SOUTHWEST FISHERIES CENTER
HONOLULU LABORATORY
NATIONAL MARINE FISHERIES SERVICE
P.O. BOX 3830
HONOLULU, HI 96812

September 1983

A FISHERY DATA COLLECTION SYSTEM: GUAM

CIC RESEARCH, INC.
1215 Cushman Avenue
San Diego, CA 92110

Not for Publication

ADMINISTRATIVE REPORT H-83-21C

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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 Government of Guam, Division of Aquatic and Wildlife Resources. 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.

David C. Hamm
Computer Systems Analyst

September 30, 1983

A FISHERY DATA COLLECTION SYSTEM: GUAM

FINAL REPORT

Prepared for:

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September 1983

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INTRODUCTION

Over the past 20 years, Guam's fisheries have experienced increasingly significant fishing pressure from recreational, subsistence, and commercial activity, as well as destructive illegal fishing practices. In an attempt to quantify this fishing pressure, the Department of Aquatic and Wildlife Resources (DAWR) has been monitoring the Island's fishing activities. An integral part of this monitoring effort has been the collection of fishing data. In hopes of identifying trends in fishing participation, effort, and catch, the DAWR has sponsored a wide variety of data collection methods over the past 20 years. Even though these data collection efforts have resulted in a fairly substantial data set, the reliability of the total data set has been questioned, because of frequent personnel changes and poorly documented sampling procedures. Hence, without the necessary documentation, the evaluation of fishing data cannot be properly accomplished. Fortunately, since 1977 significant progress has been made by the DAWR to rectify the shortcomings surrounding its fishery data collection operation. Currently, the DAWR's data gathering operation lacks the formal design and documentation necessary for ensuring a useful Fishery Data Collection System (FDCS) in the future.

A Fishery Data Collection System is a set of procedures, methods, and principles which direct the collection process of fishing data. 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

The purpose of this study is to provide the framework for such a FDCS. This project has two major tasks: first, the study will analyze the present information-gathering system and survey techniques. Second, the study will design a statistically reliable data collection system to provide and process the needed information on a continuous basis. Where appropriate, the existing survey structure will be utilized in the FDCS.

The body of this report is divided into two sections. Section I contains a general description of the current fishery data collection system. Contained in this section is a brief historical background of DAWR's data collection efforts. The current system is then reviewed in some detail. This review

considers separately the two primary fishing surveys, i.e., the inshore survey and offshore survey. An overall assessment of the current system concludes this section of the report.

Section II presents the proposed FDCS. Each of the eight elements (identified above) of the system are presented and discussed. The sampling design and the expansion algorithm elements comprise the major efforts of this project. Specifically, the sampling design element explains the proposed statistical sampling techniques and provides the estimates of the manhour and dollar resources required to implement the system. The expansion algorithm element presents the methodology for arriving at the numerical estimate for the total Island-wide catch as well as specifying the reliability of this estimate. Both these elements are presented in detail for use in the FDCS. The remaining six elements are discussed only in terms of their relationship to the sampling design and expansion of algorithm elements.

Throughout this report, possible alternatives or strategies for the FDCS will be discussed and assessed. The most feasible solution will always be identified.

SECTION I

GENERAL DESCRIPTION OF THE CURRENT FISHERY DATA COLLECTION SYSTEM

INTRODUCTION

The first step in designing a sampling program is to review and study past efforts. Valuable insight from such a study will assist in avoiding previous sampling pitfalls and identify worthwhile procedures. At the present time, the DAWR is the primary source of fishery information for Guam.

BRIEF HISTORICAL BACKGROUND OF DATA COLLECTION EFFORTS

Fishery data collection efforts on Guam were initiated by the DAWR in the mid-1960's, primarily through the use of creel survey techniques and aerial surveying. Since that time, a number of survey methods and a variety of procedural changes have occurred. Nevertheless, some level of sampling effort has been maintained to the present time. From the outset of these early sampling efforts, the DAWR has attempted to quantify the Island's fishing activity in terms of catch, effort, and participation information.

Due to a lack of procedural documentation, insufficient sampling levels or structure, and missing data, a significant portion of the data collected over the past 20 years cannot be

included in the Island's fishery data base (data collected prior to 1970).

In addition, the Western Pacific Regional Management Council recently funded a study by the Pacific Basin Environmental Consultants to study Guam's fisheries data for the period of 1970 to 1980. This report provides a detailed description of all fishery data collected during this period. The report shows approximately 80 percent of the data collected by the DAWR during this 10-year period was collected from 1977 to 1980. Due to the amount and quality of the data collected since 1977, coupled with the lack of sampling documentation prior to 1977, the DAWR believes that all years prior to 1977 should be omitted from the data base as well. Thus, for analytical purposes, the available data base includes information collected from 1977 to the present.

Aerial Survey

The aerial fisheries survey effort was initiated in mid-1960. This roughly instantaneous assessment of fishing activity (the flights averaged 1½ hours in duration) was implemented during nine of the 17 years, during the period of 1963-1979, with a total of 169 flights. These flights were divided more or less equally between weekend/holiday days (WE/H) and weekdays (WD). The basis for the division of sampling effort between WE/H and WD originates from the significantly different fishing activity which normally occurs on the Island between

these two periods. This temporal distinction is carried over to the creel survey efforts as well.

All in all, the aerial surveys were a valuable activity. These surveys provided participation data, i.e., number of fishermen by fishing method for the entire Island. Only an aerial survey can provide this type of information. This type of Island-wide information will greatly assist in the assigning of proportional weights to areas which are not now surveyed due to geographical or other constraints.

Data from the aerial fisheries survey were compiled for geographical areas (Figure 1) that would allow comparison with data collected within inshore creel census regions.
Under the current survey program, DAWR has divided the creel survey area into three regions. Figure 1 shows the location of these regions, as well as the non-creel survey areas. As mentioned above, the aerial survey's purpose was to measure fishing participation. During the conduct of the aerial survey, once a fisherman was sighted, the survey area was noted, along with the fishing method used. Interestingly, during the nine survey years between 1963 and 1979, only two percent of the fishing methods were determined to be unidentifiable. Table 1 presents the percent of fisherman using one of the four principal fishing gears.

The data in Table 1 show combined gill and surround netting to be the most popular fishing method. The remaining

Figure 1

INSHORE FISHING SURVEY REGIONS

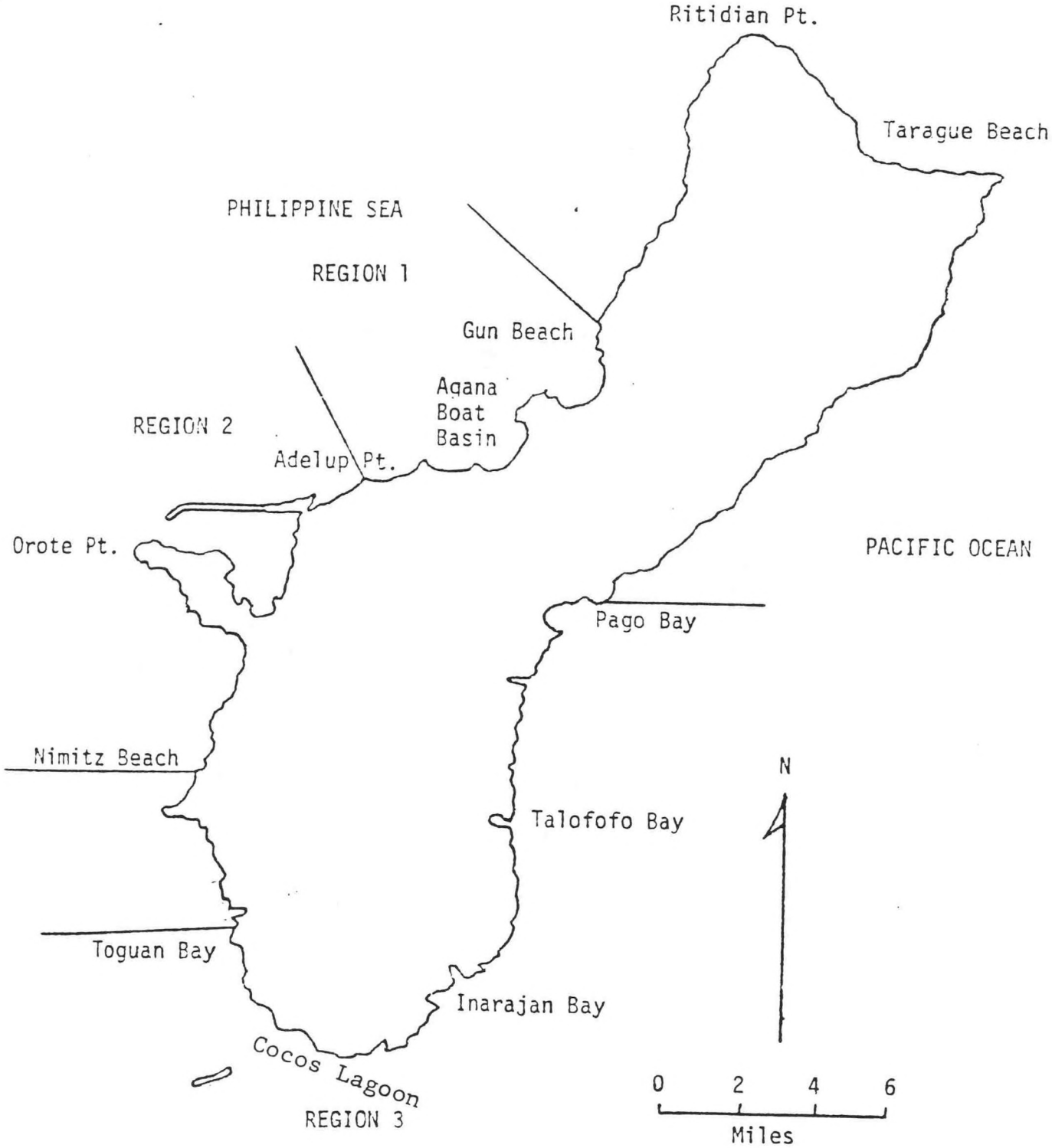

Figure 1. The Island of Guam. The Inshore Fishing Survey Regions are as follows: Region #1 - Gun Beach to Adelup Point
Region #2 - Adelup Point to Nimitz Beach
Region #3 - Pago Bay to Toguan Bay

Table 1

AERIAL FISHERIES SURVEY:
PERCENT OF FISHERMEN USING GIVEN GEAR

	Percent of Fishermen					
Fishing Gear	Percent Using Method	In Non-Creel Region	In Creel Region	In Creel Region 1	In Creel Region 2	In Creel Region 3
Hook and Line	19.5%	6.9%	93.1%	32.0%	34.2%	26.9%
Cast Netting	17.6	20.4	79.7	24.2	25.9	29.6
Gill and Surround Netting	38.1	9.9	90.1	39.8	17.9	32.4
Spearfishing	17.9	20.0	80.0	24.2	32.9	22.9
Other*	6.9	22.8	77.2	--	--	--

*"Other" category includes octopus hunting, clamming, shelling, and unidentified.

Source: DAWR
CIC Research, Inc.

three identified fishing methods are relatively equal. A close look at the last three aerial survey years (1976, 1978, 1979) reveals that the relationship between the four major inshore methods remains relatively stable except for a marked decline in spearing participation in the 1979 survey (9.4%).

Offshore Survey

While the aerial survey dealt primarily with the inshore fishery, the creel survey efforts from 1977 to 1981 focused on both the inshore and offshore fisheries. Offshore fishing requires the use of a boat and the fishing activity is concentrated beyond the reef area. The three principal offshore fishing methods are trolling, bottom fishing, and spearfishing.

Past offshore surveys, 1977 to 1981, have been directed at obtaining not only participation data, but catch and effort information as well. Basically, the information collected during these years includes number, weight and length of fish caught, species identification, hours fished, weather data, fishing location, gear type, and number of fishermen. The consistency and quality of this information has varied throughout the years with the more recent years producing the better data set.

Sampling effort has been directed at the principal boat basins, i.e., the Agana and Merizo boat basins. Other possible offshore launch areas, such as the Apra Harbor, have only been obtained sporadically during this five-year period. Offshore sampling effort was two days per month in 1977 and grew to

six days per month by 1981. During 1981 the Agana Boat basin was sampled on an average of four days per month, while Merizo was sampled twice a month. Since 1977, total sampling effort has changed dramatically from a low of 11 total sampling days in 1977 to a high of 69 days in 1980. An average of 44 sampling days per year were expended during the five-year period.

The sampling effort was more or less equally divided between WE/H and WD.* Hence, the expansion method employed to arrive at catch estimates separates the sample catch figures with respect to WE/H and WD. Sampling days were randomly selected by a lottery method, although personnel and funding problems over the years sporadically resulted in rescheduling census days to maximize data collection. In addition, over the course of this five-year period, the actual surveying was shifted more and more towards the later afternoon and evening hours, since this time period saw the greatest activity at the boat basins.

By far the most frequent method of offshore fishing is trolling. Table 2 summarizes the results of the offshore sampling effort by fishing method from 1977 to 1981. Interestingly, during the latter years, the participation levels among the different fishing methods stabilized. Also, since 1979 the sample effort for this survey has greatly increased.

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*It is interesting to note that the origin for equally dividing sampling effort in this fashion was based on aerial surveys conducted in the early 1960's. However, there is no doubt that significantly different fishing activity occurs between these two periods.

Table 2

OFFSHORE FISHING: PERCENT OF BOATS USING FISHING GEAR

1977 to 1981

	Percent of Boats Using Fishing Gear					
Fishing Gear	1977	1978	1979	1980	1981	Avg.
Trolling	81.2%	78.9%	87.4%	78.7%	78.4%	80.9%
Bottom Fishing	9.4	13.2	9.1	15.6	17.7	13.0
Spearfishing	9.4	8.0	3.5	5.7	4.0	6.3
Total Days Surveyed	11	33	57	69	52	44

Source: CIC Research, Inc., 1983.
DAWR

Inshore Survey

The inshore creel survey has been the major focus of the DAWR. Like the offshore survey, the inshore survey collected a similar set of information, i.e., catch, effort, and participation data, along with other pertinent information. In the case of the inshore fishery, the fishing activity occurs in or near the reef area, with the primary fishing methods being hook and line, cast netting, gill netting, surround netting, and spearfishing. In 1978 an attempt was made to sample each region twice a month, once on a WD and once on a WE/H. In addition, no two regions were sampled on the same day due to personnel and time constraints. Thus, under this design a total sampling effort of six days per month was expended on the inshore survey. On a given sampling day within a region, the goal was to obtain as many interviews as possible without backtracking on the census route.

Total sampling effort has varied little over the five-year period from a low of 4.2 days/month in FY 1981 to a high of 6.0 days/month in FY 1977. An average of 65 days were sampled per year. Sampling days were selected at random with sampling effort again divided equally between WE/H and WD.

An entire day was sometimes necessary to adequately sample a region. Interestingly, a look at the information collected over this period exhibits a fair degree of consistency. Table 3 shows the percent of fishermen using a given fishing method during

Table 3

INSHORE FISHING: PERCENT OF FISHERMEN USING A GIVEN GEAR

FY 1977 - 1981

Fishing Gear	Percent of Fishermen Fishing					
	1977	1978	1979	1980	1981	Average
Hook and Line	21.9%	30.9%	42.4%	45.1%	46.2%	39%
Cast Netting	21.2	14.3	12.0%	16.4%	19.4%	16
Gill Netting	52.8	29.9	20.2	19.5	16.3	22
Surround Netting		12.8	16.4	13.5	12.3	15
Spearfishing	4.2	12.1	9.1	5.5	5.8	8
Total Sampling Days	36	68	87	68	51	65*
No. of Months	6	12	15	12	12	

*Based on FY 1977-1981, doubling 1977 data and using the first 12 months of 1979.

Sources: DAWR
CIC Research, Inc.

fiscal years 1977 - 1981, while Table 4 presents the percent of total catch attributable to each method. Tables 3 and 4 show some interesting, but not startling, results. While the hook and line method accounts for an average of 40 percent of the participation, it accounts for only 13 percent of the catch. Surround netting is the most productive method in terms of percent of total catch.

Also of interest, is the comparison of gear-use distributions from the aerial and inshore surveys. Not suprisingly, the difference occurs between the spear and hook and line methods. In terms of the inshore survey, the spearfishing method is the most difficult to observe, while the converse is true of the hook and line method. For the aerial survey, the opposite appears to be true. All in all, the results between the surveys are compatible. Further analysis of these tables will occur in the following section.

CURRENT DATA COLLECTION SYSTEM

Before reviewing the specifics of the current fishery data collection system on Guam, a few general comments concerning the system seem appropriate. As the discussion on the system's historical background showed, for all intents and purposes, a data collection effort of sufficient quality did not commence until 1977. Since that time, sampling effort was increased and, more importantly, written documentation concerning the survey's

Table 4

INSHORE FISHING CATCH: PERCENT OF CATCH USING A GIVEN FISHING GEAR

Fishing Gear	Percent of Catch					
	1977	1978	1979	1980	1981	Average
Hook and Line	2%	15%	14%	14%	25%	13%
Cast Netting	54	16	9	12	16	20
Surround Netting		31	29	51	42	35
Spearfishing	2	8	19	5	6	9

Sources: DAWR
CIC Research, Inc., 1983

procedures and methods was maintained. A look at the past five years clearly indicates that the entire sampling program has undergone a valuable evolutionary process. This process essentially has been the result of a conscious effort by DAWR to develop a high-quality, more efficient data collection system. Today, the fundamental tenets of the sampling program are derived from the experiences of the past sampling years.

Currently, the DAWR participates in two creel surveys identified as the offshore and inshore surveys. Both these surveys are discussed in some detail on the following page. Currently, these surveys require a total of 10 sampling days, or approximately 80 manhours of effort, allocated each month to collecting the desired fishing data (60 percent to the inshore program and 40 percent to the offshore program).

Offshore Program

The fiscal 1982 report indicates two objectives for the offshore creel survey:

1. To quantify and monitor trends in fishing participation, effort, and catch which occurs outside the reef margins in boats.

2. To collect biological data from specimens examined during fishermen interviews.

In addition to the above objectives, the procedures implemented during the 1982 (FY) creel survey were designed to maximize (1) the collection of biological data and (2) the number of

completed fishermen interviews per unit time spent in the field. To these ends, the sampling procedures for 1982 took into consideration variables and methods not utilized in previous years, i.e., weather, sea state, and daily temporal trends in fishing activity. While it would be impractical to expect that a sampling program should maintain complete coverage of the entire boat-accessible coastline 24 hours a day, the program should generate a representative picture of fishing activity.

The presentation of the current offshore sampling program will focus on three areas: survey coverage, survey frequency, and sampling methods. Survey coverage deals with where the sampling takes place, while survey frequency reveals how often the sampling will be done. For FY 1982, sampling occurred at two locations: the Agana Boat Basin, located on the leeward side of the Island and the most active boat launch area on the Island, and Merizo Pier, located within Cocos Lagoon on the southern tip of Guam. Due to manpower and logistics difficulties, Merizo was sampled during only the first third of the fiscal year, for a total of six sample days. An attempt was made to obtain fishing data through telephone interviews which, not suprisingly, proved unsuccessful. Therefore, the offshore sampling program was essentially measuring the fishing activity of the Agana boat basin.

With only a few exceptions, the Agana boat basin was surveyed four times a month, twice on WD and twice on WE/H. The DAWR believes strongly that the vast majority of offshore fishing activity passes through the Agana boat basin and to a lesser extent, Merizo Pier. Generally, the sampling effort was conducted between 5:00 p.m. and 9:00 p.m. This time period was thought to coincide with the return of that day's fishing fleet. The sampler attempted to determine the number of boats returning prior to his/her arrival. This information was used in calculating a proportional factor which was to be incorporated into the estimate of daily offshore participation. Another component added to the sampling program was the adjustment for "bad" weather days. On those days when the sampler determines that the weather and/or sea conditions prohibit offshore fishing, no survey was conducted and the survey that day was rescheduled. All survey days were determined by lottery.

The above discussion of the offshore sampling program really deals with sampling methods. While no formal guidelines exist, the sampler follows a fairly well-defined sampling scheme. To record sampler findings, two survey instruments are utilized: an "Offshore Fishing Participation Census" form and an "Offshore Creel Census" form. The "Participation Census" form contains participation information (see Figure 2) including boat, number of people, gear, etc., plus a diagram of the boats moored at the boat basin. This diagram enables the sampler to quickly

Figure 2

OFFSHORE SURVEY FORM: PARTICIPATION

DIVISION OF AQUATIC & WILDLIFE RESOURCES
DEPARTMENT OF AGRICULTURE
GOVERNMENT OF GUAM

Offshore Fishing Participation Census
Agana Boat Basin

Date_____ WE/H WD

Time_____

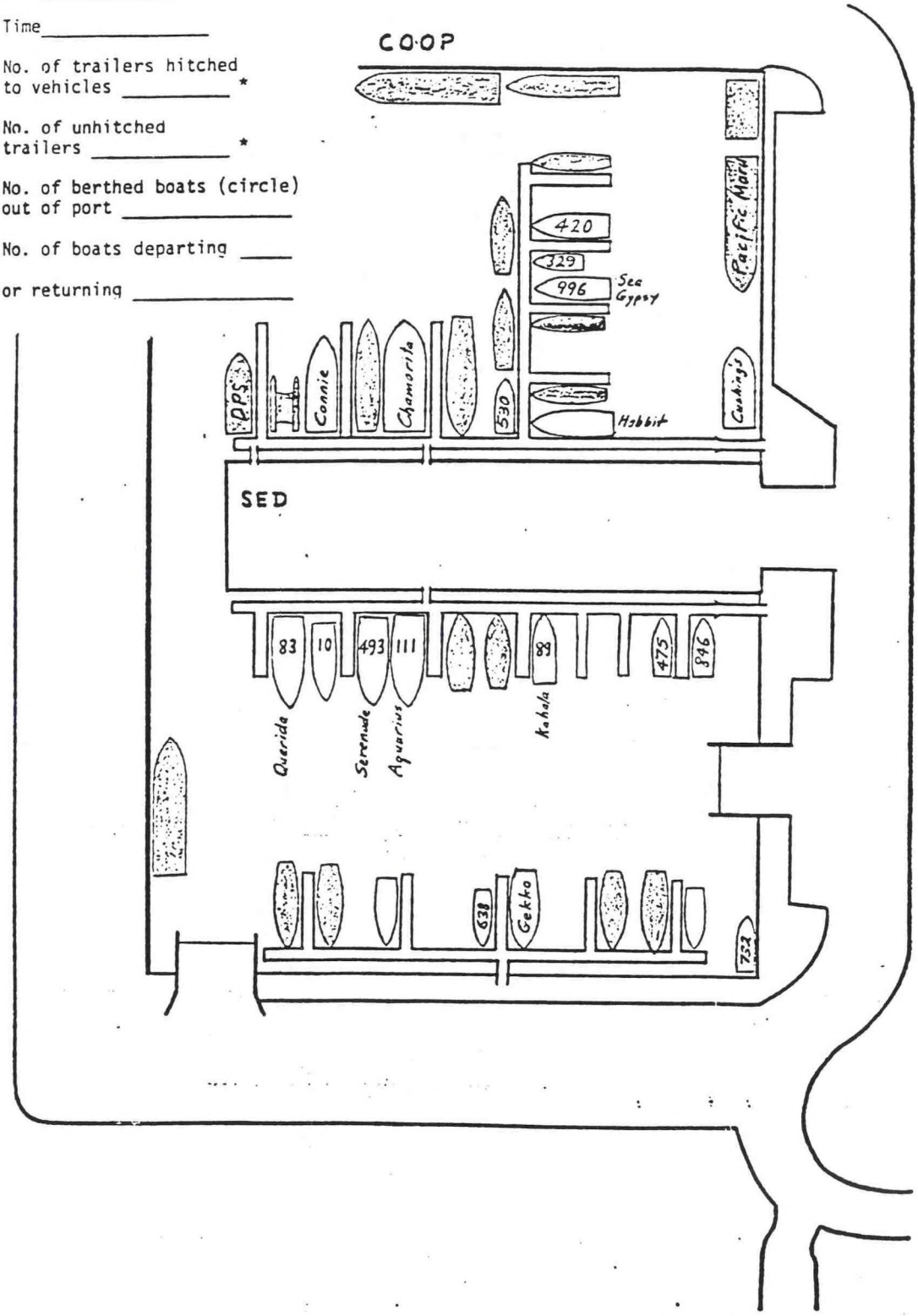
No. of trailers hitched to vehicles _____ *

No. of unhitched trailers _____ *

No. of berthed boats (circle) out of port _____

No. of boats departing ____

or returning _____



* Please note location of all trailers on map above and indicate whether or not they are hitched to a vehicle.

Figure 2 (Cont'd.)

OFFSHORE SURVEY FORM: PARTICIPATION

Date ____________ WE/H WD Interviewer__________

Boat No.	Time	Location	No. of Persons	No. of Gear Units & Method	Est. distance offshore	Direction headed or anchored	Weather & Water Conditions

identify which boats are still out and to locate boat trailers for further reference that evening. This form is utilized during an inshore census day to aid in an offshore census conducted later in the day. The "Creel Census" form contains the detailed catch and effort data (see Figure 3) and is utilized during the offshore census.

During a survey, the sampler first determines the status of the boats in the basin using the diagram mentioned above. Moored boats still fishing are identified as well as the location of the boat trailers. Also, the sampler attempts to determine if any boats came in prior to his/her arrival and, if possible, interview the boats' skippers. This information assists the sampler in determining the fishing participation, i.e., number of boats for the day.

When a boat returns during the sampling period, the sampler interviews the skipper about his catch, time spent fishing, gear, location, and the other items contained in the offshore creel census questionnaire. Depending on the size of the catch, the interview can vary from a couple of minutes to half an hour; however, the average is five to 10 minutes. The sampler attempts to interview as many fishermen as possible. When multiple boats come in simultaneously, the sampler uses his/her own discretion as to which boats to sample. For the most part, the sampler is able to position himself/herself in such a way as to observe all the activity at the boat basin.

Figure 3

OFFSHORE SURVEY FORM: CATCH/EFFORT

DIVISION OF AQUATIC & WILDLIFE RESOURCES
DEPARTMENT OF AGRICULTURE
GOVERNMENT OF GUAM

Interview #_____
Interviewer_____
Interview time_____

OFFSHORE CREEL CENSUS

ation_____ Q=_____ Date _____ WD WE

hod:	No. lines	hrs. in use		
. Trolling	_____	_____	No. fishermen_____	FAD buoy used_____
2. Bottom fish	_____	_____	Start time_____	Where_____
3. Speargun snorkel		_____	Lost time_____	When_____
4. Speargun scuba		_____	Stop time_____	No. passes_____
Other	_____	_____	Time most fish caught_____	Catch:_____

ding_____ Boat # _____ Bait _____ TYPE DATA: 1 3 1 2

SPECIES	length	wt.	length	wt.	length	wt.	Number Act.	Number Est.	Weight Act.	Weight Calc.

TYPE DATA	1 ACT	2 CALC	3 EST
TOTAL NO. FISH			
TOTAL WT. (kg)			
TOTAL NO. SPP.			

Meteorological Data

Wind dir._____ Weather_____
Wind speed_____ Cloud cover_____
Lunar day

An essential element of the offshore program is the expansion method employed to derive the offshore estimates. Currently, the procedures involve a number of linear approximations. For example, the catch estimate is currently adjusted for weather conditions because the expansion method proportionately accounts for bad weather days, i.e., no fishing, as well as low participation days. Since sampling is now restricted to the Agana Boat Basin only, Island-wide estimates are computed through a series of proportional weights taking into consideration fishing activity in non-surveyed areas. Separate estimates are calculated for trolling, bottom fishing, and spearfishing -- the three major offshore fishing methods. For FY 1982, monthly catch estimates for Agana boat basin were computed.

Inshore Program

For fiscal year 1983, the name "inshore sampling program" is somewhat of a misnomer. The DAWR has redesigned the program to essentially estimate participation for both inshore and offshore fishing activity. For example, in the case of offshore activity, the survey furnishes superior participation estimates when compared to the offshore sampling program because the coverage as well as sampling frequency is so much greater. In order to implement this new focus of the inshore program, the collection of catch/effort data has to be de-emphasized. The collection of catch/effort data is now limited to three days/month

(one day per survey region). Catch/effort data is compiled for as many completed or as nearly completed fishing trips as possible within a maximum of six hours per day.

The inshore program will be discussed in terms of its sampling coverage, frequency, and methods. Combined, the three inshore regions encompass 60 percent of the total Island coastline. More importantly, according to the DAWR, 80 to 90 percent of the Island-wide fishing activity occurs within the three regions. Originally, the inshore program sampled each region on separate days. Now, the inshore survey covers the entire three-region area in one sampling day. While there is little doubt that fishing activity exists in the non-surveyed areas, the expenditures required to adequately estimate this effort would far outweigh the benefits of the additional information.

The inshore program is conducted on six days each month -- again evenly split between WD and WE/H. A sampling day begins either at Gun Beach on the northern tip of Region 1, or at Pago Bay on the opposite side of the Island in Region 3 (refer to Figure 1). The selection of a starting point is determined randomly each sample day. Once the starting point has been selected, the sampler drives around the Island through each region in sequence. The sampling day begins at 9:00 a.m. and runs from six to eight hours, depending on the number of catch/effort questionnaires administered. The driving is difficult in the sense that it requires an expert knowledge of the island's geographical and road layout. The coastline can be observed clearly from

a number of vantage points which are discoverable if one knows the correct road or turn to take.

The sampler carries a sufficient supply of the three questionnaires: the inshore participation questionnaire, the offshore questionnaire, and the inshore catch/effort questionnaire (see Figures 3, 4, & 5). In addition to these questionnaires, the sampler carries a code book, measuring instrument and, most importantly, a pair of binoculars. Because the sampler's objective is to observe and identify fishing activity along the Island's coastline, he or she must be able to observe as much of the coastline as possible. Because most of the fishing activity is dispersed along the reef, the only way to observe the fishing activity is through the use of binoculars. At times the sampler's observations are being made from a distance of a mile or more. The need for a powerful set of binoculars is critical to the success of the inshore survey effort. At each stop the sampler observes the fishing activity and attempts to identify the fishing method, number of people, location, etc. Often it takes a trained eye to spot the fishing activity and, in addition, determine the gear. The sampler must judge whether or not to administer a catch/effort questionnaire. If the fisherman is fishing at the reef margin, it could easily take half an hour to complete the interview, thus increasing the incentive to go after less time-consuming catch/effort interviews.

Figure 4

INSHORE SURVEY FORM: PARTICIPATION

DIVISION OF AQUATIC & WILDLIFE RESOURCES
DEPARTMENT OF AGRICULTURE
GOVERNMENT OF GUAM

INSHORE CREEL CENSUS

Date ________________ WE/H WD Interviewer __________

Inter-view No.	Time	Location	No. of Persons	No. of Gear Units & Method	Reef zone	Weather & Water Conditions

Figure 5

INSHORE SURVEY FORM:
CATCH/EFFORT

DIVISION OF AQUATIC & WILDLIFE RESOURCES
DEPARTMENT OF AGRICULTURE
GOVERNMENT OF GUAM

INSHORE CREEL CENSUS

Interview #_____

Interviewer_____

Location _____ Date _____ WD WE Interview time ___

Method:

1. Hook & Line _____ Bait _____
3. Gill Net _____ No. Sets _____
4. Surround Net _____ No. Sets _____
Speargun _____ 5. Snorkel _____
7. Octopus Hooks _____

2. Cast Net _____ No. Casts _____
Length _____ Mesh _____
Length _____ 8.Dip Net _____
6. Scuba _____ 9.Other _____
Reef Zone _____

	TYPE DATA : 1		3		1		NUMBER 2		3	WEIGHT (kg) 1		2		3
SPECIES	mm	kg	mm	kg	mm	kg	ACT		EST	ACT		CALC		EST

TYPE DATA	1 ACT	2 CALC	3 EST
TOTAL NO. FISH			
TOTAL WT. (kg)			
TOTAL NO. SPP.			

No. Fishermen _____ Weather _____
Start Time _____ Cloud Cover _____
Lost Time _____ Lunar day _____
Stop Time _____ Surf _____
Time Most Fish Caught _____
Wind Dir. _____ Swell Dir. _____
Wind Speed _____ Tide _____

Participation data is collected at offshore boat launch areas also. The inshore survey attempts to obtain an estimate of fishing participation for both inshore and offshore activity. Results from the aerial survey show that fishery participation among the three regions is fairly similar: Region 1 - 37 percent; Region 2 - 30 percent; and Region 3 - 33 percent.

Expansion methods for inshore activity follow the techniques used in previous years. Mean values for catch, participation, and effort were calculated separately by WE/H and WD for each month and each fishing gear. Where current data is missing, the appropriate numerical estimate is derived from past information. These values are then multiplied by the total number of WE/H and WD within that month. Following the necessary summation process, the desired estimates are obtained. To date, the above estimates are not adjusted for variable weather conditions (although the offshore survey is beginning to account for weather), people fishing in non-surveyed areas, night fishing, fishing performed at times of the day other than during sampling periods, nor the occurrence of illegal methods.

ASSESSMENT OF CURRENT SYSTEM

This final element of Section I is included for the purpose of assessing the sampling methods just discussed.

General Comments

The following comments address those areas where additional considerations and actions may be required. These comments are not necessarily presented in order of importance to the system.

Documentation Needs. A fundamental requirement of any data collection effort is the development and continual maintenance of written documentation explaining completely each aspect of the data collection system, its methods and procedures. Presently, the sampling programs are well-documented only in the minds of each sampler. The DAWR needs to develop in-house written documentation detailing all aspects of the data system. As a minimum, this document should include the sampling design, sampling levels and effort, sampling methods and procedures, a sampler's log book, guidelines for sampler training, a discussion of ideas that have worked or not and the reasons. This source document would be of real value to future data collection efforts.

Compatible Data Set. Undoubtedly, in the future, the DAWR will be asked to provide fishing data to a variety of individuals and agencies. Soon the data files will be accessible by computer; this will greatly increase the flexibility and scope of the division's data analysis capabilities. To assist in this endeavor, the DAWR should consider developing a data set which is compatible throughout each of the surveyed years. This effort may require devising a series of bridges between

different years. At the very least, the DAWR should review the feasibility of implementing this suggestion. In addition, current and future data collection activities must be looked at in terms of this compatibility issue. Therefore, when procedural or sampling changes occur, a corresponding adjustment should be made to the data set if necessary to insure compatibility.

Judgmental Sampling Procedures. As in any sampling scheme which requires the sampler to make sampling decisions, the collection of fisheries data introduces a judgmental element to the sampling designs. Whenever judgmental sampling enters into a sampling program, the possibility of introducing additional bias into the system exists. Both sampling programs at hand require a number of decisions by the sampler as to when, where, and to whom a questionnaire should be administered.

To assist the sampler in making these types of decisions, and to avoid possible bias problems, the programs should develop a series of general sampling guidelines. For example, during an off-shore creel survey, the possibility exists for the arrival of more than one boat at a time and the sampler is faced with the dilemma of which boat to sample. Instead of arbitrarily deciding which boats to sample, the sampler could draw from a set of guidelines as to which type of boats, gear, and fishing locations should be sampled first. A mini-questionnaire could be developed to assist the sampler in determining the proper boats to be fully interviewed. A similar set of guidelines would be valuable to the inshore sampling program.

Continual Review of Sampling Procedures. Whenever a sampling procedure is to be added, changed, or deleted, it is important to understand the reasoning behind the adjustment. A number of the sampling procedures developed over the years and currently in use by the DAWR fail to satisfy the above condition. A couple of examples will illustrate this point. Currently, inshore and offshore sampling days do not occur on the same day. The reason for this policy has not been clearly delineated. Another example involves the allocation of sampling effort between WE/H and WD. When the sampling results are processed, calculations are made separately for WE/H and WD data. Correspondingly, the sampling effort is divided equally between the two periods. Again, the reasoning behind this equal sampling allocation was never fully stated.

Each element of the data collection system must be carefully reviewed and adjusted if it no longer meets the needs of the current program. Valuable effort can easily be wasted if the program relies unnecessarily on out-dated methods. Section II attempts to address some of these elements; nevertheless, it is strongly suggested that the DAWR carefully review the sampling program with the above considerations in mind.

Expansion Algorithm. Another essential element of the data collection system is the method employed to generate the numerical estimates concerning fishing activity. Because the expansion algorithm defines the connection between the sampling data

and the final estimates, it is essential that it fully accounts for all factors influencing the fishing activity on the Island. For example, suppose that sampling occurs only during the day and that the occurrence of night fishing is common knowledge. It is inappropriate for the expansion algorithm to ignore the night fishing activity. By so doing, the methodology implicitly assumes a zero value factor for night fishing. Although the factor used to estimate night fishing may lack the desired statistical properties, nevertheless, it is at least possible to devise a plan which provides a cursory estimate of activities. If the researcher believes that a zero factor is preferable to a "ball park" estimate, then at least the issue has been addressed. In any event, the expansion method must, in principal, fully account for the entire fishing activity. The weather adjustment now utilized for the offshore estimate is a step in this direction.

Cocos Lagoon Area. The sampling program now in place virtually ignores the fishing activity in Cocos Lagoon. This area apparently is one of the most active fishing areas on the Island and needs to be sampled on a regular basis. The use of a telephone survey was attempted in hopes of gathering the desired information, but it failed. Although telephone surveys in other locations in the U.S. have proved successful in collecting certain types of fishing data, the problem of language and telephone coverage prohibits a telephone survey from working in Guam.

Hopefully, the DAWR will soon seriously consider future data collection efforts in the Cocos Lagoon.

Offshore Sampling Program. While the inshore fishing activity presents the most immediate concern of the DAWR, it is critical that the Division not diminish the offshore sampling effort. From an economic point of view, the offshore fishery may have the greatest impact on the future of Guam.

Objectives of Offshore Program. The offshore sampling program identifies two sets of objectives. The first set deals with collecting the necessary information required to monitor offshore activity, while the second set considers the importance of obtaining the maximum number of interviews per unit of time. The DAWR should consider the compatibility of these two sets of objectives.

Scope and Structure of Offshore Program. Over the years, the offshore survey apparently has become somewhat myopic in nature. Currently, only the Agana Boat basin is being sampled, and only in the afternoons and evenings. This is not necessarily incorrect methodology; at issue is how well this approach reflects Island-wide offshore fishing activity. The participation survey (inshore program) now under way is a positive step in addressing the offshore fishery in its Island-wide perspective. Instead of starting with a single sampling element and expanding to the entire Island, the proper perspective entails first developing a sampling strategy for the entire offshore

fishery, and then determining which elements can be adequately sampled and which elements must be estimated by other means. Apparently, the vast majority of elements of the sampling program exist and are properly in place. What is missing is a formalized structure to the program, so that the program can be reviewed easily and adjusted if required. The quality of the data currently collected at the boat basin appears to be good.

Public Relations Needs. Good public relations are essential to a successful sampling program, and the samplers have developed the necessary rapport with the fishermen to obtain high quality information. In addition, Robert Meyers has recently published a book on Guam's fisheries which could be an excellent vehicle to further enhance the good relationship between the fishermen and DAWR. Presenting the fishermen with a book, or other appropriate item at the close of the interview could reap rewards in terms of better cooperation. With only a few such adjustments, the offshore program will be able to fulfill its intended objectives.

Inshore Sampling Program

The inshore sampling program is essentially a participation survey this year. For this reason, a few factors must be considered when assessing the program.

Mechanics of Inshore Program. The mechanics involved with the inshore survey require special skills. The sampler must be able to view fishing activity under numerous conditions and from a variety of locations. Often, finding these observation areas can be difficult for the untrained observer. The DAWR is fortunate to have experienced individuals with extensive training in biology conducting the sampling. This high level of expertise not only results in high quality data being collected, but greatly enhances the efficiency of the sampling. To assist the sampler in observing the fishing activity around the Island, powerful binoculars are needed. The sampler must be able to not only identify a fisherman, but also be able to determine the gear being used. The binoculars currently being used for these tasks are not adequate.

The sampling route is unique, hence it would be advisable to chart the route on a map to assist future sampling efforts, especially in case of personnel changes. Accompanying this map should be a narrative describing the route in light of existing road signs and markings.

Another area of concern with the inshore sampling procedure results from beginning the survey at one of only two possible points. By having only two possible starting points for the survey, the time at which samples are taken becomes predictable. For example, Gun Beach is sampled only in the mornings or late afternoons, never at any time in between. The DAWR should consider randomizing numerous starting points

and then begin the sampling in a continuous manner from there. Granted, this will add additional driving time; however, a more randomized sampling program will result. In addition, by staggering the sampling hours to include early morning and evening fishing, better overall coverage of fishing activity will result.

Catch/Effort Data Requirements. Although the inshore sampling program is essentially a participation survey, the sampler must obtain catch/effort data whenever possible. Unfortunately, the nature of the program creates a significant incentive for the sampler to take only "easy" samples. If in fact this is true, then these "easy" samples could introduce unnecessary bias into the sampling program. The DAWR looks upon the current program as a short term activity.

DAWR's Capability

The ability of the DAWR to sample inshore activity is only limited by its manpower resource. The basic elements of proper sampling techniques are understood by the DAWR and for the most part have been incorporated into the system.

Expansion Algorithm. One significant problem occurs in the expansion methods employed by the DAWR, however. A number of factors, i.e., weather, night fishing, etc., which readily impact fishing activity have not been accounted for in the expansion method. The DAWR must begin to develop estimates of these factors either through sampling or by some other means.

Best Participation Survey Method. Finally, in terms of the participation survey, the aerial survey appears to provide the best estimates of inshore activity.

Concluding Assessment

All things considered, the current sampling programs are working well. In recent years, the DAWR has made great strides in implementing a useful fishery data collection system. Existing deficiencies can be easily corrected within current budgeting constraints. The result will be a viable system which will enable the DAWR to accurately monitor the Island's fishing activity. The overriding factor which will allow this system to operate successfully is the caliber of people participating in the project. These individuals are willing to experiment in looking for better methods and techniques. Finally, the DAWR must play the central role in collection of fishing information now and in the future.

SECTION II

PROPOSED FISHERY DATA COLLECTION SYSTEM

INTRODUCTION

This section of the report formalizes the initial steps in developing a complete Fishery Data Collection System by establishing the fundamental elements of the system. At the foundation of the FDCS are two basic principles. First, the system must be built on sound conceptual and statistical principals. In this regard, the discussion of the sampling design and expansion techniques are critical. Second, any data collection system proposed must fit within the constraints imposed by Guam's existing fishing culture. Thus, the proposed FDCS's structure draws heavily from current as well as past data collection methods and techniques. In fact, the proposed system is essentially a composite of these tested methods. For ease of study, the proposed FDCS is divided into eight elements. These elements are:

- Description of the FDCS objectives
- general design components for the FDCS
- sampling design
- sampling activity procedures
- processing of the system's data base
- expansion algorithms and their reliability

- quality assurance methods
- presentation of the FDCS's results

The primary focus of this section is on the sampling design and expansion algorithm elements. Discussion of the remaining six elements is limited in content to those matters which directly pertain to the sampling design and expansion algorithm factors. In addition, at times, alternative strategies will be identified and discussed in an attempt to provide a complete presentation of the FDCS and its development. Each of the eight components to the FDCS is presented and discussed individually in the remainder of the section.

OBJECTIVES OF A FISHERY DATA COLLECTION SYSTEM

The objectives of a FDCS provide the conceptual background needed in directing the collection of fishery information. The FDCS's objectives reveal what universe is to be studied, in a statistical sense. Within the universe, the objectives identify which characteristics are to be observed and measured and which structural processes are to be examined. Each year, the DAWR states in its annual fishery report the objectives of the data collection efforts for that year. These stated objectives describe the goals surrounding the data collection effort.

The DAWR was asked to review its past objectives and goals with regard to data collection activities, and to identify a set of objectives which would serve as a basis for the proposed

FDCS contained in this report. As a result of this effort, the overriding objective for a FDCS on Guam is to obtain reliable Island-wide total harvest estimates. The nature of the fishing activity is such that the fishing on Guam can be naturally divided into inshore and offshore activity. Thus, the primary objective translates into generating Island-wide catch estimates for both inshore and offshore activity.

To assist in developing meaningful Island-wide estimates, DAWR identified key characteristics which must be examined closely. These characteristics include fishing effort, participation, fishing gear used, area fished, and species catch compositions for both the inshore and offshore fisheries. To insure that these characteristics are properly analyzed, adequate sampling effort must be undertaken. The objectives for the proposed FDCS can be summarized 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.

GENERAL DESIGN COMPONENTS FOR A FISHERY DATA COLLECTION SYSTEM

General design components refer to these considerations which must be examined in the formulation of the overall sampling design approach. In effect, these components act as framing constraints to the system and encompass three areas: the fishing experience, sampling factors, and sampling effort. These three areas are undoubtedly influenced by each other's activities.

The Fishing Experience

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.

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 Guam. The closest information which could be used to extract participation rates comes from the National Recreation Fishing Survey conducted by NMFS. However, in talking with the DAWR 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.

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*On Guam, fishermen fish for one of three reasons: recreation, subsistence, and commercial.

Because Guam is an island, the second factor in the fishing experience, the spatial factor, is well-defined. In principle, fishing could take place anywhere on the Island's coastline. Thus, the FDCS must define some means of determining what level of fishing effort is occurring at a specific location. In the case of the offshore fishery, this will involve assessing the launching sites around the Island and determining how best to examine these sites. The variety of possible methods for examination is broad, ranging from actual sampling to ignoring the site completely. Critical to the data collection system is assigning a method to each site so that the entire Island is covered. Any spot which is omitted could introduce unnecessary bias into the system. As a rule, examination methods should be re-evaluated periodically.

A similar approach must be taken for the inshore fishery. The entire shoreline of the Island must be reviewed and a method for measuring the fishing activity determined. It is important to note that due to any number of reasons, e.g., budgetary, safety, it is possible to omit an area from consideration. However, without the use of a proxy measure, one must realize that omitting an area explicitly assumes zero fishing activity for that area.

The final factor in the fishing experience is the temporal factor. The unit of measure 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. Some means of estimating the fishing activity during these hours must be developed. For Guam, the major temporal problem is the night fishing activity which will be discussed further in the next element of the FDCS -- the sampling design. Both the inshore and offshore fisheries must be viewed from this temporal dimension in order to insure a complete FDCS. By combining the three fishing experience factors, a better insight is gained into the feasible approaches to the FDCS.

Sampling Factors

Sampling factors represent the second design component. A number of sampling factors exist which, upon identification, assist in revealing the most promising sampling procedures to be followed, First, the determination unit must be specified, i.e., what items are to be sampled and measured. For both the inshore and offshore fisheries, this unit is ultimately the fisherman.

The nature of the fishery and the program's objectives are such that the measurements at another level, i.e., the retail outlet, would not lead to satisfactory results because not all fishermen sell their catch to retail outlets. Also, sampling at the fishermen level reduces the chances of losing information about basic fishing data. At times, the offshore sampling

activity at Agana Boat Basin may have to rely on the Guam Fishermen's Coop for the trip information, should a fisherman be missed. In most cases when this occurs, the Coop is able to identify the fisherman and the missing information is obtained. Nevertheless, the objective of any sampling scheme should be to interview the individual doing the fishing.

While the name associated with the present sampling schemes uses the word "census," these programs do not collect information on all participants. The proposed FDCS will rely heavily upon sampling methods. Two sampling methods will be employed: face-to-face interviews and sampler observation. Other means of sampling, such as telephone sampling or mail sampling, would not provide the quality of data desired. The face-to-face interviews will be directed at the fishermen in the hopes of obtaining information not otherwise available, specifically catch and effort information. However, in the collection of participation data, sampler observation methods should be utilized whenever possible.

Sampling Effort

The final design component to be considered deals with sampling effort. Three factors influence sampling effort: costs, variability, and tolerated error. In the real world, budgetary considerations are the fundamental constraint to sampling effort. For Guam, the availability of funds is to a large extent independent of need. Instead, Guam is faced with the age old problem of cutting up the pie among many claimants. Exact costing figures for existing sampling programs are not readily available.

However, estimates of the variable cost of the sampling programs, made available by the DAWR, showed that for the inshore surveys the cost per interview was approximately $2 to $3, while offshore figures ranged from $3.50 to $4 per interview. These figures translate into a daily cost of $52 for the inshore survey and $44 for the offshore survey. While no fixed cost information is available, this variable cost information will assist in evaluating the financial feasibility of alternative FDCS's especially in terms of specifying sampling effort.

Another element of the sampling effort issue is the variance associated with key variables. The greater this variability, the greater will be the required sampling effort to obtain a reliable estimate. The existing fishery data set, which the DAWR is now computerizing, will furnish valuable variance estimates. Finally, DAWR selected a target confidence level and tolerated error for the program; the values were 95 percent and 10 percent, respectively. Tables 5 and 6 contain the sample sizes for generating fishing estimates for the primary fishing methods for both offshore and inshore sampling.

To illustrate sampling effort sensitivity to selected tolerated error values, sample sizes were computed for three separate error values. The proportions used in computing the variances were five-year averages derived from the DAWR data set. The inshore proportions were derived by averaging inshore creel and aerial participation rates.

Table 5

COMPUTED SAMPLE SIZES FOR VARIOUS TOLERATED ERRORS BY SELECTED FISHING METHODS: OFFSHORE SURVEY

	Tolerated Error		
Fishing Methods*	.05	.10	.25
Trolling	340	90	15
Bottom Fishing	3,790	1,800	385
Spearfishing	4,800	3,010	830

*Participation rates used were .81, .13, .06, respectively.

Source: CIC Research, Inc., 1983.

Table 6

COMPUTED SAMPLE SIZES FOR VARIOUS TOLERATED ERRORS BY SELECTED FISHING METHODS: INSHORE SURVEY

Fishing Methods	.05	.10	.25
Hook and Line	2,640	595	100
Cast Netting	4,120	1,490	275
Gill Netting	3,275	1,085	190
Surround Netting	4,465	1,680	315
Spearfishing	5,070	2,045	395

*Participation rates used were .30, 18, .24, .16, .13, respectively.

Source: CIC Research, Inc., 1983.

In computing the sampling values in Tables 5 and 6, the following formula was 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 the 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.

Current sampling levels are such that their relative size to the population as a whole requires the inclusion of the finite population correction factor in Equation (1). With annual sampling levels ranging from 2,000 to 3,000 interviews for the inshore survey and 800 to 900 interviews for the offshore survey, a lower bound estimate of the population can be derived. For the purposes of Equation (1), the population estimate for inshore activity is 10,000 trips and for offshore activity, 6,000 trips. Thus, under current sampling levels, approximately 20 percent of the inshore trips are being sampled and 15 percent of the offshore.

In computing the sample sizes for Tables 5 and 6, 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

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*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.

error in its relative sense implies the error value is dependent upon the participation rate under 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.

Tables 5 and 6 show the total number of trips that must be sampled in order to adequately cover a specific fishing method. For example, in the case of the offshore fishery, 3,010 fishermen must be interviewed to obtain an acceptable spearfishing estimate within the parameters defined, i.e., tolerated error. A review of the offshore fishery sampling requirements (Table 5) shows that at the 10 percent tolerated error value, current sampling levels adequately survey only trolling. In the case of bottom fishing and spearfishing, current sampling levels result in a tolerated error in the neighborhood of 20 and 25 percent, respectively. For the inshore fishery (Table 6), current sampling effort meets the desired levels, i.e., 10 percent tolerated error. In conclusion, the current levels of sampling yield numerical results which can be considered worthwhile.

THE SAMPLING DESIGN

The sampling design describes the procedures to be followed in generating the desired data base. The overall design is

comprised of two basic methods: statistical survey methods and qualitative inference methods. A statistical survey method refers to those procedures which involve observing fishing activity in a systematic fashion and relying on sound statistical survey theory. Qualitative inference methods, on the other hand, do not rely upon a statistical basis but involve more arbitrary observation techniques and procedures.

Three survey procedures comprise the set of statistical survey methods proposed, while two qualitative methods are required to insure completeness of the FDCS's sampling design. The three survey procedures are: an offshore sample survey, an inshore sample survey, and a Merizo area survey. The two qualitative methods are aimed at quantifying night and illegal fishing activity. Together, these methods -- the statistical survey and qualitative inference methods -- will generate a data collection system which will provide a complete estimate of Guam's fishing activity. Each of these methods will be discussed in detail below.

Statistical Survey Methods

Each of the three survey methods is directed towards obtaining information concerning daytime fishing activity. The purpose of the three survey methods is to identify and provide an estimate of a particular portion of the daytime fishing activity. In addition, the three methods were designed in

such a manner as to insure that the proper expansion could be made.

Geographical Division of Coastline. The DAWR has developed a fairly specific geographical coding system to assist in identifying the location of the fishing activity. In the system's most general sense, the Island is divided into surveyed and non-surveyed coastline. Within the surveyed coastline are the three survey regions -- Regions 1, 2, and 3. Next, each region is divided into areas. In Region 1 are the Tumon and Agana areas, in Region 2 are the Asan/Piti, Harbor and Agat areas, and finally, in Region 3 are the Manell/Inarajan and Talofofo/Pago areas. The most notable area missing from the current surveyed coastline is the Merizo area.

The final level of disaggregation is referred to as sectors. In all, the entire coastline of Guam is divided into 92 separate sectors. Sector 1 is located at Gun Beach with Sector 92 located just north of Gun Beach. The following table shows the relationship between the different geographical sectors. This geographical division of the coastline will assist the sampler in uniquely identifying the fishing location of each sighted fisherman or vessel trailer.

Table 7

GEOGRAPHICAL DIVISION OF
SURVEYABLE COASTLINE

Region	Area	Sector
1	Tumon	1 - 4
	Agana	5 - 11
2	Asan/Piti	12 - 15
	Harbor	19 - 27
	Agat	28 - 36
	Merizo	42 - 50
3	Manell/Inarajan	51 - 57
	Talofofo/Pago	60 - 72

Variability of Fishing Activity Between WE/H and WD. Data collected during 1980 and 1981 shows that 44 percent of all fishing activity occurred on WD, while 56 percent of the activity occurred on WE/H. If, in fact, significantly different rates of fishing exist between WE/H and WD, it must be reflected in the proposed survey design. Unfortunately, a review of the DAWR's participation data between WE/H and WD showed a considerable amount of variability.

In order to properly account for the difference in variability, sampling effort must be stratified by WE/H and WD. Should the DAWR desire separate estimates for WE/H and WD, additional sampling effort will be required. The DAWR should closely analyze this 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, DAWR maintains a record of weather conditions. DAWR should study these 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.

The current offshore survey methodology attempts to account for varying weather conditions by adjusting the number of available fishing days -- a measure of normal fishing days. From the total number of available fishing days, the number of bad weather days (i.e., no fishing days) and the number of poor fishing days (i.e., less than normal days based on the issuance of small craft advisories) are subtracted out. For example, a poor fishing day may correspond to three-fourths of a normal day.

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 Guam. 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. DAWR 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 that 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

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*See "An Evaluation of the Roving Creel Survey with Non-uniform Probability Sampling." by Stephen P. Malvestuto, William D. Davies, William L. Shelton; Transcript American Fishery Society 107(2): 255-262, 1978.

between the probability 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.

Offshore Sample Survey. The offshore survey is a sample survey and its purpose is to obtain estimates of catch and effort activity within the offshore fishery. As Table 2 showed, of the three principal offshore fishing methods, trolling is by far the most prevalent fishing method. Essentially, the offshore survey now in operation in Guam is the basis for the proposed offshore survey. Therefore, this discussion will focus on formalizing the offshore survey operation with the proposed general design.

The offshore sample survey has a simple random sample design. There are a number of reasons for this. While a number of boat mooring and launching sites exist around the Island, basically all catch/effort sampling is done from two basins, Agana and Merizo. DAWR estimates that the activity of these two basins accounts for well over 90 percent of the offshore fishing activity. The infrequency of offshore activity elsewhere precludes any meaningful sampling of catch and effort information. Hence, the offshore survey cannot effectively sample areas outside of these basins. However,

activity outside these basins will be partially observed by the inshore survey and incorporated into the overall survey results; participation estimates in these infrequently used offshore launching areas are being compiled by DAWR and can be used as a check when reviewing the offshore activity.

Two underlying assumptions are made to insure that the data generated are complete. First, the assumption is made that no offshore activity originates from outside DAWR's three regions. Second, it is assumed that the catch/effort figures collected from these two basins do not differ from the other offshore launch areas.

Special circumstances surrounding the Merizo area, i.e., the need to combine the inshore and offshore sampling activity, require a separate survey. (See discussion on page 69.) Hence, the offshore sample survey consists of sampling one basin, the Agana Boat Basin. However, as offshore activity increases around the Island, and the need for additional sampling is required, the sampling program can easily be expanded. For example, it may become necessary to group the boat basins, one group being sampled within any one sampling unit. The groups are randomly chosen with probability proportional to the amount of fishing expected to occur in that group.

The subsampling unit is the fishing vessel with the observation being made of the fisherman and his catch. On an offshore sample day, the sampler observes and intercepts boats as they

return with the objective of collecting catch/effort information. In addition, the sampler maintains a count of departing and returning fishing vessels.

An important issue for a sample survey involves coverage, that is, obtaining data on each observation unit. The sampler need not spend the entire day at the basin if the catch/effort data does not vary by time of return. While the majority of boats return in the later afternoon and early evening, the sampler must be sure that the catch/effort results obtained during these periods do not differ from earlier times of the day. This issue can easily be tested by simple statistical mean difference tests using existing data.

During the course of the sampling, the sampler must be aware of the activities in the boat basin. Should a number of boats arrive in the basin at the same time, the sampler may have to undertake subsampling procedures. If this occurs, the proper notation should be made. The objective of the sampler is to survey all the boats on a survey day. When this cannot be done, the decision as to which boats to sample should be determined by the type of fishing gear and/or location of fishing in an appropriate sample allocation scheme. Fortunately, the sampler, in the case of the offshore fishery, is dealing with completed fishing trips.

In keeping with the present continuous sampling program, a one-month time block is proposed for the offshore survey.

The blocks are divided into two sampling units: A.M. and P.M. DAWR estimates that the average offshore fishing trip is one day, or 12 hours (fishing time). Primarily, boats leave in the early morning hours and return in the late afternoon or early evening. Thus, according to DAWR, the vast majority return during the P.M. unit. DAWR must assign to each sampling unit a sampling probability proportional to the expected return of the fishing vessel. These probability values are derived by reviewing historical data on when boats returned and computing the proportion of boats returning in the A.M. and P.M.

Activity at the boat basin appears to differ between WE/H and WD, with WE/H being more active. An analysis of 1982 offshore catch data shows that the average WD catch for trolling was 38 kg, while the WE/H averaged 30 kg. Interestingly, no statistical difference between these two mean values existed at the $\alpha = .1$ level.

For the purpose of this sampling scheme, the periods WD and WE/H are treated separately, i.e., the sampling scheme is stratified. The primary reason behind this treatment is the different participation level between the two periods. Should the DAWR decide after reviewing the entire offshore data set (i.e., for more than one year) that such a distinction is not required, the sampling effort can be reduced.

Current sampling levels, i.e., four sample days, will allow eight different sampling units to be observed. Each sampling

unit is to be randomly selected within each one-month block on the basis of the assigned probabilities. First, however, sampling units are equally stratified by WE/H and WD (four sampling units each. Giving all days within a strata equal probability of being selected, four sample days are chosen. Then, within a sample day, the sampling unit (A.M. or P.M.) is selected according to the proportional probability computed above. One would expect that the vast majority of sampling would be done in the P.M. period.

Inshore Sample Survey. The inshore survey is also a sample survey and its purpose is to collect information concerning catch and effort activity by the inshore fishermen. Of the five major fishing methods utilized by the inshore fishermen, hook and line is the most prevalent inshore fishing method, while surround netting accounts for the greatest proportion of catch (35%). The inshore sampling program which the DAWR has used in the past to collect catch and effort data will serve as the foundation for the proposed inshore survey.

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. Like the offshore survey, the inshore survey is a continuous program. Again, 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 by the DAWR, the following stratification system has been developed.

As mentioned earlier, DAWR defines the Island's coastline into surveyed and non-surveyed regions. Non-surveyed regions represent those areas where either fishing accessibility is restricted or observation of fishing activity is not possible. During the aerial survey, it was possible to obtain participation estimates for the entire Island, surveyed as well as non-surveyed regions.

Table 8 indicates the proportion of fishing activity between the two types of regions by fishing gear (figures taken from Table 1). The rates shown in Table 8 are used in computing

Table 8

PARTICIPATION RATES FOR FISHERMEN IN SURVEYED AND NON-SURVEYED REGIONS BY FISHING METHOD

Fishing Method	Participation Rate	
	In Non-Surveyed Regions	In Surveyed Regions
Hook and Line	.069	.931
Cast Net	.204	.797
Gill and Surround Net	.099	.901
Spearfishing	.200	.800
Other	.211	.789

Sources: DAWR
CIC Research, Inc.

proportion of fishing in non-surveyed regions. The computations for the non-surveyed regions are presented in the expansion algorithm section. The first level of stratification is the three survey regions. Over the past two years, 55.8 percent of the sampled catch occurred in Region 1 with 20.6 percent, and 23.6 percent in Region 2 and 3, respectively. For the inshore survey, sampling effort is allocated by the proportional size of first the particular area strata and then by the time period (sampling unit). Therefore, 56 percent of the overall sampling effort is to be allocated to Region 1 with Region 2 and 3 receiving 21 and 23 percent, respectively. Then, for example, the 56 percent allocated to Region 1 will be disaggregated proportionally to the three sampling unit time periods. DAWR can develop these probability values from their existing inshore data base. 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.

Since the late 1970's, DAWR has sampled the inshore fishery at a level of four to six days per month. On the surface, this level of effort meets the sampling requirement depicted in Table 6. To more precisely determine the sampling effort required for the inshore survey, an analysis of CPE figures should be undertaken. By computing the average CPE, by species if desired, and the appropriate variance, sample effort levels

can be determined. Formulas for these computations are contained in most statistics texts. A review of the data profiled by DAWR for this study indicates that a six-day per month sampling level would be adequate. Again, DAWR should analyze the CPE values according to the above methods.

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 a review of the inshore fishing data supplied by the DAWR, it was not apparent if average catch figures differed between WE/H and WD periods.

In reality, the set of sampling units become 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 DAWR's inshore catch/effort and participation questionnaires 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.

For the most part, sampler's interviews will be made on incompleted trips. Thus, the assumption must be made that the CPE for incomplete trips equals the CPE for complete trips.

It would be worthwhile for the DAWR to conduct a study to verify this assumption. Also, a key variable to the expansion algorithm is the average length of the fishing trip. While this information is collected during the interviewing process, DAWR should consider conducting a survey dealing specifically with the average trip length issue.

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:

   Offshore Survey

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

   Inshore Survey

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

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

   Offshore Survey

   A total of four basic probabilities need to be calculated:

   $P_{AM}^{WE/H}$ = For WE/H, the probability of an incoming vessel returning in A.M. hours.

   $P_{PM}^{WE/H}$ = For WE/H, the probability of an incoming vessel returning in P.M. hours.

   P_{AM}^{WD} = For WD, the probability of an incoming vessel returning in A.M. hours.

   P_{PM}^{WD} = For WD, the probability of an incoming vessel returning in P.M. hours.

Computationally, the WE/H and WD probabilities are calculated separately. For example, WE/H specific data is reviewed to determine the number and subseqently the proportion of vessels returning in the A.M. and P.M. hours. Thus,

$$P^{WE/H}_{AM} = \frac{\text{the number of vessels returning in A.M. on WE/H}}{\text{total number of vessels returning on a WE/H}}$$

The other possibilities are computed in a similar manner when the appropriate substitutions are made. If the data is available, these probability values can be computed on a month-by-month basis. The quantity and quality of the data will determine the disaggregation level of these probability values.

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., $P^{WD}_{AM,\ Region\ 1}, \cdots$

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 $P^{WE/H}_{AM}$ and $P^{WE/H}_{Region\ 1}$ can be computed with the product of these values equaling the desired joint probability.

4) Randomly Select Sampling Units

Offshore Survey

A total of eight sampling units are to be sampled each month. As an illustration, suppose the selection of sampling days is to be in February. For this example, February has 18 WD and 10 WE/H. The sampling is divided evenly between the two periods, four units for WE/H and four units for WD. A total of 36 sampling units are possible for WD and 20 for WE/H. In the case of WE/H, 10 sampling units are A.M. and 10 are P.M. Suppose 75 percent of the vessels return in the P.M. hours ($P^{WE/H}_{PM}$), the remainder returning in A.M. hours, 25 percent. Thus, of the four sampling units

to be surveyed, 3 (4 x .75) will be surveyed in P.M. hours and 1 (4 x .25) will be surveyed in A.M. hours. The particular days to be surveyed are then randomly selected, a total of four sampling days being selected.

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 the February sample again, 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 $P^{WE/H}$ $P^{WE/H}_{AM,Region\ 1}$ = 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

Merizo Area Survey. The two previous survey designs have omitted the Merizo or Cocos Lagoon areas (sectors 42-50) from consideration. The reason for this omission centers around the unique environment setting of the lagoon. Under the sampling scheme proposed for the remainder of the Island, it would be impossible to adequately survey the lagoon. While the offshore activity originating from the lagoon does not pose any special survey problems other than sampling logistics, the inshore activity is another matter. Inshore fishing can take place along the reef which protects the lagoon or in small vessels within the lagoon itself. The inshore activity cannot be surveyed without the use of a boat, which necessitates implementing a special survey for the area. In order to efficiently utilize sampling resources, the survey would combine the data collection efforts of both inshore and offshore activity. In addition, the DAWR should consider other biological studies that could be undertaken during the down time of the sampling activities.

Essentially, the sampling design for the Merizo area would follow the basic framework outline for inshore and offshore activities, except all surveys would be conducted during the same day. The Merizo survey could provide participation information, and the inshore and offshore catch and effort data. The prevelance of the major fishing methods used in the area are similar to Island-wide rates with the exception of inshore

spearfishing and hook and line methods. In the Merizo area, spearfishing accounts for 32 percent of the fishing participation while hook and line only constitutes 18 percent of the activity.

Overall sampling effort for this survey would appear to be between two and six days per month. This range is based on the sampling efforts required for the other surveys, along with a brief review of Merizo-specific fishing data provided by DAWR as well as meeting minimum coverage factors for each time period. To obtain a better estimate of the required effort, the DAWR should analyze the available Merizo data in terms of catch and effort statistics. This analysis would assist in determining the additional level of sampling effort necessary to generate the desired catch and effort information.

Qualitative Inference Methods

The previous sampling designs together provide a method for generating statistically based fishing estimates for daytime fishing on Guam. In order to complete the fishing picture on Guam, two additional fishing activities must be considered: nighttime and illegal fishing. Unfortunately, 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.

Nighttime Fishing. According to the DAWR, nighttime fishing activity is prevalent enough to warrant numerical estimates. Without the use of a comprehensive survey, other techniques must be developed to provide a nighttime fishing estimate. Basically, the nighttime estimate is a proportional figure tied to the level of daytime activity. For example, if daytime catch is estimated at 100kg and the proportional nighttime rate is 25 percent, then the estimated night 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. Attached to the catch/effort surveys could be a question concerning night fishing activity. The scope of the question could include not only the night activities of the intercepted fisherman, but also those of individuals known by the fisherman. Questions involving fishing method, location, size of catch, etc., could be asked. Another approach would be for the DAWR's conservation officers to keep a tally of night fishing during the officers' patrols. The use of the 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.i.e., asking "knowledgeable" individuals, is endless. The most productive method, however, appears to be utilizing the conservation officers and attaching night fishing questions to the existing surveys.

Illegal Fishing. Unfortunately, Guam is faced with a fairly significant illegal fishing problem, e.g., dynamiting and chlorinating, which over the long run could have a lasting destructive impact upon the inshore fishery. From a data collection point of view, 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 the illegal 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. The public should be informed about the adverse impacts of illegal fishing. Their assistance should be solicited in reporting illegal activity to the DAWR conservation officers. All reports would be compiled to determine a measure of the activity. To assist in calculating the catch associated with the illegal fishing, the DAWR could estimate possible kill rates for particular illegal fishing activity. These estimates would take into account location, 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 fishermen of the desired information's purpose and

confidentiality. Also, questions on illegal fishing activities could be added to the catch/effort surveys. Finally, any information obtained by conservation officers involving illegal fishing should be transmitted to the fishery data collection personnel.

The problem of illegal fishing cannot be ignored by not incorporating the activity in the Island's catch estimates. Instead, the DAWR must experiment with different procedures for measuring the Island's illegal fishing activity.

THE SAMPLING ACTIVITY

This element of the FDCS deals with the support activities surrounding the actual implementation of the sampling design. In all, the sampling design proposed in the previous section requires five separate data collection activities: inshore fishing, offshore fishing, Merizo area fishing, night fishing, and illegal fishing. To successfully implement such a data collection system requires careful planning so that the sampler's efforts result in the collection of information which is of the desired quality, well-documented, and concisely maintained. The scope of the project does not include a detailed discussion of the necessary support procedures to insure the above result. However, a brief outline of the major procedures involved is provided as a guide to DAWR in its efforts to establish a complete FDCS.

Prior to conducting the actual survey operations, a number of preparatory steps must be undertaken. First, the theoretical structure of the sampling design must be formulated in terms of a series of detailed and well defined sampling precedures. The information presented in the sampling design section, coupled with DAWR's sampling knowledge, will provide the necessary information required to compile the list of sampling procedures.

All recording forms, i.e., questionnaires, tally sheet, sampler's log books, etc., must be properly constructed. The survey instruments currently being administered by the DAWR would serve as a basis for the set of recording forms. At any stage of the sampling program where information is being collected, the proper form must be in existence. In addition, sampler information gathered during the survey activity must be documented on the proper forms. This information will aid in the adjustment process and ongoing survey requirements.

A survey protocol packet should be developed and provided to each sampler. Items in the protocol should include at least 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 sheet
- Administrative requirements
- Sampler's log book

Each individual involved in one of the six survey procedures must thoroughly understand their specific sampling responsibilities as well as have a general knowledge of the program.

EXPANSION ALGORITHMS AND THEIR RELIABILITY

The expansion algorithm defines the mechanism for generating the desired numerical estimate from the survey results. However, survey results provide information only for the sampled 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 yields 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

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

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, $\overline{C}_i$ = 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)" $\overline{C}_{WE/H}$ or $\overline{C}_{WD} = \sum g_i \overline{C}_i$

where,

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

N = total number of days sampled

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

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

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

where,

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

n_k = the number of days sampled with the kth 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:

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

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

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

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. Then, the value of N in the above equation can be adjusted according to the method currently in use by DAWR for the offshore survey. DAWR should also 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 $N \times \overline{C}_d$

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

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, offshore and Merizo. In order to derive a total Island-wide estimate, the night fishing and illegal fishing values must be factored in. Basically, these two variables enter as scalers in the computation procedures for the catch estimate objective.

PROCESSING THE SYSTEM'S DATA BASE

In general terms, as the survey work is completed, data processing procedures must be in place to insure that the final data set is accurate. These data processing procedures commence the moment a questionnaire is brought out of the field. Each questionnaire must be checked for completeness, consistency, and proper coding. Data from all questionnaires should be keypunched into a computer file as soon as possible

in order to minimize the possibility of misplacing the questionnaires. Of great importance at this stage of the data collection activity is the existence of clearly-stated procedures for processing the raw field data into the form and configuration of the final data set.

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 levels. 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. Together, these QA methods provide the insurance necessary to generate a useful and viable fishery data collection system.

Sampling procedure checks are QA efforts directed at the survey activity element of the system. These checks include reviewing sampler-specific survey results to uncover potential sampler bias and assessing and adjusting, when necessary, sampling allocation factors when new information is acquired. The FDCS calls for a number of data handling phases and with each handling, e.g., keypunching, the chance of error increases. The QA techniques are geared to evaluating if this additional

error is significant, and if so, to correct the problem. An example of such a technique is subsampling the data set and checking this sample with the original questionnaire. If the error rate from the sample is significantly higher than the desired rate, then the entire data set would have to be re-checked. This test boils down to a simple proportional statistical test. Additionally, more sophisticated procedures can be devised if required by the sampling program.

External methods provide a valuable means for assessing the reasonableness of the final fishing activity estimates. These external methods involve developing fishing estimates from independent sources. Such sources would include demographic data, other surveys, i.e., the recreational fishing survey, and other reports. For example, fishing participation estimates can be compared with population figures to determine if the relative sizes are reasonable. 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 tables, but in the written text as well. The effective presentation of the FDCS depends, in part, on the reader of the report.

Together, these considerations will ensure that the FDCS is presented in a clear and concise manner.

SUMMARY

The proposed FDCS presented in this report focuses on two specific elements: the sampling design and expansion algorithm procedures. In developing this system, the unique structure of Guam's fishing environment and the data collection expertise of the DAWR were integrated into the design. Essentially, the sampling design is comprised of two survey approaches: statistical survey methods and qualitative inference methods.

Two statistical survey methods involved three separate survey procedures: offshore sample survey, inshore sample survey, and the Merizo area survey. The offshore and inshore sample survey furnish participation, catch and effort information. In addition, these two sample surveys collect information on length of fishing trip, species composition, gear, weather, and other variables. Finally, the Merizo area survey, which was not designed in specific terms, supplies fishing activity information for the Cocos Lagoon region of the Island.

To obtain estimates of fishing activity, i.e., night, illegal, not readily available by sample survey techniques, a series of qualitative methods were suggested. At the very least, these methods would generate information concerning the

level of night and illegal fishing. Basically, the qualitative methods involve collecting information using informal methods, i.e., conservation officers, as observers.

Data collected from these data-gathering activities provide the basis for the estimated total catch figures. Once the survey results are formalized during the data processing procedures, the total catch variables can be computed using the equations specified in the expansion algorithm section. The gear-specific average catch estimates derived for inshore and offshore activity are expanded by the total number of fishing days and the level of fishing participation for that time period. Adjustments for night and illegal fishing are factored into the equation as well. To assist in measuring the reliability of the total catch variable, its variance is derived. Confidence intervals can now be calculated for the total catch variable.