW to the survey instruments now being used. The DFW must first determine what type of information it desires in its efforts to describe the Island's fishing activity. Usually, fishing data comprises information on catch, effort, and participation. Also, to assist in evaluating this data, information concerning gear used and weather conditions is often collected. The questionnaire should be easily understood by the respondent to ensure that it is properly filled out. In addition, information from fishermen should be sought concerning the questionnaire design. The scope of the questionnaire must also be defined. For example, is the survey instrument to be used for all types of fishing activity (i.e., full-time commercial, part-time commercial, recreational) or is a separate questionnaire required for each group? The DFW must resolve each of these issues before the program can be properly implemented.

Overall Data Collection Strategy

By focusing on only the commercial fishing sector, the DFW is segmenting its data collection efforts. In view of the fact that the DFW has been collecting fishing data for only a short while, this strategy is sound. In building a data collection program, often the entire program is started up at once. This type of start-up process usually leads to numerous problems in all areas and significantly reduces the quality of the data being collected. By implementing the data collection effort in

a step-wise fashion, the likelihood of having a successful program is greatly increased.

Other Activities Involved in Collecting Data

Even though the DFW is targeting the commercial fishery alone, a number of activities must be engaged in to ensure that the desired data is obtained. The entire program must be fully documented in terms of procedures and methods introduced to collect the fishing information. Without proper documentation, future analysis of the data would be severely restricted. Specifically, the DFW must define the following activities:

- Data tabulation methods
- Data processing methods
- Data expansion procedures
- Quality assurance methods
- Document surveying procedures
- Alternative survey strategies
- Presentation of results

Often, little thought is given to the many activities surrounding the actual collection procedures. Failure to consider the activities listed above leads to the collection of a body of numbers with little, if any, value to providing insight into fishing activity. Sections II and III of this report address these issues in detail.

Summary

Basically, the DFW is proceeding with a data collection program which, if implemented properly, should be successful. However, the program will require constant attention, especially during these early stages. The DFW must look at the current program within the context of a completed FDCS -- an outline of which is presented in the next section. The process of collecting meaningful fishery data is based upon structuring a feasible system of data-gathering procedures. The DFW is now beginning that process.

SECTION II

ELEMENTS OF A FISHERY DATA COLLECTION SYSTEM

INTRODUCTION

This section of the report describes the basic elements of an FDCS without addressing the specific needs of the Saipan fishery. In addition, this section outlines the activities that must be undertaken in order to implement such a system. For ease of understanding, this section of the report is written in semi-outline form, identifying those key factors which comprise each element of the FDCS. These elements are:

- description of FDCS objectives
- general design components for the FDCS
- required sampling designs
- sampling activity procedures
- processing of the system's data base
- expansion algorithms and their reliability
- quality assurance methods
- presentation of the FDCS's results

Each of the eight components of the FDCS is presented and discussed in the remainder of this section.

OBJECTIVES OF A FISHERY DATA COLLECTION SYSTEM

Before undertaking a survey investigation, it is essential for the investigator to consider the kinds of things

he/she would like to know. The investigator should determine what the ultimate objective is and be prepared to state it clearly as the research goal. The essence of an FDCS is reflected in its objectives which provide the conceptual framework needed in directing the collection of fishery information. The following factors must be addressed during this initial stage of defining the FDCS:

- Specify research goal.
  - Compose a broad statement concerning the overall purpose of the research. This statement may deal with objectives beyond the results derived by the immediate study.
  - State the overall strategy for the data collections effort.
- Establish working objectives.
  - Break down research goal into a series of small operational objectives. The sum of these objectives is another way of stating the research goal.
  - Determine whether each individual's working objective may require a separate data collection activity.
- Define universe to be observed.
  - Specify what entities are to be observed in obtaining information concerning fishing activity.
  - Provide the statistical framework for future analysis.
- Delineate specific concepts and characteristics to be observed and measured.
  - Identify which characteristics are to be selected from the universe.
- Determine numerical values to be developed.
  - Decide which averages or totals are to be compiled.

- Decide which processes are to be examined.

Each of the above items is to be reviewed within the context of collecting fishing information. Many times the failure of a fishery data gathering effort can be traced to the lack of clearly-defined objectives. Properly stated objectives provide the directional focus for the FDCS.

GENERAL DESIGN COMPONENTS FOR FISHERY DATA COLLECTION SYSTEM

General design components refer to those considerations which must be examined during the formulation of the overall surveying design. In effect, these components act as framing constraints to the FDCS. The set of general design components can be divided into three groups: fishing experience, surveying factors, and surveying effort. While these three groups undoubtedly influence each other, for the purpose of this presentation each group will be outlined separately.

Fishing Experience

Understanding the nature of the fishing experience enhances the likelihood of selecting the proper structure for the FDCS. The fishing experience can be looked at in terms of its human, spatial, and temporal elements. Each of these elements must be considered in regard to the following factors.

- Consider human factors in the fishing experience.
  - Determine what is known about the fisherman participating in the fishing activity.
  - Assess what information is available concerning the fisherman's catch, participation, and effort.

- Classify the fisherman according to the reason for fishing, e.g., commercial, recreational, subsistence.

- Determine what is known about the non-fisherman. This information will assist in developing participation rates. If this information is not readily available, adjustments will be required in the FDCS.

- Identify primary fishing methods: inshore and offshore with respect to gear.

- Develop a fisherman profile built on existing data and knowledge. Once the FDCS becomes operational, this profile may change.

- Consider spatial factor in the fishing experience.

  - Identify locations for fishing activity, both inshore and offshore. The goal is to define the level of fishing effort occurring at a specific location. In the case of the offshore fishery, these locations are boat launching sites.

  - Determine how best to examine these sites, again both inshore and offshore.

  - Account for the entire Island in terms of its fishing activity or lack of it.

- Consider temporal factors in the fishing experience.

  - Select temporal unit of measure, usually a day.

  - Determine how FDCS will cover the entire 24-hour period.

  - Establish means for estimating the fishing activity during the 24-hour day.

Surveying Factors

A number of surveying factors exist which, upon identification, reveal in general terms the surveying procedures to be followed. These factors are as follows:

- Select unit on which determinations are to be made.
  - Determine which items are to be sampled and measured (ultimately, this unit is the fisherman; however, other units, i.e., boats, fishing sites, retail outlets, can provide information useful in the design and effort allocation stages.)
  - Determine advantages and disadvantages associated with each possible unit.
- Review possible surveying or sampling methods.
  - Specify methods: face-to-face interviews, sampler observations, telephone interviews, or mail interviews.
  - Determine the best way of obtaining the desired information.

Surveying Effort

The final design component to be considered deals with surveying effort. Three factors influence surveying effort: costs, variability, and tolerated error. Specifically, the following items must be considered when assessing these three factors.

- Develop preliminary cost information.
  - Review the proposed surveying proposals, and estimate cost figures.
  - Identify the fixed and variable costs from the above calculations.
- Assess variability of key variables to the FDCS.
  - Identify key variables for catch, participation, and effort (this is a statistical or numerical issue).
  - Develop some measure of the variance associated with each of the above variables.

- Identify factors, e.g., fishing gear, which tend to effect the variability of the above three variables.

- Select tolerated error level.
  - Determine the amount of error the FDCS will tolerate, i.e., 5, 10, 20, 50 percent.
  - Specify reasons for selected error figure. (Error level will be affected by budgetary factors, FDCS's objectives, uses of the data.)

Together, these three factors will enable actual levels of surveying or sampling effort to be determined. Such figures will be helpful during the sampling design stages.

THE SAMPLING DESIGN

While this element of the system is entitled Sampling Design, in fact it encompasses all designing functions related to the development of the entire FDCS, whether actual sampling is required or not. Hence, the sampling design specifies what procedures are to be followed in generating the desired data necessary for estimating fishing activity, especially total Island harvest. The determination of these procedures evolves from a selection process which takes into account each factor of the FDCS previously discussed, as well as the proposed expansion methods to be used. Essentially, the design procedures can be classified as two basic techniques: either statistical survey methods or qualitative inference methods. A statistical survey method refers to those procedures which involve observing fishing activity in a systematic fashion and thus rely primarily upon sound statistical survey theory. Qualitative inference methods, on the other hand, do not rely upon statistical bases, but involve arbitrary observation techniques.

Statistical Survey Methods

- Determine whether or not the observation unit can be surveyed.
  - Define nature of activity each observation unit is involved in, e.g., day inshore fishing (usually, the observation unit is the fisherman).
- Select survey method to be used.
  - Decide between sample and census
- Design survey procedures needed to properly examine the observation unit. (These procedures will obviously vary with each survey program. For the FDCS, the survey procedures center around catch, effort and participation activities.)
  - Determine if the activity to be surveyed can be stratified in some manner.
  - Choose sampling unit for each surveyed activity, e.g., fisherman, boat, fishing site, and so forth.
  - Decide if the survey requires sampling and, if so, determine the number and type of stages and places in the design. (A sampling stage refers to a level of sampling; if a two-stage design is employed, two levels of sampling exist. For example, an offshore design may require sample launch sites to be taken, then a sample of boats within each site. A sampling phase deals with the number of variables to be measured -- one phase for each variable.)
  - Determine sampling effort, i.e., the number of sampling units to be taken at each stage and at each phase. Allocate survey effort.
  - Estimate cost of survey operation.
  - Choose method for selecting sampling units, i.e., probability or judgment.
  - Outline procedures for dealing with "hard-to-get" fishing activities through sampling, e.g., night fishing.
  - Outline methods of making estimates from surveyed data.

Qualitiative Inference Methods

- Re-examine fishing activities which cannot be surveyed.
  - Determine why activity cannot be adequately surveyed.
- Identify and select those procedures which will provide information about these activities.
- Describe method for obtaining information about these "hard-to-get" activities, e.g., illegal fishing.
- Calculate costs and effort required to measure activity by qualitative means.
- Outline methods of making estimates from information obtained from the selected procedures.

The sampling design element of the FDCS is the single most important component of the system. This element lays out the entire design for obtaining the desired numerical estimates of fishing activity. Properly designing the system minimizes future problems that always occur in any data collection system.

THE SAMPLING ACTIVITY

This element of the FDCS deals with the actual implementation of the sampling design. Under normal circumstances, a sampling design dealing with fishing activity requires multiple data collection operations. Successfully implementing such a data collection system requires careful planning and involves a number of activities outlined below:

- Formulate sampling design structure into a series of detailed survey procedures.

- Fully describe the sampling design. (This step is an operational effort. It takes, for example, the idea of sampling offshore fishing 30 percent of the time to sampling every other day from 6 a.m. to 5 p.m. at a given site.)

- Design all recording forms.

  - (Examples of recording forms are questionnaires, tally sheets, samplers' log books, survey protocol packets, coding books, and any forms required for conducting the surveys).

  - Use existing forms as a basis for the set of recording forms. (A good rule of thumb is that a form should exist at each stage of the sampling program.)

  - Maintain tally sheets as questionnaires are collected, indicating whether or not the questionnaires are fully or partially completed, edited, etc.

  - Document sampler information gained during the survey activity on the proper forms. (This information will aid in the adjustment process associated with a new survey, as well as ongoing survey efforts.)

  - Keep the information in a sampler's log book, documenting the sampler's daily activities.

  - Develop a survey protocol packet and give one to each sampler. Items in the protocol should, at least, include the following:

    - sampler instruction manual, including a question-by-question discussion of questionnaire administration

    - statement of purpose and background of the study

    - scheduling calendar

    - tide and moon phase calendar

    - special instructions and notes of unique circumstances of which the sampler should be aware.

- map of survey route
- coding sheets
- administrative requirements
- sampler's log book

- Select and train sampler
  - Make sure that each individual involved in the survey procedures thoroughly understands their specific survey responsibilities as well as the program's objectives. (The training process is especially needed for those individuals participating in the qualitative inference methods.)
- Develop controlling procedures for sampler.
  - Adopt methods which allow the sampler's activities to be monitored and evaluated on a continuous basis.

PROCESSING THE SYSTEM'S DATA BASE

In general terms, as the survey work is completed, data processing procedures must be in place to ensure that the final data set is accurate. These data processing procedures commence the moment a questionnaire is brought out of the field.

- Prepare data processing facilities.
  - Set aside the necessary space to meet expected incoming data requirements.
  - Review processing status forms to make sure each processing step is properly set up. (The processing status form defines each of the steps necessary in processing the raw field data into the computerized form of the final data set.)

- Define data processing procedures.
  - Explain in detail each step of the data processing sequence, detailing how, what, when, and by whom that particular step is to be implemented.
- Review data set format designs.
  - Examine the format design and the incoming data to make sure they are compatible.
- Keypunch data into computer file.
  - Maintain original questionnaire for at least a year after all activities for that year's FDCS have been completed. (If space is available, hold questionnaires longer.)
  - Maintain necessary back-up files.

The key to this stage of the data collection activity is the existence of clearly-stated procedures for processing the raw field data into the form of the final data set.

EXPANSION ALGORITHMS AND THEIR RELIABILITY

The results of the survey activities provide numerical estimates of surveyed fishing activity only. The goal of the system is to develop estimates of Island-wide fishing activity. Obtaining Island-wide estimates from sampled data requires the use of an expansion mechanism. This expansion mechanism defines the functional relationship between the sample results and the desired Island-wide results. The expansion procedure involves calculating a point variable, usually total catch.

- Describe Island-wide fishing activity in terms of a mathematical equation.

- Write the equation first, in an implicit form, i.e., total catch equals offshore plus inshore catch. (Identify all variables in the equations.)

- Write out the equation next, in an explicit form, actually defining the mathematical relationship between the variables.

- Define the catch, effort, and participation activities through these equations.

- Review results of survey efforts.

  - Identify which survey results can be used to replace variables in the expansion equation.

- Review results of qualitative inference efforts.

  - Identify which qualitative results can be used to replace variables in the expansion equation.

- Review entire expansion equation to insure that all elements of the equation can be numerically estimated.

  - Document how proxy measure was calculated, if additional variable specification is required.

- Compute appropriate variance measure for each expansion equation.

  - Identify variables in equation with non-zero variance.

  - Specify variance calculation for those variables. (The nature of this calculation will be dependent upon the sampling schemes employed in estimating those variables. For example the variance formulated for a simple random sampling scheme and a stratified random scheme are different.)

  - Compute variance measure for the equation as a whole, drawing upon the mathematical properties of a variance (i.e., the variance of a sum of variables or a product of variables has certain functional forms).

- Define reliabliity measure.

  (This measure is usually a statistical confidence interval.)

QUALITY ASSESSMENT METHODS

An essential part of the FDCS is a series of quality assessment (QA) procedures. These procedures act as checks to insure that the data being collected, processed, and manipulated meet the desired quality level. QA procedures can be classified into two groups: internal and external. Internal methods involve sampling procedure checks and data processing checks, while external methods entail comparing estimated results with data from independent sources.

QA -- Internal Methods

- Undertake sampling procedure checks.
  - Direct these efforts to the survey activity element of the system.
  - Review sampler-specific survey results to uncover potential sampler bias.
  - Assess and, if necessary, adjust sampling allocation efforts from a review of new incoming data.
- Undertake data handling checks.
  - Gear these checks to evaluating whether additional error is being introduced into the system.
  - Subsample the data set and compare this sample with the original questionnaire. (If the error rate from the subsample is significantly higher than the desired rate, then the entire data set would have to be rechecked.)

QA -- External Methods

- Compile independent source material.

- Use these sources to develop independent fishing estimates. (Examples of these independent sources include demographic data, other related surveys and reports, e.g., the National Marine Recreational Fishing Survey.)

- Compute independent measure and compare with FDCS estimate. (For example, fishing participation estimates can be compared with population figures to determine if the relative sizes are reasonable.)

Together these QA methods provide the assurance necessary to generate a useful and viable fishery data collection system. Hence, a fundamental part of the FDCS must be a well-defined QA program.

PRESENTATION OF THE FISHERY DATA COLLECTION SYSTEM

Careful consideration must be given to the FDCS's presentation format. The governing criteria in this area is whether or not the presentation format correctly reflects the information collected by the system, not only in terms of the tables but in the written text as well. The effective presentation of the FDCS depends, in part, on the reader of the report.

- Design presentation format.
  - Take into account all tables, charts and figures.
  - Consult other reports, books or manuals dealing with fishing data for examples of clear and informative designs.
  - Include in the statistical results standard error measures.
  - Attach copies of questionnaires to the report.

SECTION III

RECOMMENDATIONS FOR IMPLEMENTING A FISHERY DATA COLLECTION SYSTEM

INTRODUCTION

Now that the DFW is instituting a formal fisheries data collection program it has the opportunity to develop a valuable tool for monitoring the fishing activity in Saipan. To assist the DFW in these efforts, this final section contains recommendations on the system's overall design as well as how to effectively implement the system. Generally speaking, these recommendations insure the development of a properly timed and flexible FDCS to meet the data collection needs of Saipan.

The data collection system must be built on sound conceptual and statistical survey principals. In this regard, special emphasis will be given to the recommendations involving the sampling design and expansion algorithm elements of the FDCS. In addition, each recommendation must fit within the constraints imposed by Saipan's existing fishing culture. Thus, the recommendations concerning the FDCS's structure will take into consideration present data collection methods and procedures. Recommendations related to each of the eight components to the FDCS are presented and discussed individually in this section.

OBJECTIVES OF A FISHERY DATA COLLECTION SYSTEM

Before proceeding with any additional data collection efforts, the DFW should formulate the objectives for the FDCS. These objectives should be clearly and concisely written and then reviewed by the appropriate DFW staff. Actually, the Division is faced with developing two sets of objectives: program and timing. Program objectives refer to those goals which identify the purposes and desired outcome of the data collection effort. The process for defining these objectives requires following the basic steps outlined in Section II. On the other hand, timing objectives specify when certain key events in the implementation process for the FDCS are to take place. For example, these timing objectives will denote when a given survey effort (e.g., an inshore survey) is to commence.

The DFW was asked to state its present and future objectives with regard to data collection activities. These objectives are summarized below:

- Biological information
  - Catch
  - Species composition
  - Species seasonality
  - Species location
  - Species weight/length relationship
- Fishing activity information
  - Fishing effort

- Fishing participation
- Fishing methods/gear

- Economic information
  - Cost
  - Earnings

Once the FDCS if fully operational, information concerning the above variables will be readily available. However, during the preliminary stages of the FDCS development, any attempt to measure all these variables will probably meet with little success.

In specifying the program and timing objectives, the DFW must realize the complexity associated with the FDCS. Therefore, the objectives set during the early stages of the FDCS should focus on the primary variables of the fishing activity. The overriding objective for a FDCS is to obtain reliable Island-wide total catch estimates. When the data collection activities are operating efficiently and a sufficient data base has been compiled, the more specialized variables can be measured. The initial objectives for the FDCS should be as follows:

- To obtain reliable Island-wide total harvest estimates as well as obtaining estimates of catch and effort with respect to fishing method, fishing areas, and species composition.

In conclusion, the universe under consideration for this data collection system is the fishing activity on the Island. The DFW should expect to spend five to 10 days of effort in specifying the system's objectives.

GENERAL DESIGN COMPONENTS FOR A FISHERY DATA COLLECTION SYSTEM

A review of the general design components (see Section II) uncovers a number of important factors that must be considered by the DFW prior to specifying a survey design. The following descriptions provide critical background information required when determining the feasibility of a proposed survey program.

Fishing Experience

While Saipan offers a unique fishing experience, it is possible to classify the Island's fishing activity into a fairly standard framework. First, Saipan's fishing activity, i.e., the survey universe, can be divided into two categories: inshore and offshore activity. Inshore activity is defined as fishing between the reef and the shoreline. This area includes the lagoon areas located on the leeward side of the Island. Hence, inshore activity can take place in a boat as well as on foot. On the other hand, offshore activity is defined as fishing which occurs beyond the reefs and, therefore, always requires the use of a boat.

Understanding the fishing experience enhances the likelihood of selecting the proper structure for the data collection system. There are three aspects to the fishing experience: the human, spatial and temporal. First, consider the human aspect of the fishing experience. Since it is the individual who participates in the fishing experience, the fishing experience must be measured in terms of the fisherman's activities. Information concerning the fisherman's catch and effort must be compiled as well as the overall fishing participation.

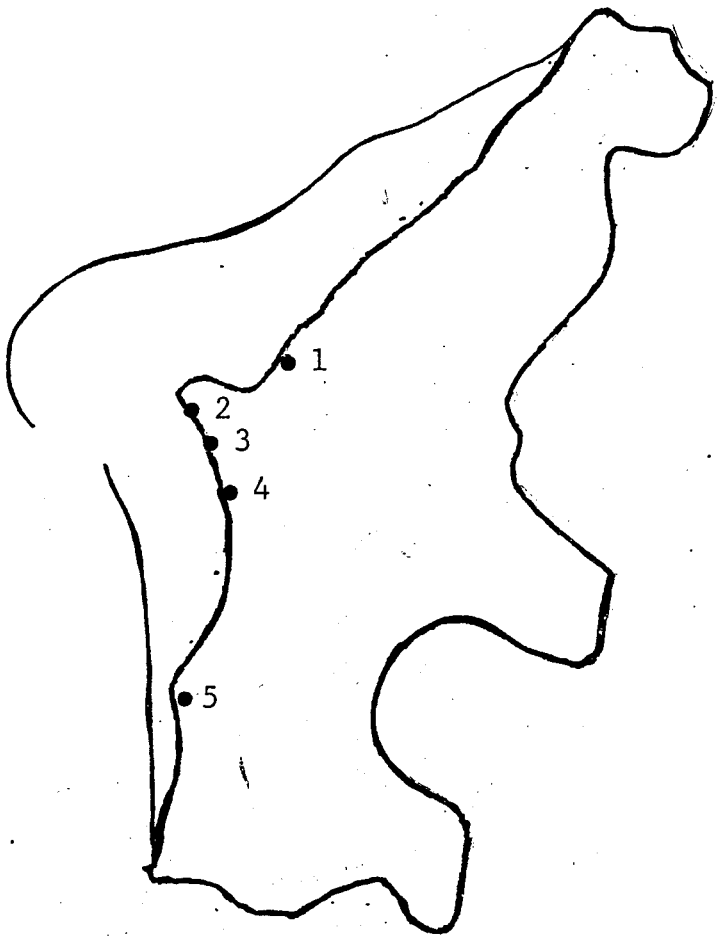
Human Factor. The human element is comprised of two groups: fishermen and non-fishermen. The fishermen and non-fishermen make up the population needed to determine the participation rates often used when assessing fishing activity. Therefore, in order to derive the necessary participation rates, information concerning the relative sizes of these two groups must be known. Unfortunately, this information is not available on Saipan. The closest information which could be used to extract participation rates comes from the National Recreational Fishing Survey conducted by NMFS. However, in talking with the FDW and reviewing the 1979 results, the concensus was reached that the participation information available from this recreational survey did not reflect the true levels of participation, and significantly underestimated the activity. Hence, the use of participation figures in evaluating fishing activity must be de-emphasized.

In Saipan, fishermen fish for one of three reasons: recreation, subsistence, or commerce. As Table 1 showed, the commerical fishery is primarily made up of part-time fishermen. For offshore fishermen, the principal methods are trolling, spearfishing, handline, and bottom fishing. While little, if any, data has been collected on inshore activity, the principal methods appear to be spearfishing, hook and line, and netting, i.e., cast, gill, surround. Also, within the reef area boats are able to troll and bottom fish, especially during seasonal runs. This presents the DFW with a problem of determining whether or not the above activity is inshore or offshore. According to the definition provided above, this activity must be classified as inshore fishing.

Spatial Factor. The second factor the DFW must consider is the spatial factor. Because Saipan is an island, this factor is well-defined. In principal, fishing activity could take place anywhere on the Island's coastline. Thus, the FDCS must define some means of determining exactly what level of fishing activity is occuring at a specific location. In the case of the offshore fishery, this will involve assessing the launching sites around the Island. Figure 3 identifies the five major launching sites for offshore fishing activity. Each site is located on the leeward side of the Island and is protected by the reef. Information provided by the DFW implies that little, if any, offshore boat launching occurs elsewhere on the Island.

Figure 3

MAJOR LAUNCHING SITES FOR OFFSHORE FISHING ACTIVITY



1 - Tanapag Village; Sand launch area

2 - Commercial Port and Sea Plane Ramp

3 - Memorial Park Boat Basin

4 - Garapan Fishing Basin

5 - Sugar Dock

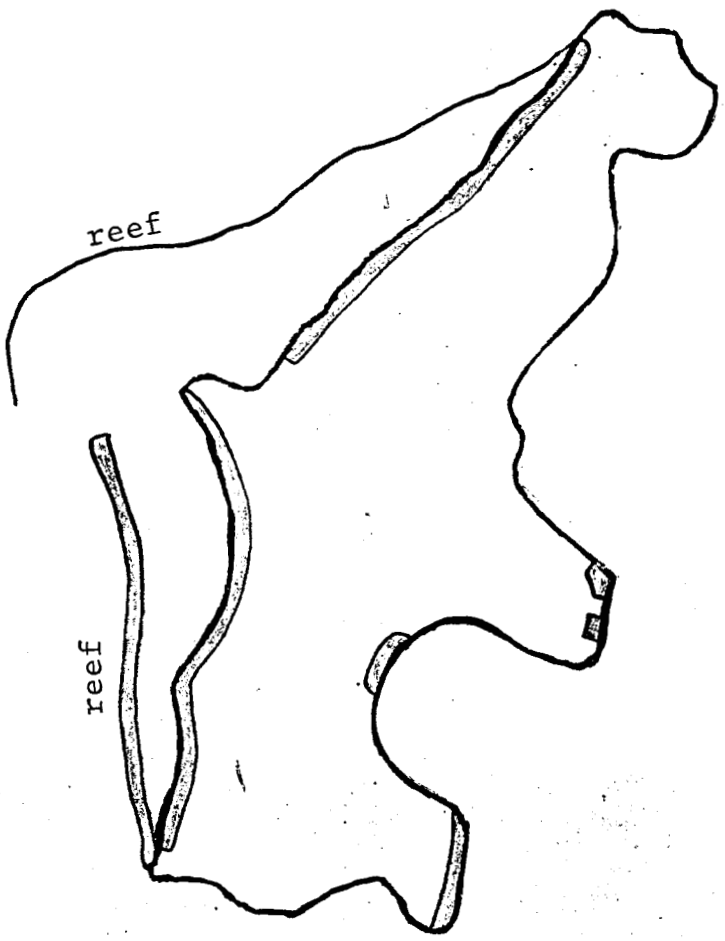
A similar approach must be taken for the inshore fishery. The entire shoreline of the Island must be reviewed and a method of estimating the fishing activity determined. Figure 4 indicates expected areas of inshore fishing activity. Again, the bulk of fishing effort is concentrated on the leeward side of the Island where the majority of the population is centered.

Depending on the selected sampling design, it is important to note that due to any number of reasons (i.e., budgetary, safety, etc.) it is possible, and in many instances desirable, to omit an area from consideration. However, without the use of a proxy measure, we must realize that omitting an area explicitly assumes zero fishing activity.

Temporal Factor. The final factor in the fishing experience is the temporal factor. The unit of measure of this factor is a day. Of essence here is the coverage aspect of the factor: the FDCS must take into account the entire unit of measure -- a 24-hour day. The simplest division for this factor is day fishing, i.e., dawn to dusk, and night fishing, i.e., dusk to dawn. The sampling design element of the FDCS must develop some means of estimating the fishing activity during these periods. For Saipan, the major temporal problem is the night fishing activity, especially for the inshore fishery. Both the inshore and offshore fisheries must be viewed from this temporal dimension in order to insure a complete FDCS.

Figure 4

EXPECTED AREAS OF INSHORE FISHING ACTIVITY



Denotes areas of inshore fishing

N

Surveying Factors.

Surveying factors represent the second design component. The first consideration in this area is the selection of what items are to be sampled and measured. For both the inshore and offshore fisheries, this unit is ultimately the fishermen. Basically, the FDCS is interested in the catch of the fishermen. Predominately, fishing activity in Saipan is collected at the market level, i.e., the retail outlet. The nature of the fishery and the habits of the fishermen are such that measuring fishing activity at the market level does not produce satisfactory results because the amount being bought and sold may not coincide with the amount caught. In addition, not all fishermen sell their catch. Therefore, the existing data may not necessarily reflect the total catch in the fishery. A review of past data by the DFW is recommended to assess the prevalence of this problem and ideally develop a measure of the non-purchased catch.

If sampling is required in the FDCS, the sampling units for the inshore fishery should be the fishermen, while for the offshore fishery, the sampling unit should be the fishing vessel. The procedure of sampling retail units may be of value when collecting economic data about the fishing activity. However, this type of sampling could introduce unnecessary bias if the purpose of the sampling is to obtain catch data. A good rule of thumb is: whenever a sampling scheme is being used, interview the individual doing the fishing if you want catch information.

Many possible means of surveying the fishing activity in Saipan exist, e.g., face-to-face interviews, voluntary logbooks, sampler observation, telephone survey, or mail survey. After comparing these methods with the objectives of the FDCS, three methods appear to satisfy the necessary requirements. These methods are face-to-face interviews, voluntary logbooks, and sampler obervations. The face-to-face interviews will be directed towards the fishermen in the hopes of obtaining information not otherwise available, specifically catch and effort information. In the collection of participation information, sampler observation methods should be utilized whenever possible.

Of special interest in reviewing possible survey methods is the apparent feasibility of voluntary logbooks. The history of logbooks in collecting fishing data does not stand out. In fact, the system of surveying a fishery through the use of logbooks usually fails. However, Saipan may prove to be the exception. The proposed use of logbooks is for the offshore fishery. If the conditions identified in Section I are met, then logbooks should be successful.

Surveying Effort

Due to the newness of the data collection activities on Saipain, the information necessary to fully evaluate this component is unavailable. However, a few general remarks concerning the three factors influencing sampling effort, i.e., costs, variability, and tolerated error, can

be made. In the real world, budgetary considerations are the fundamental constraints on the sampling effort. Therefore, it is imperative that the DFW compute exact costing figures for existing and proposed sampling programs. These calculations should fully describe each cost factor and denote whether it is a variable or a fixed cost.

Until the DFW is able to compile catch data, the possibility of deriving variability estimates will be limited. Determining the variability of key variables is critical to assessing the required level of sampling. The greater the variability of a given variable, the greater will be the required sampling effort to obtain a reliable estimate. Caution should be employed if the purchase data is used to obtain a variance estimate of the catch. Undoubtedly, the type of fish sold may not have the same characteristics as those fish not sold, expecially in terms of size variablity.

Finally, the DFW must consider the level of error it is willing to tolerate in its estimates. The lower the tolerated error, the greater the required sampling effort. In order to evaluate the required sampling effort for a particular fishing activity or method, the DFW must compute a variance measure, then select a tolerated error value and a confidence level. The actual calculation would involve using classical sample size determination formulas.

In computing sample size values, the following formula can be used:

$$(1)\quad n = \frac{N \cdot Z^2 \cdot (P(1-P))}{N \cdot e^2 + Z^2 (P(1-P))}$$

where

n = sample size estimate

N = population size estimate

Z = standard normal variate

P = proportion of fishermen using a given fishing gear

e = tolerated error

Equation (1) was selected because the sampling effort is directed towards the binomial decision of fishing or not or using a given gear compared with all other gears. Essentially, the sampling program measures the fishing activity on the Island. Therefore, if a program is to generate measures of fishing activity, adequate numbers of fishermen must be interviewed. Since the gear used by the fishermen is descriptive of the fishing activity, sampling effort is presented in a gear-specific manner. Hence, a binomial approximation underlines Equation (1). Thus, implicitly, the assumption is being made that fishing gears are independent. While exceptions to the assumption can be observed, their magnitude is insignificant as long as the fishing gear activity can be reported in an independent manner. For example, a fishing vessel on a single trip may troll and bottom fish. If the fisherman is able to separate the effort and catch related to these methods, the sampler can report these as two separate trips.

In computing the sample sizes, it is important to note how the tolerated error (e) value is calculated. Tolerated error can be viewed in either an absolute or relative sense. In its absolute sense, the value of the error term is a number independent, for the case at hand, of the fishing gear participation rate.* In other words, an error value of 10 percent will generate estimates within 10 units of the participation rate. Therefore, if the participation rate equals 20 percent, the acceptable range becomes 10 to 30 percent. Tolerated error in its relative sense implies the error value is dependent upon the participation rate consideration. Hence, an error value of 10 percent will generate estimates within .1 times P (participation rate). Following the above example, with a 20 percent rate, the acceptable range in this case becomes 18 to 22. For the purposes of Equation (1), the tolerated error term is calculated in its relative sense.

THE SAMPLING DESIGN

After assessing the body of information concerning Saipan's fishing activity, the following general sampling design is recommended. This proposed design accounts for the many unique features of the Island's fisheries plus

*See "A Recommended Approach to the Collection of Marine Recreational Finfishing and Shellfishing Data on the Pacific Coast," Contract No.6-35339, National Marine Fisheries Service, Data Management and Statistics Division, Washington, DC, August 1977, pp. 15-18.

draws from the current data collection efforts of the DFW. Basically, the design is comprised of two major independent elements: inshore and offshore activity. Each element will be discussed in detail below. Because the DFW's primary efforts to date have been directed at the offshore fishery, it will be presented first.

Offshore Fishery Survey

The proposed offshore survey is a census and not a sample type of survey. The difference between a census and a sample survey is critical, especially in developing the FDCS. A census survey's goal is to obtain information on every member of a population, while a sample survey collects information on a subset of the population.

Through the use of boat licensing records, the DFW is able to identify all boat owners. In addition, the primary use of the boat is available along with other related information. This boat list comprises the population of offshore fishermen. Members of this population are classified as full-time commercial, part-time commercial, recreational, or non-fishing.

A logbook is distributed to each fisherman. Due to the significant amount of public relations work, training, and follow-up which must go into properly distributing the logbook, the books should be time-released. Instead of being handed out indiscriminately, the logbooks should be given to certain subgroups. Once a subgroup is familiar with the logbooks, another subgroup should be added.

Three subgroup categories readily come to mind: full-time commercial, part-time commercial, and recreational.

The fishermen are directed to complete a logbook entry at the conclusion of each fishing trip. If each offshore fisherman recorded the desired fishing information after each trip, the resulting logbook information would indicate the total catch, effort, and participation of the offshore fishery. No expansion method would be required for the offshore activity.

However, the DFW must be prepared for the likely event that the 100 percent response rate does not occur. A number of possible difficulties exist with respect to the logbook program; each would require a different response. A few examples will be discussed here. For example, for the most part, the logbook operates properly except that each logbook has information missing or the fishermen fail to account for a trip. As long as these occurances do not make up a significant portion of the logbook's entries, (e.g., greater than 10 percent), the proper adjustments can be made during the expansion procedures. For example, if a week were omitted from a logbook, either the fisherman's average catch and trips could be used as a proxy for the missing week, or the activities of a comparable fisherman could be used. In either case, it is important that a proxy measure be developed for all missing information.

Should a particular subgroup fail to maintain logbook information at a desired level, two options exist. One option would be to drop the subgroup from the program and introduce a new sample survey for that subgroup. A second option is to alter the logbook program from a census to a sample program. Essentially, this would require the DFW to devise a sampling strategy for obtaining the logbook information. For example, if the part-time commerical fishermen are no longer completing the desired information on a regular base, each fisherman could be contacted and asked to participate in the program intermittently. Thus, a fisherman may be asked to fill out a logbook on every fourth trip, or for all trips during the second week of each month. Under this scheme, the logbook data could be compiled and an expansion method developed to generate the necessary estimates. Obviously, many new problems will arise, e.g., monitoring the fisherman to make sure logs are filled out at proper times. These problems must be addressed and resolved.

Finally, if the entire logbook program collapses, then a sample survey must be introduced. This new sample survey would collect data on an intermittent basis. With the vast majority of the boat activity occurring from the five launch areas identified in Figure 3 (Section 1), a surveying program involving sampling individual boats returning from fishing trips could be devised. An example of such a program is outlined in the report "A Fishery Data Collection System: Guam," which can be made readily available to DFW. Also, the

proposed inshore survey for Saipan could be adopted. Undoubtedly, modifications in the program would have to be made to fit the Saipan fishing experience.

In conclusion, if the logbook program is properly implemented and the DFW maintains continuous monitoring of the fishermen's activities, the program should be successful. Actions by the DFW currently underway are an important first step in this direction. Information from the logbook program would cover all aspects of the fishing activity in Saipan (e.g., night fishing), with the possible exception of illegal fishing. Assistance in obtaining information on illegal fishing could be available by asking the fishermen to detail on the proper form any such activity they witness.

Inshore Fishing Survey

The collection of inshore fishing data is a new experience for the DFW. Therefore, the division should give special consideration to this survey, especially during the planning stages. The following description of the inshore survey can provide insight into the development of an offshore sample survey if that should become necessary.

To insure the completeness of the inshore sampling design, a single survey procedure and two qualitative inference methods are proposed. The survey procedure is

a catch/effort sample survey. The two qualitative methods are aimed at quantifying night and illegal fishing activity.

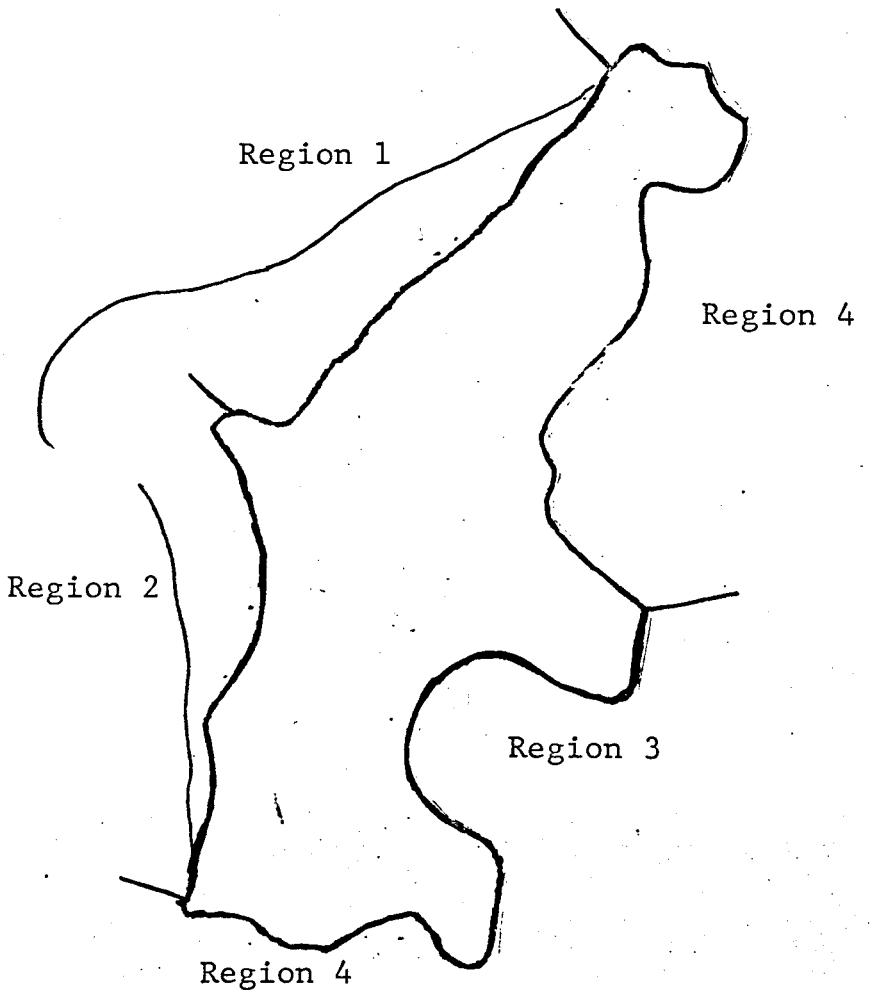
Statistical Survey Method

This survey method is directed at obtaining data on daytime fishing activity. In addition, this method is designed in such a manner as to insure that the proper expansions can be made.

Geographical Division of Coastline. Using the expected areas of inshore fishing (refer to Figure 4 as a guide), the Island can be divided into four regions (see Figure 5). Regions 1-3 define the area where the expected fishing activities occur, while little if any effort should be observed in Region 4. To further assist in the reporting of the fishing location of the fishermen, the DFW should devise a finer breakdown of the Island's geographical areas. Such a well-defined mapping of the Island will enable the sampler to assign the location of each sighted fisherman to a relatively small area.

Figure 5

FOUR INSHORE FISHING REGIONS



Variability of Fishing Activity Between WE/H and WD. If, in fact, significantly different rates of fishing exist between WE/H and WD, it must be reflected in the proposed survey design. In order to properly account for the difference in variability, sampling effort must be stratified by WE/H and WD. Should the DFW desire separate estimates for WE/H and WD, additional sampling effort will be required. After collecting a sufficient amount of data, the DFW should closely analyze the WE/H and WD information to determine the most beneficial course of action.

Impact of Weather on Fishing Activity. Changes in weather influence fishing participation for both inshore and offshore activity. These factors must be incorporated into the survey design and results (see Malvestuto, et al, Trans Am Fish Soc. 1979). Along with the fishing information collected, DFW should maintain a record of weather conditions. Once collected, DFW should study this data and correlate the relationship between climatic variables with fishing activity. If necessary, a separate study should be undertaken to develop these relationships. Once the desired relationships have been compiled and statistically supported, they can be used. As needed, periodic updates of coefficients can be undertaken.

General Design of Surveys. The foundation of the proposed sampling designs is based on a paper by Malvestuto, et al, entitled "An Evaluation of the Roving Creel Survey

with Nonuniform Probability Sampling."* In this paper, the authors detail an application of the roving creel survey with non-uniform probability sampling. The basic procedures outlined in this paper can be adapted to sampling activity in Saipan. Essentially, the sampling scheme generates an unbiased sampling and estimation of fishing success. Fishing success is defined as the weight of fish caught per fisherman hour or catch per unit effort (CPE).

The basic features of this proposed approach can be summarized as follows:

1. The entire period for which the fishery is to be surveyed is divided into time blocks. Ideally, the amount of fishing expected to take place within these blocks should be similar. DFW should review past fishing data and determine the most appropriate division of these time blocks. This review must take into account various seasonal factors, i.e., species, climate, etc. Currently, these time blocks are one month in duration. For the purposes of this study, the one month figure will be used.

2. Each time block is divided into sampling units. A sampling unit defines the time periods during which sampling will take place. In addition, all of the fishing time within a block is contained within the sampling units and the units do not overlap.

3. Assigned to each sampling unit is a sampling probability proportional to the amount of fishing expected for the unit. The sum of probabilities assigned to the sampling units within any given block equals 1.0.

4. Sampling units are randomly chosen within each block on the basis of the assigned sampling probabilities. Therefore, there exists a proportional relationship between the probability

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*See "An Evaluation of the Roving Creel Survey with Nonuniform Probability Sampling." by Stephen P. Malvestuto, William D. Davies, William L. Shelton; Transcript American Fishery Society 107 (2):255-262, 1979.

that sampling will actually be done during any given sampling unit, and the amount of fishing occurring during the unit.

5. Sampling activity is comprised of two components: fishermen counts and catch/effort interviews. Multiple gear trips must be counted as a separate trip for each gear used. This is true for both the offshore and inshore fisheries. The sampler will have to allocate certain responses to each gear, e.g., fishing effort.

Inshore Sample Survey. As the name implies, the catch/effort survey is a sample survey. Its purpose is to collect information concerning catch and effort activity by the inshore fishermen. Of the major inshore fishing methods, spearfishing and hand line are considered by the DFW to be the most prevalent. Most of the inshore fishing on the Island is done in the lagoon area.

The proposed inshore survey follows a stratified area sampling design. The survey is directed towards obtaining daytime catch information. Sampling times are to be varied to insure complete coverage of the day period. Area sampling is a term commonly used when the sampling activity is based on geographical areas. The survey is designed to intercept the fishermen along the coastline or within the lagoon. The sampling program is divided between coastline and lagoon intercepts. The reason for this division is that lagoon intercepts will require the use of a boat. To survey the entire Island will require two days -- one day for each type of intercept.

Ideally, sampling effort should be allocated to the four regions according to historical catch data; however, such data does not exist. Instead, the sampling effort between the regions will be allocated according to the distribution of households among the regions. The underlying assumption here is that coastline fishermen are more likely to fish near their residences. Table 3 presents the proportion of catch from each region.

Table 3

PROPORTION OF
CATCH BY REGION

Region	Proportion of Catch by Region
1	.20
2	.69
3	.11
4	-0-

Source: CIC Research, Inc.

These factors are guidelines for the sampler in allocating his/her time during a sample day. Thus, 20 percent of the sampler's time should be spent in Region 1 with 69, 11, and 0 percent spent in Regions 2, 3 and 4 respectively. Most of the sampler's effort is allocated to Region 2. The DFW is encouraged to develop allocation factors which may more closely reflect inshore activity.

The proposed inshore survey follows the general design previously presented, but also introduces a stratified area sampling design. Because the size of the Island's surveyable regions is so large, it is necessary to divide the Island into more manageable groups. The inshore survey is a continuous program; hence, one-month time blocks are proposed.

The survey is directed towards obtaining daytime catch information. Each time block is divided into three sampling units: A.M., Noon, P.M. Basically, these units encompass the following time intervals:

A.M. - Dawn until 1000 hrs.

Noon - 1000 hrs. until 1400 hrs.

P.M. - 1400 hrs. until dusk

The above sampling units define the temporal component of the sampling scheme.

The area sampling element must be addressed. Area sampling is a term commonly used when the sampling activity is based on geographical areas. The survey is designed to intercept the fishermen along the coastline. Using the geographical divisions developed, the following stratification system has been developed.

The first level of stratification is the four survey regions. A review of Table 3 shows that 20 percent of the sampled catch is expected to occur in Region 1 with 69 percent, 11 percent and 0 percent occurring in Region 2, 3 and 4 respectively. For the inshore survey, sampling

effort is allocated by the proportional size of the first particular area strata and then by the time period (sampling unit). Therefore, 20 percent of the overall sampling effort is to be allocated to Region 1 with Region 2 and 3 receiving 69 and 11 percent, respectively. Then, for example, the 20 percent allocated to Region 1 will be disaggregated proportionally to the three sampling unit time periods. DFW should refine these probability values by reviewing past inshore activity. For a given region, interview responses are categorized into one of the three sampling units according to the time of the interview. From these groupings probability values are derived.

A six-day per month sampling level should be adequate during the initial stages of the program. Six days of effort translates into 12 sampling units to be worked each month. The above conversion assumes that two sampling units can be surveyed in one day of effort. Thus, during each time block, the possibility exists that all regions and time periods (sampling units) will be sampled.

However, if the sampling program stratifies the effort by WE/H and WD, the above sampling effort cannot sample all regions and time periods in a time block of one month. A total of nine survey days would be required (that represents 18 sampling units). This coverage factor is not essential to the overall sampling program when taken in the context of a year. In the case of missing cells for a given time block, proxy values from past data could be used.

In reality, the set of sampling units becomes a particular region and a given time period. The set of sampling units contains nine basic elements if WE/H and WD are aggregated together, and 18 elements if WE/H and WD are separated. Assigned to each element is a probability value comprised of the product of the sample probabilities for each region and time period. Once these values are derived, the sample for a given time block can be drawn.

On a given sampling day, one sampling unit (defined as above) is surveyed by a sampler. Primarily, the sampler's activities entail making fishermen counts and catch/effort interviews. The DFW's must develop inshore catch/effort and participation questionnaires which address all the data information needs of this survey.

Once the sampler arrives at the desired region, he/she should make a count of fishing activity throughout the entire region. During this participation assessment effort, factors concerning location, gear, time, and weather conditions should be recorded. After the sampler has completed this portion of his/her activities, then catch/effort interviews are to be taken. Since the sampler has an idea of the current status of the fishing activity within the region, the sampler should be able to more efficiently interview the fishermen. By reviewing the participation results, the sampler will be able to allocate his/her time and interview a representative sample of fishing activity by gear.

To survey the lagoon will require the use of a boat. The mobility of a boat provides the fishermen with a greater range of fishing activity; therefore, the sampler should spend part of the day patrolling the entire lagoon area. The nature of the fishing activity in the lagoon is not conducive to sampling efforts. Therefore, the sampler must devise a method for obtaining the data without unduly bothering the fishermen. For example, a spearfisherman who swims from the coastline may provide the desired information while the sampler takes the fisherman back to shore. In any case, the collection of catch/effort data from the lagoon survey is going to be difficult.

As additional information about the inshore fishery becomes available, more specific allocation factors can be developed corresponding to areas within each region. Again, these sector allocation factors should not be considered as hard and fast rules governing the sampler's decisions. Changes in hot fishing spots during the sample period will require the sampler to alter his/her decisions on time allocation. The key to this survey is obtaining good quality catch and effort data.

As information is collected and analyzed, the DFW may discover that catch and effort figures do not vary within certain areas. If this is the case, the DFW should condense the sampling areas to increase the efficiency with which the

data is collected. In addition, the DFW must study how average catch figures differ between areas of WE/H and WD periods.

To determine the sampling effort required and to adequately measure average catch, disaggregated inshore catch data should be reviewed. Unfortunately, this catch data is not currently available. A possible proxy for this data may be the inshore catch values from Guam, especially for the Merizo region. The Department of Aquatic and Wildlife Resources in Guam is planning a survey effort specifically geared to the Merizo region. The data from this survey would assist the DFW in computing total sampling effort. Minimum sampling levels are guessed to be between three and four days per month for a tolerated error of less than, or equal to, 25 percent.

Major Steps Required When Implementing Sampling Design:

1) Determine duration of time blocks: 1 month. The survey period of one year has been divided into 12 time blocks.

2) Divide time blocks into sampling units:

   Inshore Survey

   Sampling units: A.M., Noon, P.M.

3) Compute and assign sampling probabilities (P) to each sampling unit.

Inshore Survey

A total of 18 basic probabilities need to be calculated:

$P^{WE/H}_{AM,Region\ 1}$ = For WE/H, the probability of a fisherman fishing during the A.M. hours in Region 1.

$P^{WE/H}_{Noon,Region\ 1}$ = For WE/H, the probability of a fisherman fishing during the noon hours in Region 1.

$P^{WE/H}_{PM,Region\ 1}$ = For WE/H, the probability of a fisherman fishing during the P.M. hours in Region 1.

Similar probabilities are calculated for Regions 2 and 3, i.e.,

$P^{WE/H}_{Noon,Region\ 2}$ $P^{WE/H}_{PM,Region\ 2}$ $P^{WE/H}_{AM,Region\ 2}$

$P^{WE/H}_{Noon,Region\ 3}$ $P^{WE/H}_{PM,Region\ 3}$ $P^{WE/H}_{AM,Region\ 3}$

In addition, another nine probabilities are computed for the WD period, e.g., $P^{WD}_{AM,\ Region\ 1}$, ...

To compute these possiblities, the survey data is categorized according to each of the nine probability descriptions for either the WE/H or WD group. For example:

$$P^{WE/H}_{AM,Region\ 1} = \frac{\text{the number of fishermen fishing in Region 1 in the A.M. hours on a WE/H}}{\text{the total number of fishermen fishing on a WE/H}}$$

If DAWR is unable to divide the survey data in the manner above, the similar probabilities of $P_{AM}^{WE/H}$ and $P_{Region\ 1}^{WE/H}$ can be computed with the product of these values equaling the desired joint probability.

4) Randomly Select Sampling Units.

Inshore Survey

The selection of sampling units for the inshore survey follows the same format, only the procedure is a bit more complicated. A total of 12 sampling units are to be sampled each month, six for WE/H and six for WD. Using February as an example, a total of 54 sampling units are possible for WD and 30 sampling units for WE/H. In the case of WE/H for a given region, 10 sampling units are A.M., 10 units are Noon and 10 units are P.M. The six WE/H sampling units to be surveyed are determined according to the probabilities computed above. For example, if $P_{AM,\ Region\ 1}^{WE/H}$ = 15 percent, then 1 (.15 x 6) of the sampling units to be surveyed falls in the A.M., Region 1 group. The particular days to be surveyed are then randomly selected, a total of six sampling days are selected for WE/H period.

5) Conduct Survey

Qualitative Inference Methods

The previous sampling designs together provide a method for generating statistically based fishing estimates. In order to complete the fishing picture in Saipan, two additional fishing activities must be considered: nighttime and illegal fishing. Neither of these activities can be adequately sampled using a survey method. Instead, some other means must be employed to furnish an estimate of these two types of fishing activity which are basically limited to the inshore fishery; each activity will be discussed separately.

(1) Nighttime Fishing. According to the DFW, nighttime fishing activity is prevalent enough to warrant numerical estimates. Basically, the nighttime estimate is a proportional figure tied to the level of daytime fishing. For example, if daytime catch is estimated at 100kg and the proportional nighttime rate is 25 percent, then the estimated catch is 25kg.

At issue is identifying and selecting those procedures which will provide information concerning the relative size of the night proportion. A number of possibilities exist for obtaining the desired information. First, attached to the catch/

effort survey could be a question concerning night fishing activity. The scope of the questions could include not only the night activities of the intercept fishermen, but also those individuals known by the fishermen. Additional questions involving fishing method, location, size of catch, etc., could be asked.

While the DFW does not currently employ conservation officers, the Division is expected to in the near future. Therefore another approach would be for the conservation officers (as part of their job description) to keep a tally of night fishing during their patrols. The use of conservation officers in this manner could prove to be most valuable. Also short-term surveys could be conducted by telephone or mail concerning night fishing. The list of subjective methods, e.g., asking "knowledgeable" individuals, is endless. The most productive method, however, appears to be utilizing the conservation officers or attaching night fishing questions to the existing surveys.

(2) Illegal Fishing. According to the DFW, Saipan is faced with a fairly significant illegal fishing problem, which, over the long run, could have a lasting destructive impact upon the inshore fishery. From a data collection viewpoint, however, the illegal fishing must be numerically estimated. The same proportional method used for night fishing is to be employed in developing an illegal fishing figure. The nature of il-

legal fishing activity prohibits the use of traditional survey methods. Instead, qualitative methods must be undertaken to determine the desired proportional rate.

One possibility for assessing the illegal fishing activity would be to inform the populace through a public relations blitz of the consequences of this activity. The public's assistance should be solicited in reporting illegal activity to DFW personnel. All reports would be compiled to determine a measure of the activity. To assist in calculating the catch associated with the illegal fishing, the DFW could estimate possible kill rates for particular illegal fishing activity. These estimates would take into account locations, species prevalence, fishing method, etc. These figures would be used in assessing the illegal rate.

Another alternative would be to ask fishermen about their knowledge of illegal fishing activity. The subject of illegal fishing is very sensitive; therefore, the sampler must take the necessary precautions to assure the fisherman of the desired information's purpose and confidentiality. Also, questions on illegal fishing activities could be added to the catch/effort surveys. The problem of illegal fishing cannot be ignored by not incorporating the activity in the Island's catch estimates. Instead, the DFW must experiment with different procedures for measurung the Island's illegal fishing activity.

Timing of Surveys

The proposed sampling design is comprised of two primary survey efforts, one generally for the offshore and one for the inshore fishery. The first effort of the DFW should be directed to the offshore logbook program; it will probably take a year to make the program fully operational. Once the offshore program is operating correctly, the inshore program should be implemented, first the participation census, and then the catch/effort survey. Should the logbook program fail, the inshore program format can be adapted to the offshore fishery.

THE SAMPLING ACTIVITY

The scope of this project does not include a detailed discussion of the necessary sampling activities. However, a few recommendations concerning these activivities are presented below.

Offshore Fishery Survey

For the logbook program to work, the DFW must fully train each fisherman to properly fill out a log sheet. This training includes explaining how the log sheet is to be filled out on a question-by-question basis. Examples of completed log sheets would help the fisherman visualize how the sheets are to be completed. Also, the fisherman must understand the need to have a sheet completed for each trip. Once the fisherman is trained, the DFW must monitor the activities of each fisherman, especially during the early stages of the program. The DFW

should devise a regular schedule for meeting with the fishermen and reviewing his logbook.

Inshore Fishing Survey

Prior to conducting the actual survey operation, a number of preparatory steps must be undertaken. First, the sampling design must be transformed into a series of detailed and well-defined sampling procedures. For example, the driving route for the participation census must be designed, tested, and timed.

The DFW must design an inshore participation and catch/effort questionnaire. In constructing this instrument, the DFW should carefully review existing questionnaires used elsewhere (the closest being Guam). In addition, the DFW must develop the corresponding survey documents that are required to assist in the data collection effort. Finally, the samplers must be thoroughly trained in the techniques of collecting fishery information.

PROCESSING THE SYSTEM'S DATA BASE

The key to processing the FDC's data base is knowing where and how to find each survey instrument at any time. Thus, when mistakes are made in creating the data base, they can be corrected. During the processing procedure, each questionnaire must be checked for completeness, consistency, and proper coding. Finally data from all the questionnaires should be keypunched into a computer file as soon as possible.

EXPANSION ALGORITHMS AND THEIR RELIABILITY

The expansion equation is the device which tranforms the survey results into the desired Island-wide estimates. The primary estimate for the FDCS is the total Island catch. The catch expansion equation can be viewed in two ways: in terms of the area or type of fishing activity involved, or the individual variables which make up the equation. With regard to fishing activity, the equation is simply the sum of the estimated offshore and inshore catch. Depending on the success of the offshore logbook program, the offshore catch figures will either represent the actual total offshore catch or an estimate. On the other hand, the inshore catch figure will always be an estimate.

However, survey results provide information only for the sampled inshore fishing activity. In order to ultimately develop the desired Island-wide estimates, a series of equations are used to transform the survey data into its final form. The expansion methods can be viewed in terms of three general steps:

- Computations for daily catch estimates
- Computations for mean daily catch
- Computations for mean daily catch per month

The sample data is expanded as follows:

Computations for Daily Catch Estimates

(1) First, calculate an estimate of total sampling period effort

$$e = n \times \bar{h}$$

where e = total effort expended during sampling period

n = number of fishermen (vessels) counted

$\bar{h}$ = average number of hours fished

Inshore and offshore total sampling period effort are calculated separately. Since the inshore survey primarily deals with incomplete trips, $\bar{h}$ equals actual hours fished plus the additional expected hours to be fished. Equation (1) can be disaggregated by gear (or other variables) if desired. For example, Equation (1) becomes

$$(1)' \quad e_i = n_i \times \bar{h}_i$$

where, i = gear being used

therefore,

$$(1)'' \quad e = \sum_i e_i$$

(2) Second, determine the estimate of total day effort

$$E = e / p_1 p_2$$

where,

E = total island effort for fishing day

p_1 = proportion of fishing activity occurring in a given sampling period

p_2 = Proportion of fishing activity occurring in a given region

Obviously, the key to Equation (2) is properly specifying P_1 and P_2 for both inshore and offshore activity. The disaggregation of Equation (2) by gear yeilds the following

$$(2)' \quad E_i = {}^{C_i}/_{p_1 p_2}$$

if possible, the p_1 and p_2 variables should be gear specific therefore,

$$(2)'' \quad E = \sum E_i$$

(3) Next, calculate the estimate of catch per unit of effort

$$CPE = \frac{B}{P}$$

where,

CPE = catch per unit of effort

B = total recorded weight of fish sampled

P = total measured pressure recorded during sampling, e.g., total number of actual hours fished.

The data for Equation (3) is supplied solely from the survey results. Equation (3) can be disaggregated by gear as follows:

$$(3)' \quad CPE_i = \frac{B_i}{P_i}$$

therefore,

$$(3)'' \quad CPE = \sum w_i \, CPE_i$$

where,

$$w_i = \frac{P_i}{\sum P_i} \; ; \; \sum P_i = P$$

(4) The final calculation of this category is to estimate the total day catch

$$C = CPE \times E$$

where, C = total day catch.

Disaggregated by gear Equation (4) becomes

$$(4)' \quad C_i = CPE_i \times E_i$$

therefore,

$$(4)'' \quad C = \sum C_i$$

Computations for Mean Daily Catch

The mean daily catch is determined for each stratum. For the case at hand, the allocation between WE/H and WD, represent separate strata.

(5) The mean daily catch for each stratum is defined as

$$\bar{C}_{WD} = \sum_{\ell=1}^{n_{WD}} C_{WD,\ell} \Big/ n_{WD} \; ; \; \bar{C}_{WE/H} = \sum_{\ell=1}^{n_{WE/H}} C_{WE/H,\ell} \Big/ n_{WE/H}$$

where,

$\bar{C}_{WD}, \bar{C}_{WE/H}$ = mean daily catch

$C_{WD,\ell}, C_{WE/H,\ell}$ = estimated total day catch for ℓth day

$n_{WD}, n_{WE/H}$ = number of days sampled

Disaggregated by gear Equation (5) becomes

$$(5)' \quad \bar{C}_i = \sum_j C_{ij} \Big/ n_i$$

where, $\bar{C}_i$ = mean daily catch for i^{th} gear

C_{ij} = estimated total day catch for i^{th} gear on j^{th} day

n_i = number of days sampled for i^{th} gear

therefore,

(5)" $\bar{C}_{WE/H}$ or $\bar{C}_{WD} = \sum g_i \bar{C}_i$

where,

$$g_i = \frac{n_i}{N}$$

N = total number of days sampled

Note: $\bar{C}_{WD,i} = g_i \bar{C}_i$

The variance associated with the mean daily catch is defined as follows:

$$(6)\ \text{Var}\ (\bar{C}_k) = \frac{\sum_{\ell=1}^{n_k} C^2_{k\ell} - \left(\sum_{\ell=1}^{n_k} C_{k\ell}\right)^2 \Big/ n_k}{n_k - 1}$$

where,

k = the strata, i.e., WE/H, WD

n_k = the number of days sampled with the k^{th} stratum, i.e., n_{WD}; $n_{WE/H}$

Computations for Mean Daily Catch Per month

To calculate the mean daily catch per month, the following equation is used:

$$(7)\ \bar{C}_d = \frac{N_{WD}}{N} \bar{C}_{WD} + \frac{N_{WE/H}}{N} \bar{C}_{WE/H}$$

where,

$\bar{C}_d$ = Mean daily catch per month

N_{WD} = Total number of WD in month

$N_{WE/H}$ = Total number of WE/H in month

N = Total number of days within month

Disaggregated by gear, Equation (7) becomes

$$(7)' \quad \bar{C}_{di} = \frac{N_{WD}}{N} \bar{C}_{WD,i} + \frac{N_{WE/H}}{N} \bar{C}_{WE/H,i}$$

therefore,

$$(7)'' \quad \bar{C}_d = \sum_i \bar{C}_{di}$$

The variance for the mean daily catch per month is defined as:

$$(8) \quad \text{var}\,(\bar{C}_d) = \sum_k W_k^2 \ \text{var}\,(\bar{C}_k)/n_k - \sum_k W_k \ \text{var}\,(\bar{C}_k)/N$$

where, W_k = the stratum weight (N_k/N)

The expansion system can account for the climatic impact on fishing activity in one of two ways. First, a sampling day could be used regardless of climate condition. Thus, changes in activity would already be accounted for in the survey results. Second, sampling could take place during "normal" climatic conditions only. DFW should consider the option of conducting a study on how climate conditions affect fishing activity for both inshore and offshore activity.

The final steps in the expansion involve the following three steps:

(9) The total harvest for the month ($\hat{C}$) equals N x $\bar{C}_d$

(10) The standard error of the total harvest (s) equals N ($\sqrt{\text{var } (\bar{C}_d)}$)

(11) The 90 percent confidence limits for total harvest are $\hat{C} \pm t_{df}$ s. The degrees of freedom (df) which determine the t value can be approximated using the number midway between the smallest value of n_k-1 and $\sum n_k$.

It should be noted that the same sequence of calculations can be followed to estimate total effort or CPE by making the appropriate substitutions.

The above methods furnish catch estimates for inshore activity. In order to derive a total Island-wide estimate, offshore actitivy night fishing and illegal fishing values must be factored in. Basically, night and illegal fishing variables enter as scalers in the computation procedures for the catch estimate objective. Should the offshore program require sampling, a similar sampling scheme to the inshore can be developed easily.

QUALITY ASSESSMENT METHODS

The FDCS calls for a number of data handling phases, e.g., keypunching, and with each handling the chance of error increases. Therefore, the quality assurance techniques must be geared to evaluating if this additional error is significant and, if so, to correct the problem. The DFW must care-

fully review each step in the data collection and processing sequence and identify those areas where special quality assurance procedures should be implemented. For example, as the data is entered into the computer, an error program could be used which checks the range of each variable as it is entered and rejects any answer which does not fall into the acceptable range.

PRESENTATIONS OF THE FISHERY DATA COLLECTION SYSTEM

In conjunction with developing the FDCS's sampling design, the DFW should construct the presentation format for the FDCS. By undertaking both of these activities during the same period of time, the DFW can be assured of the compatability between these two components. The results of these efforts will be the presentation of an FDCS in a clear and concise manner.