POPULATION SURVEY OF COCONUT CRAB (*Birgus latro*) IN THE HUVALU

FOREST CONSERVATION AREA, NIUE ISLAND, SOUTH PACIFIC

RAS/91/G31/E/1G/99

A project of the South Pacific Regional Environment Programme (SPREP) administerwed by the United Nations Development Programme (UNDP) with financial assistance from Global Environment Facility (GEF)

by

M. A. BERETEH
ENVIRONMENT AND BOIDIVERSITY ADVISOR
(South Pacific Biodiversity Conservation Programme)

June, 1997

HUVALU FOREST CONSERVATION AREA, NIUE ISLAND, SOUTH PACIFIC

THE ECOLOGY AND POPULATION DYNAMICS OF COCONUT CRAB (*Birgus latro*) IN THE HUVALU FOREST CONSERVATION AREA, 1997

(Summary of Survey Analysis and Results)

1. The mean CPUE (Catch Per Unit Area) which is an expression of the total density of five distinctive vegetation categories shown in Table 1 is 3.28 per square km.
2. The actual sample population count is estimated to be 166 individuals as compared to 224 in 1990 for 35 transects and 124 transect surveys completed out of 198 (62%) and effective patrols 4 times on average.
3. An estimated total count for Huvalu C. A. is 88,908. In 1990, 147,180 coconut crabs were counted in the coastal forests of Niue Island which was 36.93% of total and 125,400 in the secondary forest. The high density is most likely overestimated because of the breeding season or spawning activities in the month of March,1997. Repeatability of sample survey sites will give a more reliable confidence limits and unbias sampling ground. A larger sample size and random surveys throughout the year will give a more appropriate result.
4. The male and female ratio is 1.5 to 1and the data in relation to the actual count gives the mean thorax lenth and mean weight as follows:

   Male TL 37.18mm (n=99), WT 346.48g (n=99)
   Female TL 28.29mm (n=67) WT 191.33g (n=67)

The total mean TL is 28.83 and the total mean weight is 246.27g.These measurements are relatively high and show good records of growth.

5. From 1988 to 1997 in the same month of March the data showed disparity in growth rate. In seems that hunting pressure is considerably reduced since the 1970s resident human population decrease of 48.75% from 5,200 to 1990. The present low human population maybe responsible for the increase in the size structure such as sex, population abundance age in relation to thoracic length and weight measurements.
6. For the past ten years there has been an increase in morphometric data from male TL 28.4mm (N=75) to TL 37.2mm (N=99) and the WT from 235 g. (N=37) to WT 346.6 g. (N=99). The female TL decreased from 25.6mm (N=82) to TL 28.3mm (N=67) and the WT from 151.9 g. (N=82) to WT 191.3 g. (N=67).

No. 1990/91 estimates was total of 181,440, including 137,560 in coastal land. That was 75.8 % of total.

Or it could be due to low recruitment.

INTRODUCTION

A follow-up to previous studies of coconut crab (birgus latro) was conducted in march 1997 to monitor the status of uga (coconut crab) in the Huvalu Forest Conservation Area which is 5400 ha. Of diversified forest types. The main objective is to increase the available data for a more detailed statistical analysis for accuracy and near precision information gathering on uga population structure for management decision. This baseline surveys are designed for one year and will be conducted on quarterly basis. The first report took two weeks from the 3-17 March 1997 as the first quarter survey. The Conservation Officers will continue to monitor the line transects while at the same time collecting resource data on the biodiversity of the Huvalu CA during normal field operations and routing patrols.

Description of Niue

1. Geography

Niue Island is 259 sq. km. In area (21km x 18km) and roughly circular. It is one of 22 islands countries (out of 30) operation areas of the South Pacific Regional Environment Porgramme. Niue is the largest upraised single coralline limestone land mass atoll in the wolrd within the broad cultural divisions of the South Pacific Region (Micronesia, Melanesia, Polynesia). This small island, the 9th from the bottom has 390,000 sq. km. Of Exclusive Economic zone or seas area and a population of 2,000. The estimated annual population growth rate is -3.5% out of a regional 2.3% average in the last decade.

1.1 Location

The isalnd is 480 km east of tonga, 560 km South East of Samoa and 930 km west of Cook Islands (Rarotonga).

New Zealand which was the colonial master until 1974 self governance is 2, 400 km south west of Niue with a day difference. Niue is on the eastern side of the internaitonal dateline and is 11 hours behind GMT while New Zealand is on the western side and one hour ahead.

1.2 History

In 1901, Niue was annexed to New Zealand after one year of gaining British Protectorate. The Island was first sighted by the British Navigator, James Cook in 1774. It was not until1846 when the London Missionary Society established christianity on the island.

1.3 Geography

The island formation and geology as an upthrust coral atoll is over geological time which ovvurred in stages out of the ocean. This fact is basedo nthe assumption that volcanic rocks such as limestone are formed only under water and since Niue is predominantly of limestone outcrops it is evident that the land was raised or the sea level fell derived from internal volcaninc activity as opposed to buckling of Pacific tectonic plate prior to its subduction into the Tongan trench. The changing sea levels would also have altered the relative level of the shoreline over time. The atoll has three terraces with the rim ofthe lower terrace averaging 28

metres above sea level while the upper terrace averages 69 metres above sea level. Below the sea level are two futher terraces indicating previous shorelines.

Ther is no surface or running freshwater and no natural good harbour. The island is on the edge of the hurricane belt and severe destruction hurricanes have occurred. In 1958, 1960, 1968, and 1979 (Cyclone Ofa). There is no true reef and no lagoon in the south eastern side is almost devoid of reef flat except for Avatele,landing site and Ana-ana submerged reefs. Isolated reef platforms surround the whole island although they are highly disintegrated.

1.4 Climate

Niue is located on a hazardous track of the southern tropical cyclone belt (10 degree South) with temperatures at 27 degC and above). Niue's climate is influenced by the moderating effect for much of the year by the south east tradewinds. Unfortunately, the isalnd has been subjected to severe cyclones on the average of every ten years. In less than two years, cyclone Ofa on 8Feb 1990 was the most recent and the most destructive followed by cyclone Val of December 1991. Temperatures do not vary greatly. As a result of the modifying influence of the sea on this small land mass the wet season has a maximum air temperature of 30 degC (Jan-Feb) with a mean daily minimum of 23 degCelsius. In the dry season, the July maximum is 26 degC with a mean daily minimum of 19 deg C.

The average monthly relative humidity varies from 85-90% throughout the year. Rainfall average is 2000 metres with large annual variations between 839mm and 330 mm.mostly concentrated in the wetr season (68%). And the pattern is erratic with very dry or very wet months possible at anytime of the year.

Wind blows from the east to south east sector which is consistent with Niue's southeast radewinds bent. The strongest winds usually occur in the first four months of the year now comonly known as th ecyclone season.

Climate change although of univesal concern Niue is not so susceptible to sea level rise. Unlike islands of low lying plains of the South Pacific Region. However, the increasei n fequency and severity of tropical storms and cyclones is of particualr concern to Niue.

Natural Resources Survey

Simple random selection odlongititude and latitude coordinates and a compass bearing generated by computer is used of block of stratified random selection survey. Sites for accuracy of coconut crab density and abundance estimates. It should be noted that where simple random site selection is necessitated the time constraints and any limited number of surveys may increase the accuracy of coconut crab density and abundance estimates.

Coconut Crab Survey

Of all the natural resources, the cocount crabs are the most important although the suitable habitat is of coastal and inland forest. Coconut crab was studied on the coastal forest which was habitat for uga studies. And could be considered to include all the lower terace forest and most of the upper terrace forest.

For distribution of coconut crabs it is necessary to combine stip counts in all of the five habitat categories where coconut crabs are found to be significant or common. ($P< 0.01$ using students T test).

Further information is a concern that local coconut crab hunters indicatd that the coconut crab species were rarely found in fernland and scrubland. The main concern of coconut crab surveys tske into consideration five objectives:

1. the populatio nsurvey using strip count method on short teerm basis
2. line transect method for long term surveys
3. estimation of population abundance and density
4. population structure and
5. spawning grounds.

In review, Huvalu is in the vicinity of largely inaccessible lower terace which is assumed to contain most oof the island's coconut crabs. The first scientific description of coconut crabs in th eSouth Pacific was by Rumphus in 1705 and the species has been known to man some 300 years ago. However, the most significant detailed study was not until 1932 by Harms and betwen 1965-68 by Reyme.

The Huvalu CA crop survey takes into consideration a combination of the strip count temporary anecdotal and observational data.

On Niue Island the most recent uga surveys were conducted by Dr. Craig B Schiller using a simple random strip count/ CPUE to determine the index of relative abundance and absolute abundance. Dr. Karen Kool compared two of Schiller's transect surveys in the Huvalu CA on the Hakupu Togo sea track by December 1996.

In this report, monitoring and evaluation reveal analysis of data throughout the life of the Huvalu CA project and therefore information gathered in this frist quarter report is a preliminary documentastion .Yhe survey takes into consideration all basic survey techniques and methodologies applicable to the coconut crab habitat of Niue. It should be noted that the coconut crab surveys previously casrried out used a conversion factor of 12,000 derived from similar habitats on Vanuatu Island. The interpretation of the statistical data will take into consideration the estimate of the population size structure and distribution for stock assessment.

Background survey indicate that management and research authorities were contacted by Brown and Fielder (1992) in 27 countries and territories in the Pacific and South East Asia countries to assess coconut crab's distribution and abundance. Based on the results of the questionnaire, coconut crabs are considered generally abundant in the Solomon Islands, locally abundant in Trut and the Republic of Vanuatu. They are generally common in Niue which is under investigation, Tokelaus, and Marshall islands. In other places the population levels were locally common to rare.
The biodiversity conservation is important to the region and therefore continuous assessment of coconut crab is locally a priority environmental issue. Genetically, Vanuatu and the Solomon Islands support a uniform stock of *Birgus latro* different from that of Niue and that of Cook Islands which have separate populations. Most recent research assumes that thre

female coconut crab population is on the decline due to hunting exploitation throughout the year.

Population Survey Technique

a). Catch Per Unit Effort (CPUE)

Relative estimate of abundance is calculated by CPUE as a multiplier with a given constant or conversion factor . In this case, the number of coconut crabs caught or observed along a transect is compared to the number of coconut baits on that transect. A similar CPUE value in different areas should indicate a simsilar coconut crab density. Because of similariy of habitats and climatic conditions as in the case of Niue and Vanuatu, it is possible to calculate an overall density from Vanuatu figures of a conversion factor of 12,000 (Fletcher, 1988 Report quoed by Craig Schiller).

b) The Mark-Recapture data can be used to estimate density and abundance in a long term study programme. Coconut crab were marked by scratching with a metal and not by freeze branding the carapace. However, permanent colour markers were used as codes for distinguishing sample areas and movement or habitat preferences. The M -R method is most applicable to the Niue situation because of the difficult terrain along limestone outcrops, crevices and steep cliff edges which cannot be convenient for line transects. The multiple mark-recapture method has the fewest assumption in field techniques and yields the most information when used in combination with the CPUE method.

If field studies are well conducted, the parameters will indicate amongst other characteristics the following:

- length of time individuals will remain in a population (with the assumption that moulting and hunting have statistically an insignificant effect on the population)
- Distances covered and the distribution patterns as well as the direction of dispersal.
- Proportion of the population that is mature and legally harvestable or the main viable population which is predominantly made up of the reproductive class.
- The dynamics or changes in morphometric data of weight and thoracic length with season

In the multiple M-R method, the individual coconut crabs are randomly caught marked and then released. The process is continuous with as many crabs as possible being marked. It is assumed that handling the marking ofthe crab would not affect the probability that it will repel human contact rendering the crab impossible to be recaptured at a later date. In the foregoing survey the result will investigate the assumption in th elong run if there is any evidence of interference.

On the other hand, in the M-R method, the hypothesis is that it may be possible to mark all the crabs or the entire area can be searched. Theories, assumptions and natural field conditions are never the same. However, on Niue it would be appropriate because of the terrain to do much of the sampling on the coastal terrace. This method has never been used in Niue but was suggested by Schiller. From the above assumptions HFCAP has adopted two methods that are mutually exclusive. Therefore marking crabs can go on while carrying out CPUE surveys so that much information can be obtained.

Population Survey Methods (Random Samples & M-R Method)

1. Area Sample: All aminals within a known fraction of the ttoal area under investigation are counted. Meristic data is then convertedd to an estimate of the toatal animal population using the formula: P = S x A/a. P = population, S = counted animals in Sample A = total area under investigation, a = area sampled). In the field survey the formula was used to stratify random sampling to give an estimate of a total count.
2. Time Samples: This is a method used for long term population estimate using the M-R method. It can also be referred to as the Lincoln Index game census method because of an unknown population in the sample. This is an incomplete count conducted of animals in the area under incvestigation. Estimate of population is calculated by detemining the fraction of animals reobserved in an umknown population. This remote sensingtechnique otherwise known as Mark-Release and Recapture method under population survey techniques.

Analysis of Methodology

Coconut crabs are being relatively immobile and are well suited to both area and time sampling. For long term monitoring and evaluation, the M&R methodology is most appropriate. For a time limited research, area sampling in the form of strip count surveys can be successfully used within a relatively short term to estimate population size. This latter technique produces count data that is converted to absolute density and abundance values. It may be assumed that the terrain is not so rugged as to pose difficultiues or make transect surveys on the fringing coastal region prohibitive.

An unbias strip count involves an observer walking along a predetermined live transect and counting all individuals observed within a predetermined distance either side of the threadline (centre) and no baits are used.

Strip counts are one of the simplest methods of obtaining meristic data to estimate the size and density of animal populations.

The Catch Per Unit Effort (CPUE) is a less direct survey technique in collecting count data from baited transects. The CPUE is a relative estimate of abundance (not density) and can be defined as the number of coconut crabs caught/observed along a transect compared to the number of baits along the transect. The CPUE values can be considered as an index of absolute abundance and can be used in calculating:
a) a relative estimate of abundance and
b) an index of absolute abundance (otr the total population in a given sample area).

Transect Selection and Establishment

Coconut crabs occur approximately 2.5 km away from the coast. Fletcher (1988) found few crabs occurring > 2.5 km from the ocean in Vanuatu of similar size to Niue.

Stratified random selection using vegetation map of 1:30,000 (DAFF, 1990) was used in previous surveys. The island was diveided into 4 strata based on the main vegetation categories of coastal forest, high forest, regenerating forest and fernland of herbaceous community dominated by Nephrolepsis Histula (Sykes 1970). Proximity of the different habitats to the coast was determined and each stratum was subdivided into substrata vegetation types to maintain random heterogeneity in sampling.

Comparative Study (Coconut Crab Survey, 1997)

The number of transects allocated to each vegetation type was predertimed on the basis of local knowledge of hunters and previous scientific study areas. While this may appear inconsistent as opposed to stratified unbias random sampling, the CPUE method minimizes any inherent error taking into consideration the homogeneity of vegeation type in relation to its absolute sample size. In this respect three factors were used in locating the number of transects:

1) the study sites of previous coconut crab surveys by Craig B. Schiller and Karen Kool in the Huvalu Forest Conservation Area
2) the relative size of the vegetation category in relation to the total sample area and
3) each habitat type has sufficient number of transects to give a reliable statistical survey results. The total area of each vegetation category within the HFCAP is based for comparison on previous study by Schiller obtained by digitizing the 1:30,000 vegetation map using scriptel digitizer and autodesk.

Autocad Version 11 software on a PC via the polygon method. For the purpose of this preliminary stage of monitoring uga population, no modification of the GIS or scriptcad used demands further input. However, reference has been given to the vegetation types and land area of Niue for comparison.

Within the Huvalu CA, twelve transects were established, six of which werer on the Liku and another six on the hakupu end. In Schiller's survey, 34 transects for Niue was not optimal to provide meaningful and statistical relevant population data. Conversely, only 9 transects were completed in Huvalu CA which in this report was increased to 12 with more manpower which involved a taskforce of four surveyors of 24working nights per transect per week. In order to conduct the transect surveys within two weeks in March 1997 for the first quarter, the conservation officers were given the responsibility to accoimodate 48 transects, each for a total of 96 observations to/fro of all transects extending for 400 m each randomly distributed within Huvalu CA sample blocks. These were more detailed and intensive than Schillers 8 transects or 16 observations per person per month in 1991. And Kool's 2 transects of 1996 on the hakupu sea side track at Togo. Ten surveys (five for each transect) were caried out in four weeks in the cpoastal forest during the training of Hakupu uga working group.

Huvalu Conservation area survey

1. Strip Count and Mark-Recapture Method

This method was adopted to collect as much information as possible and well incorporated for a diversified species inventory. The data format and record sheets give provision for recording habitat and topography as well as comments on other species observed. These categories of information are equally weighted against the background of morphological and count or meristic data as well as the CPUE which characterize the transect surveys.
The population census has five objectives to be accomplished from the data collected. These have broadly been divided into two for dasta analysis.
a). Morphological data is used for the investigation of the mean individual size and the size structure of the population
b). Meristic data which gives count or numerical information for estimation of the distribution , abundance and density of coconut crab population.

The CPUE is linearly related to absolute density and the effective range of attraction of coconut crasbs to baits. However, more information is needed to know feeding activity or the overall crab "cachability" if it is constant amongst different sample plots. For each transect survey the CPUE values have been calculated as follows:

$$CPUE = \frac{\text{Total Catch}}{\text{Hunting Effort}} = \frac{\text{Total Number of Crabs per Transect}}{\text{Total Number of Baits per Transect}}$$

In this monitoring survey, some analysis have been made to determine the status of *Uga* population. Several Tables and illustrations infigures are attached in the annexes for reference. The parameters used to define the objectives of this research are compiled in a manner that can be self-explanatory as given in the reference to statistical analysis (Annex 1).

Survey Methods, Design and Implementation

The land area and vegetation classification is based on calculations made by digitising the Niue forestry topographic map of 1990 culled from the 1:25000 vegetation map of SPOT satellite imagery. This map may be digitised to be used on MapInfo GIS system.

The CPUE and the line transects count surveys were used and enhanced by the Mark and Release method. Twelve transects were cut in two days on the 3rd and 4th March,1997. Two groups of 4 surveyors carried out the alignment of each transect using a compass bearing which were fairly straight in spite of the dense vegeetation and difficult terrain. A steel tape was used to measure the four hundred metres and the hip chain lost thread was fixed above the ground at an interval of ten metres for easy reference to location and marked with ribbon. The search intervals between each coconut bait was at fourty metres and at each location a small opening was made in a coconut with a bush knife so that it could last for several days for sampling at least in two weeks in the early hours of dusk. The survey intensity was 25% along a 400m transect line at 40m bait interval with an observation radius of 2.5m on both sides of the lost thread for a habitat of obscure visibility. The total of 12 transect survey sites each approximately 10m wide of the sampling area will therefore give a total sampling intensity of 0.089% of the Huvalu conservation area. This was to ensure that any assumption or temporal variation in species variation in species abundance, size structure, density and distribution pattern would be represented in the results and conclusions of the survey. The behaviour and breeding habitats were also studied in February, 1997, as a result of the feasibility studies carried out in the coastal areas of Ana and Namuke for spawning behaviour and site preferences of larvae recruitment of coconut crabs (See results in Table 9).

Essential equipment were used including a steel tape to avoid sagging and to avoid accuracy. Coloured ribbons were used, a compass for calculating the vector quantity, calipers for thoracic length measurement, spring balance graduated in millimeters for weight measurement, nails for branding and markings as well as paint for spraying as codes for different sample plots. The nails were used to avoid the risk of paint deterioration over a long period of monitoring for grinding code numbers on to the carapace. There is , however, a strong assumption that the shell of the coconut crab will be replaced during hybernation as a result of moulting. In any case since the survey is an on-going process throughout the year, more useful information will be provided with regard to the species phyletics and written life history to advance scientific evidence of documentation particularly in the study area. The coconut crab is known on Niue Island as *Uga*,(*Birgus latro*), and is endemic to the South Pacific Region of the world's fauna resources.

Most other invaluable field material inputs include a halogen beam spot light, a record book in the form of survey format or check sheets as shown in the annexures and writing materials for field workers (pen, pencil, erasure etc.).

Results

The estimated total population in the intensive survey area was restricted to the Huvalu conservation area. A total of 166 individuals were counted i.e captured, marked and released and data analysed for different vegetation categories. In 1990, within a 7.5 month period (May to December), 272 coconut crabs were counted on Niue Island and the coastal Forest Vegetation category is estimated to have 137560 (75.8%) out of a total of 181440. The sample size of the Huvalu C.A. is the dominant suitable habitat type which can be generally classified as a homogenous coastal forest with an estimated population size of 147,180 (Table 1). Since there is no accurate data for each vegetation caytegory, it is assumed that the sum of transect mean CPUE of 0.62 is calculated for 54sq. km of the Huvalu conaservation area. The coastal forest is vaguely described as an area consisting of the whole of the lower terrace and most of the upper terrace comprising of inland primary forest. The mean CPUE population size and percentage total for the C.A. for each vegetation category are shown in Table .This can be compared to Niue Island crab population for h,abitat types in Annex 111. The total population for all the vegetation types is estimated to be 147,180 coconut crabs in the coastal primary forest alone on the island. The difference in population is 1,200 crabs less than the 1990 survey. It is estimated that the results of the surveys can still be considered to be incomplete for the final statistical analysis for management decision. The standard deviation for the entire population will be provided for comparison although it has been omitted in Table 4.

Not correct

" "

The mean CPUE in the conservation area can be compared with previous studies for Togo and Ana survey sites as follows:

	TOGO	ANA
Schiller (1990)	0.23 (n=11)	0.48 (n=8)
Kool (1996)	0.26 (n=7)	0.26 (n=11)
Bereteh (1997)	0.47 (n=10)	0.70 (n=10)

(Average for coastal forest = 0.378)

The non-parametric man- whitney U-test applied to the two sets of data (1990 and 1996) for both Togo and Ana transects. Differences were found to be statistically significant probably due to the variance within sets of data. The 1997 survey result is not based on computer statistical analysis where parameters are calculated using the statistical package such as SAS ver 6.03 or the T-test. Obviously, it is easier to understand the mathematical calculations without computer analysis until enough data is available to choose between accuracy and precision or *if possible*, the confidence limits can be established. It should be noted that the CPUE values given in comparison with the entire cocnut crab population on the island is an index for Huvalu area only.

Estimates of abundance is calculated as the absolute density of coconut crabs per square km; which is given as 0.62 x 12,000 (where 12,000 is a conversion factor). The total for Huvalu C.A. is 7,440 coconut crabs per square km. The absolute abundance is shown in Table 11 for a total of 88,908 crabs that were counted in all the sample areas. Apart from the line transect

survey figures, the absolute population density was extrapolated for five vegetation categories according to the conservation area map and its classified zones is 147,180 coconut crabs for the coastal primary forest; 126,000 in the secondary forest; 125,400 in the inland primary forest, and none for scrub and fernland.

INVESTIGATION AND DISCUSSION OF SURVEY OBJECTIVES

The main objectives of the study covered the population dynamics, size structure, abundance, density CPUE values, distribution patterns, morphometric data, sex ratio and gravid spawning activity were investigated. However, repeated sampling surveys will eliminate any conclusions that may be fraught with potential bias or over estimation. For example, 81.12% of cocnut crabs have been recorded in the Huvaslu coastal forest which is much higher than the 75.8% estimated by Schiller for the whole island If the convertion factor of 12,000 is most suitable for Niue Island, then as much as 398580 coconut crabs can be estimated for the conservation area alone and a minimum of 88,908 for the high density and vulnerable areas. It should be noted that without a standard deviation, the high population density reflects the marked variation and disparity in the estimated land areas of the different vegetation categories of Huvalu conservation area. For comparison, the coastal forest area of the C.A. is similar to the low exploitation habitat region of Christmas Islands with 420,000 and in Vanuatu with 402,000 coconut crabs.

In Vanuatu, Schiller indicated that 140,000 crabs were estimated to inhabit an area of 30 sq. km; and when this is compared with Huvalu C.A. which occupies an area of 54sq. km; with only 88,908 there is a significant difference showing a lower density for the latter. The high density was however, found in the coastal area unlike that of Huvalu where samples were taken in a mosaic of diversified habitats for the conservation management area in situ. Studies indicate that the highest density of coconut crab on Niue Island occur in the coastal forest which is still below its carrying capacity by almost three times (with a ratio of 2.8:1) when compared with other islands using the same conversion factor. No reference is made to a T-Test and no P-value was determined other than mathematical inferences.

The sex ratio and morphometric data are premises drawn from the parameters used for analysing the population structure as given in Table 111. For comparison with Pilot Stock Survey of March, 1988, the March, 1977, statistical analysis shows that there are larger males and females now than almost ten years ago (see Table 1V). There were more coconut crabs sighted than in 1988 by vegetation type or vegetation classes which are shown in Table VI(A).

SEX RATIO

The male and female ratio shown in Tables IV and V show a mean thoraccic length of 37.2mm and 28.3mm respectively. The population ratio is 1.48: 1 as compared to 1: 1.09 males to females of 1988. The data for the former was collected predominantly towards the end of the spawning period while the latter was collected during the reproductive phase. The survey sites were similar and transects were located near ocean and foreshore (see map of Figure I).
Ther is a significant temporal change in the sex ratio influenced by gravid coconut crabs movement torelease their eggs and the changes that are taking place in the population affect distribution pattern in the different hasbitats. Other limiting factors that affect the inference of the sex ratio and size structure are due to spawning activities and coconut crab hibernation.

Spawning grounds are highly vulnerable to hunting impacts and human activities like fishing and these factors together with the life cycle characterise the variation in male female ratio. There were 60% males against 40% females in the population and the lowest M-F ratio was in the secondary forest. It increased to 1.4 to 1 in the costal primary forest with increasing distance away from the coast.

Due to a lack of sampling frequency along some inland transects, the data available can be skewed because surveys are insufficient to demonstrate at this srage any reliable change in the population structure (size and sex ratio) as analysed in Table 6. On tye basis of this observation, sex specific CPUE values sould not be calculated although the male and female population size have been given only for the specieis captured and counted. The age index in given in Annex VI of Von Bertalanffy growth curves.

ABSOLUTE DENSITY

It should be noted that although a Comprehensive Survey data is not yet available this report is detailed enough for analysis of the first quarter records and will be used as reference for future surveys for monitoring and evaluation. No computer analysis have been made other than the use of empirical formula and biostatistical sampling procedures for calculating density.

The estimates of aobsolute density is based on crabs per square km to show abundance of population using 12,000 as a given Conversion factor. For Niue, the Conversion factor can be calculated only if crabs could be sighted along a line transect without using baits but this is only restrkicted to the coastal shoreline areas during spawning activities. In this case the result will be bias without random sdelection of sample areas by using CPUE relative density and absolute density for the same survey region. Where this is possible the data obtained is then used to determine the relationship between both relative and aobsolute densities and quantified into a conversion factor.

POPULATION SIZE STRUCTURE

The Huvalu Conservation Area estimates were calculated from an index derived from CPUE relative abundance for each terrain, vegetation types or catergory using the formula: Absolute Density = CF X CPUE

The CF is calculated from trip-count survey conducted independently and the CPUE Survey is then carried out the following night. Both the initial line transect and CPUE Count Surveys will be carried out along the same comparison transects.

HABITAT PREFERENCE AND DISTRIBUTION PATTERN

With regard to population size structure, the number of coconut crabs was calculated in six major vegetation categories using the mean CPUE for each major habitats or become complex. The result of the distribution pattern in Tables 6 and 8 can be used to determine the habitat preferences. It is also useful in the study of coconut crab phyletic and ecology. Analysis of the specieis main, primary, suitable and sale habitats (vegetation combination due to edge

effect) can now be used as basic units in relation to population, dentisity and biomass in occupied habitats or geographic area for management decision.

There were 80.7% of coconut crabs inhabiting the coastal primary forest above the 75.8% recorded in 1990 of total estimated population. The variables within the data collected are not statistically for comparison of the Huvalu CA and Niue Island. About 13.3% of the crabs were located within inland forest and only 6% in the secondary forest.

The size structure shows that male coconut crabs have greater theracic length and the corresponding weight than females. In both 1990 and 1997, the qualitative morphometric data are closely related in spite of higher numbers of coconut crabs being surveyed as shown in Table 6(b). Lower measurements for both sexes in 1996 is probably due to a function of a small sample area (T4 and T5) and not the n-value or population size. Comparison of the CPUE values have already been given for 1990 and 1996 to the sets of data earlier presented in the results of this report.

SPAWNING BEHAVIOUR

Coconut crabs fhave an instinct of movings to the sea at particular periods of the year. In January and February, the spawning behaviour was studies and the results are given in Table 7 for two study sites: Namuke on the Hakupu side and Valikulu on the Liku coastal area. It was found that female crabs are very active during the early hours sof the evening soon after the twilight is seen between 7:30 to 9:30pm. The Female Coconut Crab releases its eggs into the ocean either at the cliff edge when the abdomen protruding is in contact with the Waves or it goes down to the sea shore and swims on the reef at low tide. Once the abdomen is in contact with water the mosquitoe - like lurvae asre then released within a few seconds and the crabs move back to land. The larvae are in active stage but hardly visible to the natural eyes.

It is assumed that crabs lay their eggs on land too but the majority of the gravid population use the salt water in the coastal areras as their spawning grounds. The non-gravid population sighted in relation to gravid crabs were as follows:

1:48 for Ana (T4) and 1:9:7 for Namuke (Tio) out of a total population of 162 coconut crabs counted. For a rough estimate of specieis returning to the main forest area inland, the absolute density based on anecdotal survey was as high as 3.6 per sqare km (out of 18 being sighted after 10pm).

MARKET SURVEY

Reference is given to June 1987 market survey data which shows that 93% of coconut crabs available are male. In the statistical analysis givens the male has an average TL of 24.628 and female as TL 18.815. These figures can be used to calculate the weights of multiplied by 0.02170 for the males and by 0.0462 for the females (formulas generated from regression analysis of thorax-weight data).

Although this is not an indication that the minimum size for harvesting coconut crabs at 36mm is adhered to, the village shows have encouraged the hunting of larger crabs are being encouraged for competition. Surveys in May 1997 at Makefu gives an idea that Niue still has crabs for beyond the minimum legal harvesting size as well as the 32.0mm TL of the mean

viable population level for recruitment ranging from 1.3kg to 2kg in weight and with theracic length of 58mm to 63mm. Using the transgression formula for claculating unknown weight and thoracic length, the mean WT is 1.6kg and mean TL is 60.5mm for males. (Females weigh up to 1.309kg and males 2.788kg).

The Hakupu Show day in June 1997 also indicated that coconut crabs harvested weigh from 3kg to 2.5kg and the TL range from 42mm to 61.5mm. The species with the biggest TL 61.5mm weighed only 2.4kg less than the first prize winner of 2.5kg with TL 58.5MM. This variation is probably due to loss of weight during prolonged period of domestication for inverse relationship in thethorax-weight data.

The mean TL IS 52.7mm and the mean CWT is 1.35kg randomly selected for coconut crabs/ measured during the Hakupu Agricultural show.

of limited relevance; show you will always be very large.

In 1987, the twelve months data given during the pilot - stock survey was 5,800 coconut crabs that were exported to New Zealand out of an annual harvest of 49,824 for export and consumption which is equivalent to 27% of total stock on Niue Island. The mean size of female coconut crabs was greater in 1988 than in 1990 and the mean size of male in the population was less in 1996. This is an indication that male crabs still contunue to be harvested because of their large size for the market and village agriculture shows.

It is possible on the other hand that the sightings of larger crabs is the result of habitat deterioration and improved visibility. aLthough density of population can not be accurately calculated because sof obscure visibility nevertheless the survey results show that there may be a lesser impact or hunting pressure because of a considerable decrease in human population from 5,200(1971) to 2532(1988) and 2239(1991) to 2300(1994).

CONCLUSION:

The first quarter survey report is not the basic reference for a final conclusion to be mae. However, the data collected within two weeks was 22.2% of survey intensity which is relatively high for the 54sq km of the sample area under study. Thee were 25 effective patrol days (52% of the number of transect surveys scheduled) and because of irregularties and inconsistency in manpower output 48 transect surveys were not completed. However, because of the survey intensity and a larger total coconut crab population caught in the sample area, the result is more meaningful for comparison with previous research work as shown in Table 9.

It is against the background of the combined effects of over-exploitation and habitat destruction that this follow-up survey has been conducted in order to protect in the absence of an invironmental or wildlife legislation. This is to give effectiveness to management data in the biodiversity conservation programme both for Niue Island and the South Pacific region. In effect, the quarterly surveys will protect much useful data in monitoring of the size and size frequency distribution.

Also, quantification of exploitation and changes in the absolute abundance of population by the end of the year. In the final analysis, the report of coconut crab surveys will provide data on temporal patterns of recruitment (zoea stage) which will include spawning activities,

distribution and continuous mrket surveys for developing strategies for a resource management plan.

A careful study of the conclusions of the survey analysis are in the form of the attached tables. In the mean time the total absolute population density is 7,440 coconut crabs per square km and a total of 88,908 for Huvalu Conservation Area. The Costal Primary Forest has 81% of the total population estimated by vegetation category.

The survey has shown that Huvalu CA has a larger mean viable population than the whole of Niue island in Comparison with available data for surveys conducted in 1988, 1990 and 1996. The 1997 statistical analysis has currently shown an increse in the female population with Thoracic length for above the reproductive age class of 31mm TL., which is 5 years older than sexual maturity age group (see Annex 1).

Although the data available in the first quarter of the coconut crab survey is not yet adequate for implementing any management decision, it is now obvious that between January and March of 1997, there were more males than females. This m,eans that the coconut crabs observed and counted have considerably increased in size, both in Thoracic length and weight morphometric data with a large disparity the sex ratio i.e. 80 % of males in relation to 20% of females in ther Huvalu Conservation Area.

THE LINE TRANSECT METHOD CASE STUDY

The count data estimate using line transects population survey of uga has many advantafes although not entirely withoput drawbacks.

1. The need to standardise different methods used by previous consultants in diffierent countries.

2. Live transects are suitable to remote environments that require repeat visits to permanent transects for long-term monitoring.

3. Suitable where the forest is remote and the Coastal Areas pose difficult access and perhaps time-consuming, and expensive.

5. Transect Survey is simple and require no special skills for field staff collecting data beyond the knowledge of the general principles of a game census reporting procedure of middle-level technicians. However, the mathematics and statistical intepretation underlying the simple random field methods may be too complicated for many biologists for conservative analysis of data.

5. The index of abundance can be calculated by direct counts for convertion to an estimate of coconut crab numbers.

6. The M-R (Mark and Release method) can complement the line-transect method where direct counts may be impossible in difficult terrain or forest habitat. It is therefore impracticable to see Uga in dencse vegetation or during moulting where they go underground.

7. The drawbacks:

   a. Permanet transects do not give reliable data on distribution patterns of species in the peripheral habitats of the Conservation area or buffer zone.

   b. Although permanent line transects are ideal for comparison of statistical data with previous studies, they should be avoided in place of stratified vegetation categories or quadrats.

   c. Additional manpower is required to have access to remote areas of forest inland and may be expensive for repeat visits for observations at night which is the time for Uga Surveys.

   d. Each transect must be visited several times in order to do 2/5 of the number of transects in the CA. For at lest two times in a week during 2 weeks census programme of 40% of five working days we surveyed 48 transects compared t0 34/month for the whole island (1991).

The probability density function f(x) is the probability of finding uga at the fixed intervals where a thorough search is made. From f(x) one obtains an estimate for f(o), which is an estimate of frequency with which the surveyor recorded uga along the line transect. The equations for calculating f(o) may however be complicated. In any case, there is a choice of formulae for calculating the variance and confidence limits of one has access to a computer.

For each transect the estimate of population density P is given by the following equation which can be used alternatively in Uga research, adapted from fauna survey in similar habitats in Africa (Cource: WCI Scanning transect survey in Gabon).

$$P = \frac{nf(o)}{2L}$$

where N = the number of uga counted in the transect
L = the total length of the transect

It is snoted that some field workers may be able to understand the mathematics although they may find such quations incomprehensible even if it is applicable for analysing data for interpretation of basic information.

TABLE 1 : HUVALU CONSERVATION AREA, NIUE DATA ON COCONUT CRAB SURVEY SHOWING LAND AREA, MEAN CPUE AND ESTIMATED POPULATION FOR VEGETATION CATEGORIES

VEGETATION CATEGORY	LAND AREA		MEAN CPUE (DENSITY)	ESTIMATED POPULATION		
	HUVALU CA (ha)	% TOTAL		ACTUAL SAMPLE COUNT	% TOTAL	TOTAL COUNT
Inland Primary Forest	1900	35.2	0.55 (6,600)	22	13	125,400
Coastal Primary Forest	550	10.2	2.23 (26,760)	134	81	147,180
*Secondary	2,100	58.8	0.50 (6,000)	10	6	126,000
Scrub/ Agricultural Clearings	800	14.8	-	-	-	0
Fernland	50	1	-	-	-	0
TOTAL	**5,400**	**100**	**3.28**	**166**	**100**	**398,580**

- Light and Scattered Forest derived from agricultural activities. The estimated population size using the formular as opposed to CPUE method is 64,029 Coconut Crabs.

TABLE 2: HUVALU CONSERVATION AREA, NIUE
ESTIMATION OF LINE TRANSECT SURVEY RESULTS

TRANSECT NO.	CPUE VALUE (CATCH EFFORT)	%SURVEY INTENSITY	TRANSECT CPUE	NUMBER COUNTED	POPULATION SAMPLE SIZE
T1	0.2	25	.2	2	2,400
T2	0.8	25	.8	8	9,600
T3	2.9	100	.725	28	8,700
T4	2.1	100	.7	15	8,400
T5	1.4	75	1.467	15	5,604
T6	0.7	25	.7	7	8,400
T8	0.3	50	.15	3	1,800
T9	0.3	25	.3	3	3,600
T10	1.1	50	.55	9	6,600
T11	1.0	25	1.0	9	12,000
T12	5.0	100	1.25	50	15,000
ABSOLUTE POPULATION DENSITY	1.46 (17.5)	56.25 (675)	0.617 (7.409)	13.83 (166)	7,409 (88,908)

ABSOLUTE DENSITY = 12,000 X CPUE
12,000 X 0.62 = 7,440/sqkm

NOTE:
The population characteristics of a representative sample of coconut crabs is calculated as follows:

a) Percentage Cover (CPUE % density) = Number of squares (baits) where coconut crabs are counted x 100 / Total number of baits 1

b) Percentage Cover of Sample area % = Number of Surveys / total number of Surveys scheduled
25/48

TABLE 3: HUVALU CONSERVATION AREA, NIUE

A) Male and Female Morphometric data in relation to Actual Count and estimated population total percentage of Coconut Crabs.

SEX RATIO	MEAN TL (mm)	MEAN WT (g)	TRANSECT SURVEYS	NUMBER COUNTED	% TOTAL POPULATION
Males	37.18	346.48	28	99	59.64
Females	28.29	191.33	28	67	40.36
TOTAL	32,74	268.91	56	166	100

TOTAL MEAN THORACIC LENGTH AND MEAN WEIGHT

TRANSECT CODE	MEAN THORACIC LENGTH (mm)	MEAN WEIGHT(g)	NUMBER COUNTED IN SAMPLE	% POPULATION SIZE
TI	25.85	130.0	2	1.20
T2	33.46	307.5	8	4.82
T3	31.87	296.96	28	16.86
T4	30.98	262.0	15	9.04
T5	34.39	322.0	15	9.04
T6	27.16	200.0	7	4.22
T7	30.43	262.94	17	10.24
T8	24.36	71.33	3	10.24
T9	29.5	193.3	3	1.81
T10	30.53	273.33	9	5.42
T11	32.81	331.1	9	5.42
T12	14.63	304.84	50	30.12
TOTAL	**28.83**	**246.27**	**166**	**100**

TABLE 4: HUVALU CONSERVATION AREA, NIUE

(A) Morphometric data for male and female coconut crabs in Comparison with Pilot Stock Survey of March 1988

LOCATION AND SEX	THORAX		WEIGHT		SAMPLE SIZE
	MEAN	STANDARD DEVIATION	MEAN (g)	STANDARD DEVIATION	
NIUE ISLAND 1988					
Male	28.4	5.8	235.0	188.1	75
Female	25.6	3.2	151.9	51.3	82
HUVALU CA 1977					
Male	37.2	-	346.5	-	99
Female	28.3	-	191.3	-	67

(B) Strip- Count Population Surveys (1/03/88 - 19/03/88) in comparison with Huvalu CA Coconut Crab Surveys (1/03/97 - 17/03/97) for major habitat types.

SAMPLE AREA (ha)	VEGETATION TYPE	NUMBER OF CRABS SIGHTED PILOT SURVEY	HUVALU CA
2,450	*Primary Forest	7	156
2,100	Secondary Forest	2	10
50	Fernland	0	0
TOTAL ESTIMATED POPULATION		9	166

*Inland and Coastal Primary Forest

TABLE 5: HUVALU CONSERVATION AREA, NIUE

Results of Strip-Count Population Surveys of Coconut Crab (Birgus latro)

DATE SURVEY	LINE TRANSECT	VEGETATION TYPE	NUMBER OF CRAB COUNTED	M:F RATIO
4/03/97	T1(Pagopago)	Secondary Forest	2	1.1
4/03/97	T2(Vaita)	"	8	4.4
4/03/97	T3(Uani)	Coastal Primary Forest	12	7.5
10/03/97	"	"	4	2.2
12/03/97	"	"	4	1.3
16/03/97	"	"	8	3.5
4/03/97	T4(Ana)	"	7	4.3
10/03/97	"	"	-	-
12/03/97	"	"	-	-
16/03/97	"	"	8	4.4
6/03/97	T5(Togo)	"	5	4.1
10/03/97	"	"	3	1.2
12/03/97	"	"	-	-
14/03/97	"	"	7	5.2
6/03/97	T6(Huvalu)	Inland Primary Forest	7	5.2
4/03/97	T7(Kokapu)	Coastal Primary Forest	7	2.5
9/03/97	"	"	8	4.4
12/03/97	"	"	2	0.2
4/03/97	T8(Kokapu)	Inland Primary Forest	3	2:1
10/03/97	T9(Vailoa)	"	3	3:0
6/03/97	T10(Fuofutu)	Coastal Primary Forest	8	5.3
12/03/97	"	"	1	1.0
9/03/97	T11(Fuofutu) Seaside	Inland Primary Forest	9	6.3
4/03/97	T12(Hiola)	Coastal Primary Forest	3	3.0
6/03/97	"	"	16	10.6
9/03/97	"	"	15	10.5
12/03/97	"	"	1	1.0
16/03/97	"	"	15	11.4
TOTAL	**12 TRANSECTS**		**166**	**99.67**

TABLE 6: HUVALU FOREST CONSERVATION AREA

Distribution Pattern, Population Structure and Morphometric Data of Coconut Crab

A)

VEGETATION TYPE	NUMBER COUNTED	SEX RATIO M:F	% TOTAL POPULATION
Coastal Primary Forest	134	78.56 (1:1)	80.7
Inland Primary Forest	22	16.6 (2,6,1)	13.3
Secondary Forest	10	5.5 (1.1)	6.0
Scrub/Agricultural Clearings	0	-	-
Fernland	0	-	-
TOTAL	**166**	**99.67**	**100**

B)

YEAR	MALE		FEMALE	
	Thoracic Length (mm) (g)	Weight (mm)	Thoracic Length (g)	Weight
1990	33.8 (n=40) (23.4-57.2)	375(n=40) (880-1200)	27.2(n=17) (22.9-33.7)	185(n=16) (100-300)
1996	28.9 (n=19) (22.1 - 40.0)	243 (n=18) (70-600)	29.3 (n=29) (23.7-43.1)	237 (n=20) (110-580)
1997	37.2 (n=99) (20.2-55.0)	346.5 (n=99) (50-1002)	28.3 (n=67) (16.5-40.7)	191.3 (n=67) (15-430)

TABLE: 7 HUVALU FOREST CONSERVATION AREA, NIUE

SPAWNING ACTIVITY OF COCONUT CRAB
(Morphormetric data of gravid population)

DATE	SURVEY SITE AND COASTAL HABITAT	GRAVID POPULATION	MEAN TL (mm)	MEAN WT (g)	CRABS COUNTED
30/01/97	ANA (Hakupu) T4	96	26.61	227.5	98
3/02/97	Namuke (Liku) T10	58	32.33	231.2	64
TOTAL POPULATION		154	29.47	229.33	162

NOTE:

Road Count Survey in a vehicle after gravid coconut crabs have released their eggs and on their way back to the forest was found to be 18. Based on anecdotal survey count, the absolute density was found to be 3.6 per square km, as compared to 3.28 per sq.km of mean CPUE total density.

TABLE: 8 HUVALU CONSERVATION AREA

Total Niue Coconut Crab Survey data showing land area, mean CPUE and estimated crab population for habitat types.
Formula Vs CPUE Method: (Using the formulas in 14b(Annex III) the estimated population size is 414,400 for 400m line transect x 10m radius)

VEGETATION CATEGORY	LAND AREA		MEAN CPUE (DENSITY)	CRAB POPULATION	
	Actual (ha)	% Total		Actual	% Total
Coastal Forest	2999	11.5	0.38 (4560)	137560	75.8
Primary Forest (Coastal)	1002	3.8	0.07 (707)	10,820	6
Primary Forest (Inland)	2046	7.9	0.014 (169)	4910	2.7
Light and Scattered (Coastal)	5685	21.8	0.063 (612)	25,840	14.2
Light & Scattered (Inland)	6406	24.6	0.004 (46)	2310	1.3
Fernland (Coastal and Inland)	7915	30.4	0	0	0
TOTAL	26050	100	0.531	181,440	100

NOTE: This table is derived from the 1990 Niue Island Survey report and can only be used for reference to Schiller's 224 Coconut Crabs counted during the 124 transect surveys.

TABLE 9: HUVALU CONSERVTION AREA, NIUE ISLAND ANALYSIS OF SURVEY RESULTS OF COCONUT CRABS ON NIUE (1990), COASTAL FOREST (1996) AND HUVALU CONSERVATION AREA (1997)

YEAR AND SAMPLE AREA	TRANSECT SURVEYS COMPLETED AS SCHEDULED	NUMBER OF SURVEY TRANSECTS AND COCONUT CRABS COUNTED	PERCENTAGE SAMPLE SIZE (ESTIMATED) POPULATION	CPUE (DENSITY) Km2)	DURATION OF SURVEY (MONTH)
1990 (259sqkm)	124 (47.2%) (62%)	35 (224)	13.5 (181,440)	0.088 1056)	7.5
1996 (30gkm)	10 (100%)	2 (48)	6.7 (N/A)	0.26 (3120)	1
1997 (54sqkm)	25 (52.1%)	12 (166)	22.2 (88,908)	0.62 (7,440)	0.5

SUMMARY ANALYSIS

OF SURVEY RESULTS FOR NIUE, COASTAL FOREST, AND HUVALU
SCHILLER, COOL BERETEH

PARAMETERS	SCHILLER, COOL, BERETEH		
1. Random lineal strip sample area [10x400m]	.058%	027%	0.089%
2. Effective patrol days per survey	198	10	25
3. total Coconut Crab Sample population	272	48	346
4. Total estimated population count	181,440	N/A	88,908
5. Mean frequency observations	4	5	2
6. Status of Survey data for management	S	I	O

[Where C= Complete 1= Incomplete S= Satisfactory]
0= on-going N/A = Not applicable

TABLE 10: HUVALU CONSERVATION AREA

Male and Female Morphometric data

TRANSECT NO.	MALE TL	MALE WT	FEMALE TL	FEMALE WT
T1	31.2	210	20.5	50
T2	27.3	250	33.8	320
	41.2	480	38.1	350
	44.4	500	32.6	280
	20.2	90	30.1	290
T3	48.5	900	32.8	230
	34.8	370	31.8	290
	32.7	330	19.5	70
	23.8	100	23.8	120
	37.7	420	34.3	350
	22.2	60	38.7	420
	41.4	510	16.5	15
	24.5	110	29.2	190
	42.5	560	30.5	220
	30.7	180	40.7	430
	41.1	580	21.1	90
	38.6	450	33.6	350
	26.4	100	30.2	290
	-	-	26.7	150
	-	-	38.2	430
T4	33.5	360	30.9	200
	31.5	250	32.1	340
	31.5	290	20.7	60
	43.7	610	36.1	390
	26.7	110	28.6	150
T4	38.2	420	19.5	80
	33.3	330	-	-
T5	55.0	950	30.4	220
	30.0	200	27.9	100
	30.5	250	30.3	250
	30.5	210	31.4	270
	31.6	250	32.4	210
	43.9	580	-	-
	31.2	210	-	-
	38.6	420	-	-
	33.6	290	-	-
	38.6	420	-	-
T6	34.6	550	25.0	100
	24.8	50	30.0	150
	(24.8)	50	-	-

TRANSECT NO.	MALE TL	MALE WT	FEMALE TL	FEMALE WT
	20.3	50	-	-
	28.3	250	-	-
T7	53.2	1000	27.21	260
	31.9	230	22.4	100
	35.9	360	26.5	140
	28.96	180	28.5	200
	32.96	280	28.8	180
	34.4	320	30.2	260
	-	-	31.3	280
	-	-	27.5	180
	-	-	29.8	260
	-	-	24.8	260
	-	-	23.0	120
T8	23.0	80	24.0	(84)
	26.1	130	-	-
T9	32.4	220	-	-
	30.6	220	-	-
	25.5	140	-	-
T10	33.2	300	30	320
	35.7	300	21.7	80
	28.3	180	26.7	180
	22.6	280	-	-
	38.1	440	-	-
	38.5	480	-	-
T11	36.5	380	25.2	100
	37.7	480	33.0	320
	50.0	1000	28.5	120
	35.6	340	-	-
	26.7	160	-	-
	22.1	80	-	-
T12	38.8	440	-	-
	30.4	240		
	33.2	260		
	34.1	420		
	35.2	360		
	23.0	100		
	45.6	980		
	30.0	180		
	38.9	500		
	21.3	80		
	29.6	580	27.1	160
	37.9	420	27.3	160
	28.0	180	24.6	120

TRANSECT NO.	MALE TL	MALE WT	FEMALE TL	FEMALE WT
	41.1	640	27.9	140
	30.0	240	25.9	140
	41.1	600	22.8	100
	33.3	360	28.6	140
	39.9	280	25.0	100
	48.5	1000	23.9	60
	27.1	280	19.5	60
	37.6	260	38.5	220
	32.0	340	26.7	160
	27.3	160	24.4	130
	32.8	280	28.9	120
	31.2	560	26.9	140
	19.6	60		
	26.15	140		
	30.2	200		
	37.1	400		
	34.15	420		
	42.2	520		
	35.8	370		
	33.2	320		
	24.2	120		
	47.5	1002	67	
99	3680.82	34,302	1895.31	12,819
AV	37.18	346.48	28.29	191.33
	(20.2 - 55.0)	(50 - 1002)	(16.5 - 40.7)	(15 - 430)

HUVALU CONSERVATION AREA PROJECT

RECORD - SHEET FOR LINE TRANSECT SURVEYS

COUNTRY GRID REFERENCE: _____ LOCATION: _____

STARTING POINT/SAMPLE AREA: _____

VECTOR QUANTITY a) COMPASS BEARING: _____ b) TRANSECT SIZE: _____

VEGETATION TYPE/HABITAT: _____

TIME: _____ DATE: _____

SURVEY TEAM: _____

_____

TRANSECT NO.	M-R CODE	TL	WT	SEX RATIO (M/F)	NUMBER OF CRABS COUNTED	REMARKS

M - R = Colour code and branding mark for mark and release method
TL = Thoracic Length in millimetres
WT = Weight measured in grams
M/F = Male and Female Sex ratio

ANNEX III

REFERENCE TO STATISTICAL ANALYSIS

1) Area samples: $P = S \times A/a$

(P= population, S= counted animals in sample
A= total area under investigation, a = area sampled).

2) Transect Surveys: CPUE= $\frac{\text{Total Catch}}{\text{Hunting Effort}}$

CPUE= $\frac{\text{Total Number of Crabs Found Along a Transect}}{\text{Total Number of Baits Used Along a Transect}}$

Two assumptions are used here a) CPUE is linearly related to absolute density and
b) the effective range of attraction of Coconut Crabs to baits, together with feeding activity (or overall crab catchability) were constant amongst different regions.

3) Absolute Density = 12,000 X CPUE
The density of a population = $\frac{\text{Size of Population}}{\text{Area Sampled}}$

4) Population Size:
Regional Population Size = CPUE X 12,000(CF) X Regional Area (sq. km)

5) Mean Regional CPUE = $\frac{\text{Transect CPUE}}{n}$

(where hunting effort was constant for all surveys)

6) Mean Regional CPUE = $\frac{\text{Total number of crabs found during all regional surveys}}{\text{Total number of naits used during all regional surveys}}$

(where hunting effort was not constant for all surveys)

7) Total Coconut crab population is calculated for vegetation types using CPUE data. The size of the coconut crab population ormean CPUE values for coastal forest category can also be divided into sub-categories or transect groups as long as the CPUE data is made available.

The sum of all categories = The total calculated crab population

The total vegetation category variance of transect CPUE values should be with acceptable range if transect groupings or sub-categories should be omitted.

8) Use of Thorax: weight ratio can generate formulas for calculating male:female data by calculating a regression analysis on population survey. In market survey if a TL measurement is impossible when crabs are bound together a weight is traken and converted to a thoracic measurement using the following formulas:

Males: TL = 24.628 + 0.02170 X Weight

Females: TL = 18.815 + 0.0462 X Weight

(Females are generally smaller than males. Market male coconut crabs mean TL of 48.1mm (n=97) and males mean TL of 32.6 mm (n=150) were recorded in 1990 over a 3 month period)

9) Mathematical and computer analysis of the standard deviation for an entire population is given as:

$$@\ STD = \frac{(li - m)}{n}$$

where li = the ith entry value from the list using lotus 123

m = mean or average of the list

n = number of elements in the list

10) Variance = Standard Deviation Squared

$$= \frac{(li - m)}{n}$$

11) Population characteristics

a) Population Number (Size)

Size of population = $\frac{\text{Area of habitat}}{\text{Area of Sample}}$ X Number of crabs in sample area

b) Size of coconut crabs using the Mark-Recapture techniques is calculated using the following formula:

The Size of the Population = $\frac{\text{Total number in first sample X Total number in second sample}}{\text{Number ofmarked animals in second sample}}$

12) Transects used in measuring population are lines drawn ina straight line across a habitat. The transect is divided up into 40 m intervals and at each interval is a bait where the population is sampled. The transect survey is most appropirate where the distribution of a species is affected by some environmental factor like inaccessible habitats or tidal movements affecting the distribution of species on therocky shore or human interference.

13) Quandrants are often used to sample areas that contain organisms which cannot move along transect lines e.g. plants. The optimum quandrant size is found when the species number per quadrant does not increase dramaltically. Aquadrant is a square frame used to isolate an area so that the mnumber of species in that area can be counted.

a) Percentage cover = $\frac{\text{Number of Squares of organisms present in}}{\text{Total number of squares}}$ X $\frac{100}{1}$

(for clustered species the quandrant is divided into grid and % cover determined)

b) Percentage Cover = $\frac{\text{The number of Coconut Crab per transect (squares) X 100}}{\text{Total number of clamped random and uniform distribution}}$

c) To prevent bias, sample areas must be chosen randomly. The habitat is divided up into a grid, and obtaining grid coordinates using random numbers generated using random numbers key on a calculator or computer.

14) Population characteristics have two parameters

a) Number counted (in sample area)

b) Size of population

e.g. 166 crabs counted along 12 transects or quandrants
Total area of habitat is calculated 54 sq km. Of Huvalu Conservation area or 259 sq km of Niue

Size of each sample is calculated (area in sq. km) and is given here as value

Area of sample is size of transect or quadrant times no of sample area or quadrants i.e. x 12 = y

Size of population equals: $\frac{\text{Area of habitat}}{\text{Area of sample}} \times \text{No of Crabs in sample areas} = \frac{259}{y} \times 166$

15) Density = $\frac{\text{Size of Population}}{\text{Area Sampled}}$

16) Age Structure

Three classes of individuals exist within a population.

Pre-reproductive (juveniles)	Reproductive (gradid pop)	Post-reproductive (non-gravid pop)

New Generation

Growth and recruitment can be determined from morphometric data of population age structure and sex.

ANNEX IV

Coconut Crab (Birgus Latro)

Ecological Assessment of the Status of Uga on Niue

(Fact Sheet and Hypothesis for investigation and monitoring)

1. FAO - SPADP funded pilot stock survey 1988 to assess the status of crab population on Niue.

2. A detailed crab population survey in 1990 for 71/2 months.

3. Survey results on Niue show only 181,440 coconut crab of mean thoracic length 32.5 male and 26.9 female. The male to female ratio is 1:.09(1988, 1990)

4. The male and female size frequency data are non normally distributed (i.e. do not follow a normal distribution curve)

5. They exhibit (i.e. size frequency) pronounced skewness and/or kurtosis due to intermittent recruitment and long term over-exploitation.

6. 75.8% (137560) found in Coastal forest occupying 11.5 % of land area.

7. Recruitment is aclosed system i.e. from within Niue.

8. Reproductive viability requires 5 batches of eggs (one per year).

9. Birgus latro: monospecies genus, family Coenobitidae largest land crab, Order Decapoda, class crustacrea (Related to the hermit crab)
   Growth rate K = 0.05 lifespan 30-40 years
   Weight 4 kg (17 kg reported in Encyclopedia Britanica)
   Adults I metre
   The coconut crab uses two large chelae or pincers to open coconuts and are capable of cutting fingers and toes in self defence.

10. Color of full grown adult is light violet to brown and deep purple. Young adults are brown with black stripes on the legs

11. Spawning is by a gravid (pregnant) crab on
    a) cliff edge 1 or 2 intertidal shelf with salt water pool
    b) intertidal shelf with saltwater pool
    c) smallsaltwater stream with or without flexing abdomen to release the eggs

12. Spawning method on the cliff edge takes about 30 mins (steep shore cliffs) and in suitable areas with intertidal shelves or gently sloping shores. It takes a few seconds by personal observation.

13. Well developed thoracic lungs and an eficient mechanism for recovery of ions excerted via the urine hence the most successful terrestial of the decapod crustaceans.

14. Geographical range is the tropical Indo-Pacific region.

15. Coconut crabs are known to man some 300 years ago and the first scientific description was by Ruphus in 1705.

16. The size and distribution were unknown until detailes study by Reyne in 1939.

17. Size and geographical distribution have declied confirmed by studies by Holthius 1959, Taylor 1973, Hofman 1973, Hostman 1976, Storch et al 1979, Amesbury 1980, Wells et al 1983.

18. Localised extinction has occured inareas where crabs were sympathetic with humans.Prolific species throughout its range 50 years ago is now classified by IUCN as endangered (1983 report by Wells et al.)

19. Management strategy should address anthropogenic factors and the species to depend on natural stochastic processes ifany success ids to be achieved. (i.e. human intervention and natural recruitment)

20. Export data in 12 months 01/06/87 indicated the 5800 indivisuals were exported to New Zealand.

21. Export data from 18/03/88 to April 1992 were unavailable.

22. 1989 data based on the month of September showed that 173 hunted crabs with a mean catch of 24 crabs, an indication of a probable monthly catch rate for a year.

23. Annual coconut crab harvest is estimated as 49,824 for both local consumption and export, 27% of the total stock on Niue. In 2 years female breeding population will be wiped out at the current rate of exploitation.

24. The 1988 stock - survey indicate that hunting pressure of the 1970s export drive to expatriates in New Zealand is responsible for the current population decline.

25. Localised extinction is reported in the regions surrounding Namukulu/Hikutavake, Toi, Mutalau, Hakupu and along the coast from Alofi to Avatele.

26. Coastal forest has an estimated 140,000 crabs within 30 sq km making it the highest recorded density or 75% of the total estimated population.

27. Coconut crab habitat is fragmented and drasticaly reduced due to human activities of agriculture and partly logging.

28. The first and second terraces which make up the coastal forest occupy only 11.5% of the available land area with (75-76 % of the crab population).

29. Coconut crab larvae are relatively intolerant and any successful recruitment into adult population is irregular. These factors combine combine with slow growth (1mm TL for 1Kg in wt) and substantial longivity make this species extinction prone i.e. being extremely susceptible to low levels of exploitation and habitat degradation.

30. Maintenance of a healthy population will depend on a suitable resource management strategy. Extinction of island coconut crab populations can crash in less than 10 years and are vulnerable to population erruption in case of natural disasters like cyclones (based on Vanuatu case history).

31. All of the lower terrace and most of the upper forests are vaguely described as the coastal lowland forest within 2 km of the coast towards inland.

32. Over 7 ½ months 124 transect surveys were completed out of a scheduled 198 with each transect being surveyed 4 times on average and only 224 coconut crabs recorded.

33. For comparative studies and monitoring on Niue, the most detailed survey data are still considered irregular and less frequent for reflecting temporal changes in coconut crab abundance and distribution (i.e. transdects must be surveyed every 4 weels and with a consistency for reliable analysis).

34. Calculation of the CPUE (Catch Per Unit Effort) conversion factor of 12,000 is used for converting CPUE to absolute density (crabs per sq.) based on previous study in similar habitats. In Vanuatu (i.e. Absolute Density = 12,000 x CPUE)

35. Population size in each vegetation category includes separate isolates or fragmented agricultural clearings for calculating the mean CPUE. Regional population size is calculated as mean CPUE x 12,000 (CV) x Regional Area (sq. km.).

36. Hunting Effort refers to the number of baits used for a constant number of transects for calculating the mean regional CPUE on the one hand and where the transects were not constant, the mean is calculated as the total number of crabs in relationship with the total number of baits ssssduring all regional surveys on the other.

37. Sexual maturity of the coconut crab is at 5-6 years of female but studies indicate that the minimum size of 31mm TL is more relaible data than age.

38. The minimum viable population (MVP) based on size and size frequency distrbution must contain females at least 5 years older than sexual maturity age.

39. Estimation of age from size in coconut crab based on lthe inverse function of the von Bertalanoff growth function (VBGF) is fraught with inaccuracy.

40. Niue coconut crab population is suffering from prolonged over-expploitation. It is estimated that approximately 90% of female cocomnut crabs have a thoracic length of 32 mm or less leaving just 10% of available females which can be sustainable harvested without seriously jeopardising the reproductive viability of the current population level.

41. The calculated male to female ratio of 1:1.09 was the same for 1988 and 1990 surveys although the overall M:F ratio in 1988 was based on data collected during the reproductive period from surveys of near ocean and foreshore transects. This can be compared with 1:.09 for Palau (1973) abnd Vanuatu (1988).

42. It should be noted that the use of coconut crab size frequency data is unreliable for estimating age structure because growth in coconut crabv is not only extremely slow where K = 0.05 bu also variable.

ANNEX V

RESULT OF SPAWNING ACTIVITY SURVEYS (Schiller 1988)

AREA	DATE OF SURVEY	NUMBER OF FEMALES		NO. OF MALES
		NON-GRAVID	GRAVID	
Anaana Point	2 days 03/88	3	12	1
North road	2 days 03/88	12	1	3
South road	5 days 03/88	4	2	6
Utuko reef	12/03/88	1	2	0
Avaiki Cave	13/03/88	0	0	0
Limu	13/03/88	0	0	0
Limufuafua Pt	4 days 03/88	30	1	69
Vaikona	17/03/88	2	14	2
Mutalau	21/03/88	1	0	0

*Surveys carried out using a motorbike
North Road - Selection of road between Ana (blowholes) and Alofi
South Road - Section of road between Alofi and Tamakautoga

ANNEX VI

NUMBER OF COCONUT CRABS EXPORTED TO NZ : 1.06.87 - 18.03.88

TYPE OF CONTAINER	NO. OF CONTAINER	AV. NO. OF CRABS/CONTAINER			TOTAL NO. OF CRABS PER CONTAINER TYPE
		Small	Med	Large	
Carton	149	27	20	15	2,235 - 4023
Hand bag	42	22	15	10	420 - 924
Chilly Bin	18	42	33	23	414 - 756
Suitcase	3	60	45	33	99 - 180
Plastic Bag	1	15	12	8	8 - 15