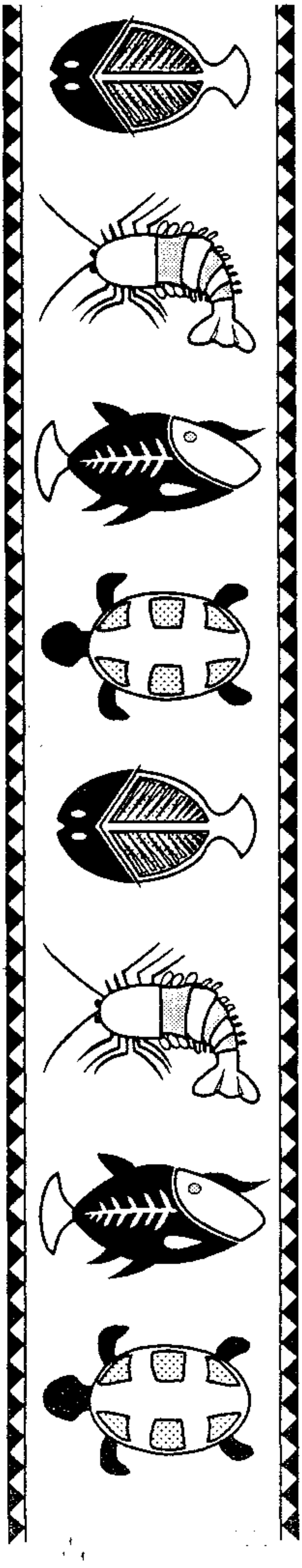

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Inshore Fisheries Research Project
Technical Document No. 3

FISHERIES RESOURCES SURVEY OF THE ISLAND OF NIUE

South Pacific Commission
Noumea, New Caledonia

SOUTH PACIFIC COMMISSION

FISHERIES RESOURCES SURVEY OF THE ISLAND OF NIUE

A report prepared in conjunction with the South Pacific Commission Inshore Fisheries Research Project and the FAO Regional Aquaculture Development Project for the Government of Niue, July 1990

Inshore Fisheries Research Project
Technical Document No. 3

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SUMMARY

A fisheries and marine resources survey was carried out jointly by the South Pacific Commission and the FAO South Pacific Regional Aquaculture Development Programme at Niue in July 1990. The fisheries component of this study consisted of a review of the literature on the fisheries of Niue, analysis of contemporary catch data from Niuean fishermen and a questionnaire survey of the Niuean pattern of fisheries resource use. Records of fishing by the Fisheries Division catamaran and by several private fishermen using canoes and outboard-powered dinghies were provided.

Bottom fish catches from dinghies were dominated by eteline snappers, followed by groupers or rock cods. Pelagic catches from dinghies consisted mainly of wahoo, followed by yellowfin tuna. The catches of pelagic fish from canoes were dominated by yellowfin tuna.

Bottom fish catch rates for one Niuean fisherman ranged from 2.1 to 8.5 kg/line-hr, with a mean of 5.5 kg/line-hr. The average catch rate of SPC masterfishermen at Niue during three visits in the early 1980s was 5.8 kg/line-hr. Average catch rates for trolling from two dinghies were 2.8 to 3.8 kg/line-hr, with an overall mean of 3.3 kg/line-hr. The average catch per trip for pelagic fishing from three dinghies ranged from 12.4 to 41.4 kg. Catches from canoes were made with vertical longlines and the average catch per unit of effort (CPUE) for two canoes ranged from 7.6 to 8.0 kg/line-hr with an overall mean of 7.8 kg/line-hr.

Catch rates of bottom fishing did not vary much throughout the year but were marginally higher in the latter half of the year. Catches of pelagic fish were highly seasonal, with an overall peak of abundance between July and December. The CPUE of both wahoo and yellowfin tuna was greatest in the middle of the year whilst that of skipjack was highest between October and March.

Flying fish catches in Niue are made at night with scoop nets, generally by a two-man crew in a dinghy. Catches are seasonal, with the main period of abundance (according to Niuean fishermen) between August and March. Available catch data show that CPUEs range from 5 to 15 kg/hr, with an average of 12.0 kg/hr, equivalent to about 40 fish per hour. Other small pelagic fish caught by Niuean fishermen include bigeye scads and round scads. No data were available for catches of these species, although the average CPUE of a hoop net employed to catch round scads was 7.0 kg/haul. The catches made with a hoop net were only for research purposes as fishing with nets for round scads is forbidden by law in Niue.

A questionnaire survey was carried out to elucidate the patterns of fisheries resource use on Niue. Most fishing is carried out by handline (36%), rod and line (38.3%) and trolling (10.3%). Set nets and spears are rarely used in Niue. About half of the total catch is taken from the reef, with the balance coming from waters beyond the reef. Most of the catch is for home consumption but a greater proportion of the beyond-reef catch is shared and sold.

The stock density of giant clams along the coast of Niue (Tepa Point to Vaigata) was 103.0 clams/ha, the two species found being *T. maxima* (89 clams/ha) and *T. squamosa* (14.0 clams/ha). Standing stocks of *T. maxima* and *T. squamosa* were estimated at 24,252 and 3,815 respectively. The average size of *T. maxima* at three locations on the west coast was approximately 12.0 cm. A questionnaire survey of socio-cultural attitudes to clam harvesting was also carried out. Approximately 10 per cent of those people surveyed ate clams regularly, about once a week. About half the respondents ate clams on average once a year. There are no customary taboos on harvesting clams other than a complete ban on fishing the reef adjacent to a village where a person has died. About 65 per cent of the respondents perceived a need for some form of conservation and management of clam stocks in Niue and about 80 per cent felt that laws restricting the harvesting of giant clams would be gradually accepted.

The reef area was deemed to be a suitable habitat for trochus. It was recommended that if introductions do occur, then some consideration be given to the origin and composition of the seed stock. On the basis of studies elsewhere in the Pacific, the potential harvest of trochus from Niue's reefs was estimated to amount to about 65 t/yr. However, there were a number of reservations about this estimate.

A survey of the inter-tidal and subtidal reef for beche-de-mer suggested that there was a total standing stock of about 100,000 animals. About 95 per cent of this consists of the non-commercial species *Holothuria atra,* found mainly on the intertidal reef. The only beche-de-mer species of commercial value was the prickly redfish *Thelenota ananas,* with stock densities on the sub-tidal reef of 17.5 animals/ha or a total standing stock of 2,188 animals. It was concluded that beche-de-mer stocks on Niue offered little commercial potential.

The density of the crown-of-thorns starfish *(Acanthaster planci)* was also surveyed on the reefs. Nine adults were seen in the 9.2 ha covered by the survey, amounting to a standing stock density of 0.98 animals/ha.

Three species of tropical spiny lobster were recognised from the reefs of Niue *(Panulirus penicillatus, P. longipes, P. versicolor). P. penicillatus* appeared to be the commonest, followed by *P. longipes* and then *P. versicolor.* Also present on the reefs were the slipper lobster, *Parribacus caledonicus,* and the crabs *Carpilius maculatus* and *Etisus splendidus.* Only one person on Niue presently targets specifically on lobsters, catching them by spearfishing. No information exists on the catch rates for lobsters on the reefs of Niue.

A more important crustacean for the Niueans is the coconut crab, *Birgus latro.* The exploitation of this land crab has been dealt with elsewhere. The major threat to coconut crabs is the large demand from expatriate Niueans in New Zealand, particularly when direct air services are operating. A total of 2 t of coconut crabs per year was estimated to have been exported to New Zealand during the 1980s.

The total fisheries production of Niue was estimated to be about 115 t/year, based on nutritional data and population census data. A further 4.9 t/yr was estimated to be exported to New Zealand during periods of direct air connections. The questionnaire survey indicates that about half of Niue's fish production comes from the coral reef areas. This amounts to a total reef yield for the 6.2 km^2 of shallow reef of 9.3 $t/km^2/yr$.

The total value of Niue's fisheries production was estimated to be about NZ$ 920,000 or US$ 561,300. However, most of this production is of a subsistence nature and on average only 10—14 t of fish with a total value of NZ$ 96,000 or US$ 52,000 directly enters the cash economy. Full-time fishing on Niue is only pursued by a few individuals; most catches are made by people with an alternative income source. Records from Niuean fishermen suggest that the gross income from fishing amounts to about NZ$ 14,000/yr, with a net income of between 11,900 and 12,000 dollars.

A number of recommendations based on the results of this study are discussed. Methods are suggested for increasing the stocks of *T. squamosa,* which may have been over-harvested in the past. The construction of clam rings is recommended, to improve recruitment to the reef. A follow-up clam survey is advised, since the study described here took place not long after a major cyclone.

Recommendations are made on the type of fishing records that should be collected by the Fisheries staff on Niue, based on the existing log book system. It is suggested that more effort be placed on recording catches of fish at the landing site when the fishermen come ashore. Other data should include species composition, lengths, weights and gonad condition. It is also recommended that the Fisheries Division place more emphasis on monitoring exports of fish, lobsters and coconut crabs from Niue by air, particularly as this will no doubt increase with the advent of a new direct air link with New Zealand. Finally, the equipment needs of the Fisheries Division are discussed in the light of the work recommended.

RESUME

Une étude sur les ressources halieutiques et marines a été conjointement réalisée par la Commission du Pacifique Sud et le Programme régional océanien de développement de l'aquaculture de la FAO à Niue, en juillet 1990. La composante halieutique de cette étude a consisté en un examen du fonds documentaire relatif aux activités de pêche conduites à Niue, en une analyse des données de prises contemporaines obtenues auprès des pêcheurs locaux ainsi qu'en une étude réalisée à l'aide d'un questionnaire sur les modes d'exploitation des ressources halieutiques. Des relevés ont été fournis par le catamaran du service des pêches et par plusieurs artisans-pêcheurs privés opérant avec des pirogues ou des youyous à moteur hors bord.

Les lutjanidés de l'espèce *Etelis* venaient en tête des poissons de fond capturés par les youyous, suivis des loches ou des mérous. Le tazar du large représentait l'essentiel des prises pélagiques réalisées par les youyous suivi du thon jaune qui est l'espèce la plus exploitée par les pirogues.

Les taux de prise de poissons de fond par pêcheur, à Niue, variaient entre 2,1 et 8,5 kg/ligne-heure, avec une moyenne de 5,5 kg/ligne-heure. Le taux de prise moyen des maîtres-pêcheurs de la CPS, lors des trois visites qu'ils ont effectuées à Niue au début des années 1980, était de 5,8 kg/ligne-heure. Les taux de prises moyens pour la pêche à la traîne à bord de deux youyous variaient entre 2,8 et 3,8 kg/ligne-heure, avec une moyenne générale de 3,3 kg/ligne-heure. Le taux de prise moyen des poissons pélagiques péchés par trois youyous se situait entre 12,4 et 41,4 kg par sortie. Les pirogues utilisaient des palangres verticales et la capture moyenne par unité d'effort (CPUE) pour deux pirogues se situait entre 7,6 et 8 kg/ligne-heure, avec une moyenne générale de 7,8 kg/ligne-heure.

Les taux de prise des poissons de fond n'ont guère varié tout au long de l'année mais ils étaient légèrement supérieurs dans le courant du dernier semestre. Les prises de poissons pélagiques avaient un caractère saisonnier marqué, avec une pointe générale d'abondance enregistrée entre juillet et décembre. La CPUE du tazar du large et du thon jaune atteignait son niveau le plus élevé au milieu de l'année alors que celui de la bonite enregistrait la poussée la plus forte entre octobre et mars.

Les prises de poissons volants à Niue sont réalisées la nuit à l'épuisette, généralement par deux pêcheurs opérant à bort d'un youyou. Les prises ont un caractère saisonnier et la principale période d'abondance (d'après les pêcheurs de Niue) se situe entre août et mars. Les données de prises disponibles font apparaître que les CPUE oscillent entre 5 et 15 kg/heure avec une moyenne de 12 kg/h, équivalant à 40 poissons environ par heure. Parmi les autres petits poissons pélagiques capturés par les pêcheurs de Niue, il y a lieu de citer les maquereaux à gros yeux et les chinchards. Il n'existait aucune donnée disponible sur les prises de ces espèces bien que la CPUE moyenne de chinchards par coup de truble s'établisse à 7 kg. Les captures ainsi réalisées avaient pour seul objectif la recherche puisqu'il est interdit, à Niue, de pêcher le chinchard au filet.

Une étude a été réalisée à l'aide d'un questionnaire afin de tirer au clair les modes d'exploitation des ressources halieutiques à Niue, où l'on pêche essentiellement à la palangrotte (36%), à la canne et à la ligne (38,3%), à la traîne (10,3%), et rarement au filet dormant et au harpon. Près de la moitié du volume total de poissons est capturé sur le récif, le reste provient des eaux situées plus au large. Le produit de la pêche est destiné à la consommation ménagère mais les poissons pris au large du récif sont, en grande partie, partagés et vendus.

La densité du stock de bénitiers le long du littoral de Niue (de Tepa Point à Vaigata) était de 103 bénitiers/ha, les deux espèces locales étant *Tridacna maxima* (89 bénitiers/ha) et *Tridacna squamosa* (14 bénitiers/ha). Les stocks actuels de *Tridacna maxima* et de *Tridacna squamosa* ont été estimés à 24 252 et 3 815 respectivement. La taille moyenne de *Tridacna maxima* en trois points de la côte ouest était d'environ 12 cm. Une étude a également été réalisée, à l'aide d'un questionnaire, sur les attitudes socio-culturelles envers la pêche des bénitiers. Environ 10 pour cent des personnes interrogées ont indiqué qu'elles mangeaient régulièrement des bénitiers, environ une fois par semaine. Près de la moitié de ces personnes en mangeaient en moyenne une fois par an. Il n'existe pas d'interdit coutumier à l'égard de cette espèce, si ce n'est une interdiction complète sur le récif

adjacent à un village où une personne en est décédée. Environ 65 pour cent des personnes interrogées ont ressenti la nécessité d'assurer certaines formes de préservation et de gestion des stocks de bénitiers à Niue et environ 80 pour cent ont estimé que la réglementation limitant la pêche des bénitiers serait progressivement acceptée.

I1 a été estimé que la zone du récif était un habitat approprié pour les trocas. Il a été recommandé, en cas d'ensemencement, de se pencher sur l'origine et la composition du stock de semences. Sur la base des études réalisées dans d'autres îles du Pacifique, la récolte potentielle de trocas sur les récifs de Niue a été estimée à environ 65 tonnes par an. Toutefois, des réserves ont été formulées quant à cette estimation.

Une recherche de bêches-de-mer sur le récif intertidal et infralittoral a permis d'extrapoler la taille du stock actuel à environ 100 000 individus, dont 95 pour cent appartiennent à l'espèce non exploitable *Holothuria atra,* qui peuple principalement le récif intertidal. La seule espèce de bêche-de-mer de valeur commerciale est l'holothurie ananas *(Thelenota ananas),* qui présente des densités de stock sur le récif infralittoral de 17,5 individus/ha, soit un stock actuel total de 2 188 individus. En conclusion, les stocks de bêches-de-mer à Niue présentent un intérêt commercial minime.

La densité de l'étoile de mer épineuse *(Acanthaster plancï)* sur les récifs a également été étudiée sur une superficie de 9,2 ha, où neuf adultes ont été observés, ce qui représente une densité de 0,98 individus/ha pour le stock actuel.

Trois espèces de langoustes tropicales ont été observées sur les récifs de Niue *(Panulirus penidllatus, P. longipes, P. versicolor).* L'espèce *P. penidllatus* semble être la plus commune, suivie de *P. longipes* et de *P. versicolor.* Les récifs sont également peuplés de cigales de mer, *Parribacus caledonicus* et de crabes des espèces *Carpilius maculants* et *Etisus splendidus.* A Niue, une seule personne pratique actuellement la pêche de la langouste, qu'il prend à la foëne. Il n'existe pas de renseignements sur les taux de prise de langoustes sur les récifs de Niue.

Sur le plan économique, le crabe de cocotier, *Birgus latro,* est plus important que les autres crustacés pour les habitants de Niue. L'exploitation de ces crabes terrestres a été traitée dans un autre document. La principale menace pour l'espèce réside dans la forte demande provenant de ressortissants de Niue expatriés en Nouvelle-Zélande, particulièrement en période d'exploitation d'un service aérien direct. Selon les estimations, 2 tonnes de crabes de cocotier par an ont été exportées en Nouvelle-Zélande pendant les années 80.

La production halieutique totale de Niue a été évaluée à quelque 115 tonnes/an à partir des données nutritionnelles et des données sur le recensement de la population. Selon d'autres estimations, 4,9 tonnes supplémentaires par an ont été exportées vers la Nouvelle-Zélande en période d'exploitation d'un service aérien direct. Selon l'étude effectuée au moyen du questionnaire, environ la moitié de la production halieutique de Niue provient de la zone des récifs coralliens, ce qui représente un rendement récifal total de 9,3 tonnes/km^2/an pour les 6,2 km^2 de récifs peu profonds.

La valeur totale de la production halieutique de Niue a été évaluée à environ 920 000 dollars NZ ou 561 300 dollars E.-U. La majeure partie de cette production étant vivrière, en moyenne, 10 à 14 tonnes de poissons seulement, ce qui correspond à une valeur totale de 96 000 dollars NZ ou 52 000 dollars E.-U. entrent directement dans le circuit économique. Seuls quelques particuliers pèchent à plein temps à Niue; la majorité des prises sont effectuées par des gens qui ont une autre source de revenu. Les données relatives à la pêche à Niue laissent supposer que le revenu brut de la pêche s'élève à environ 14 000 dollars NZ par an, et que le revenu net se situe entre 11 900 et 12 000 dollars NZ.

Un certain nombre de recommandations, fondées sur les résultats de cette étude, sont formulées. Des méthodes visant à augmenter les stocks de *T. squamosa,* surexploités par le passé, sont proposées. On prévoit notamment la disposition des bénitiers en cercles pour améliorer leur recrutement sur les récifs. Il est recommandé d'effectuer une étude de suivi sur le bénitier, car celle qui est décrite dans le présent document s'est déroulée peu après un important cyclone.

Le document comporte également des recommandations sur l'enregistrement des données de pêche tel qu'il devrait être effectué par les agents du service des pêches de Niue à partir du système actuel de tenue d'un journal de pêche. Ces agents devraient notamment insister davantage sur la consignation des prises aux lieux de débarquement. La composition par espèce, la taille, le poids et l'état des gonades sont des exemples d'autres données à consigner. Il est également recommandé que le service des pêches insiste davantage sur la surveillance de l'exportation par avion de poissons, de langoustes et de crabes de cocotier à partir de Niue, d'autant plus que cette pratique augmentera sans nul doute avec l'entrée en service d'une nouvelle liaison aérienne directe avec la Nouvelle-Zélande. Enfin, les moyens matériels nécessaires au service des pêches pour mener à bien les tâches qui lui incombent sont évalués.

ACKNOWLEDGEMENTS

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The clam survey methods in this report were based on the work of Dr R. D. Braley of the Zoology Department, James Cook University of North Queensland, to whom we extend our thanks for his advice and guidance. Both James Cook University and the Australian Centre for International Agricultural Research (ACIAR) are to be thanked for allowing Steve Lindsay to be seconded to FAO for this survey. We are also grateful to the Tuvalu Fisheries Division for the secondment of Helen Patiale to SPC for this work. We thank Mrs Kaye Legras of the SPC IFRP for preparing the fisheries survey form. Finally we are grateful to Mrs Caroline Nalo of the the SPC Publications Section who edited and proof-read the various drafts of this report.

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FIGURES

1. INTRODUCTION

The island of Niue (Fig. 1) is an uplifted tropical atoll, with a former reef and lagoon raised to about 60 m above sea level. Although Niue only has a total land area of 258 km^2 and a circumference of 64.8 km (35 nmi), it is the largest upraised coral island in the world. Like the Cook Islands, Niue has a political compact of free association with New Zealand and there has been a history of extensive migration of Niueans, mostly to New Zealand. The population of Niue at the most recent census in 1989 (Anon, 1990a) was estimated at 2,270 people, of whom about 2000 are classed as Niueans. The others are a mixture of New Zealand citizens and people from other Pacific Islands such as Tonga, Tuvalu and the Cook Islands.

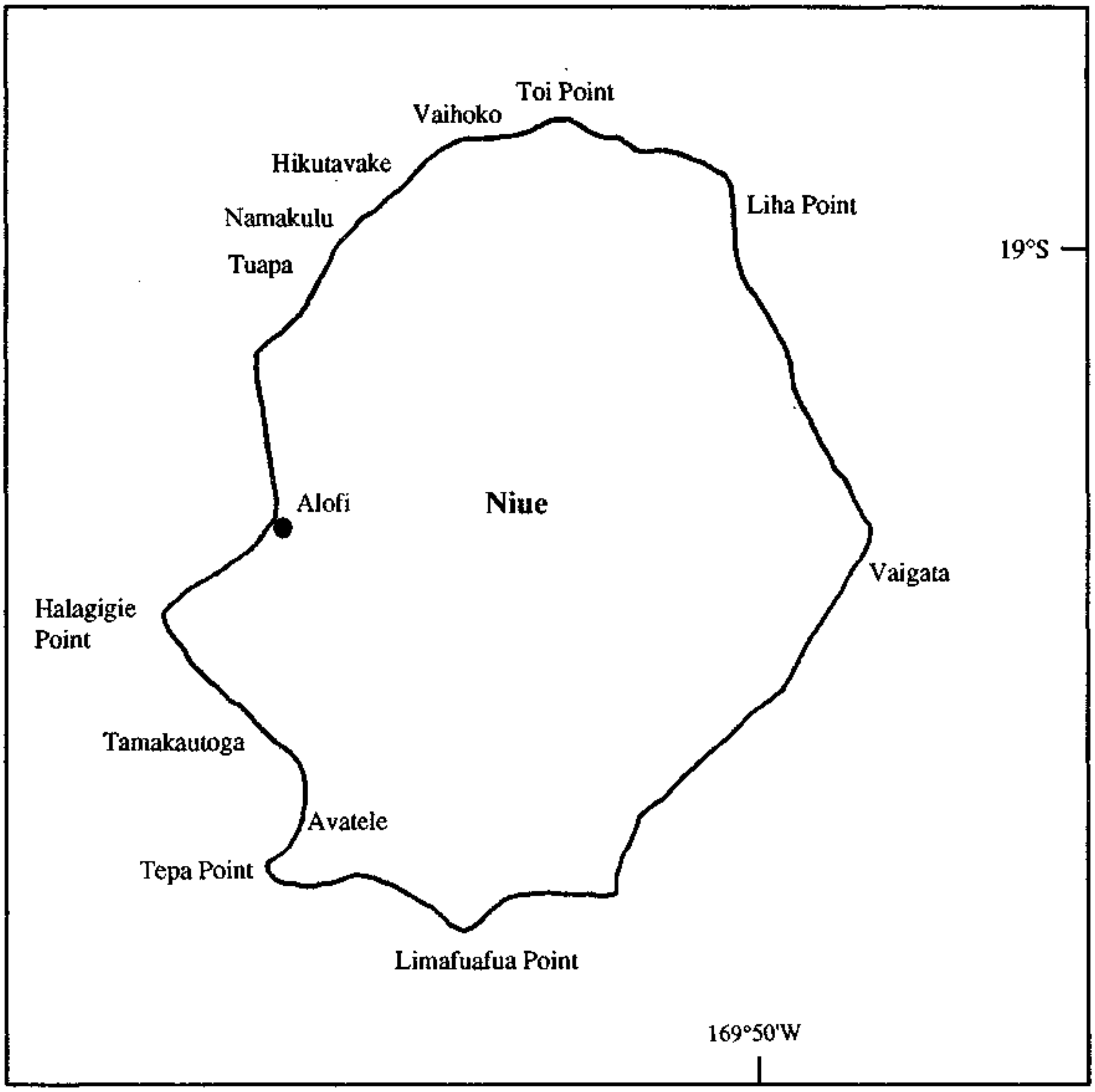

Figure 1. Map of Niue showing the places mentioned in the text

Because of its small size, the island of Niue has limited natural resources. However, unlike non-emergent atolls, the plateau of Niue will support a variety of agricultural crops, such as citrus fruits, vegetables, root crops and vanilla. Coconuts are found throughout the island, though they grow sparsely in the interior. Niue does not have any surface fresh water and, although water is drawn from artesian wells, water supply limits agricultural development. Another constraint is the distribution of soil on Niue in pockets, which, though fertile, are limited.

Niue has no lagoon and the coastline of the island descends precipitously to over 1000 m within 5 km of the shore. A narrow fringing reef is found around most of the coast. This provides the population with fresh reef fish and a variety of molluscs, including giant clams *(Tridacna* spp.). Niuean fishermen also catch small pelagic fishes, such as flying fish and scads, and large pelagic fish, such as wahoo *(Acanthocybium solandri),* skipjack tuna (*Katsuwonus pelamis)* and yellowfin tuna (*Thunnus alhacares).* The fisheries resources of Niue have been the subject of some investigation in the past, although much of this has focused on trials with different gears and boats. The resource survey described here was carried out jointly by the South Pacific Commission and the FAO Regional Aquaculture Development Project, at the request of the Niuean Government. It had five objectives:

—To summarise the existing information on Niue's fisheries resources, both published and unpublished, and report on the catch composition of different gears and their respective catch rates;

—To carry out a detailed questionnaire survey of the people of Niue with the aim of establishing the pattern of fishing activity on the island and the present economic returns from fishing;

—To carry out a detailed survey of the stocks of giant clams and other invertebrates such as beche-de-mer and lobsters, and assess the economic potential of these resources;

—To carry out a questionnaire survey of the socio-economic importance of giant clams on Niue;

—To complete a report containing summaries of all findings.

The results of these investigations are presented in this report and are discussed with reference to the possible expansion and development of the marine resources of Niue.

2. STUDY AREA

Niue lies about 19 degrees south of the equator and thus has a tropical climate with mean monthly temperatures varying between 23 and 27° C and rainfall averaging 2,100 mm/yr. Niue does not possess a true hermatypic reef but instead is in part surrounded by a rock platform, varying from a few metres to just over a hundred metres in width, cut in the original limestone of the island. Large parts of this are subtidal, the remainder intertidal. Much of the south and east sides of the island is entirely devoid of reef flat; some parts have 1—8 m wide pools about 1.5 to 2.5 m above sea level. The flat has a thin discontinuous veneer of living corals on its upper (intertidal) surface and rich coral growth over the edge in subtidal waters. According to UNEP/IUCN (1988), at least 43 coral genera are found on the Niue rock shelf.

Niue lies in the cyclone belt and was struck by cyclones in 1959,1960, 1968, 1979 and 1990. The most recent of these, Cyclone Ofa, caused extensive damage to the island and to the corals that overlie the rock shelf. Contemporary observations through snorkelling, SCUBA diving and conducting reef transects during the period of this survey would suggest that Cyclone Ofa caused major damage to the corals on the western coast of the island. In some areas of the shelf virtually all the living coral was destroyed by the cyclone. Relatively fragile corals such as staghorns (e.g. species of Acroporidae) and plate corals (e.g. species of Poritidae) were totally absent from the reef on the western side of Niue. Only the massive corals (e.g. species of Faviidae and Poritidae) appeared to have survived the cyclonic destruction.

No estimates are available of the area of Niue's reef plateau and subtidal reef. Contemporary maps deal with terrestrial features in detail but give relatively little information about the reef area. This is not surprising given the size of the reef relative to the land mass of Niue. However, for the purposes of this survey, an estimate of the reef area was important.

In 1985 the New Zealand Department of Lands and Survey issued a new map of Niue based on a series of aerial photographs taken in 1981. These photographs, with a scale of 1:10,000, are on file in the Niue Department of Land Titling and were made available for study. From them it was possible to accurately distinguish the area of reef plateau and, because of the water clarity, the subtidal reef down to a depth of about 25 m. The total area of reef plateau and sub-tidal reef was estimated at 620 ha from the photographs by planimetry. On the west coast, the photographs were detailed enough to distinguish between the intertidal plateau and the subtidal reef. Between Vaihoko in the north and Tipa point in the south there are 125 ha of plateau and 200 ha of subtidal reef.

There is a rich, though largely undocumented, marine invertebrate fauna. A checklist of marine littoral molluscs has been compiled by Cernohorsky (1970). Reef crabs and other crustaceans are well represented, with many common Indo-Pacific species. Details of the fish fauna are limited, although the position of Niue on the Indo-Pacific Plate and its position relative to the rest of Polynesia would suggest that the island has a relatively diverse fish fauna. The most detailed records of fish species are given by the SPC reports on deep slope fishing in Niue. Information on the species found in the shallow coral areas has previously been limited to observations by Hinds (1970) who recorded fishes recognised from the book *Sea fishes of Southern Africa* by Smith (1965).

The lack of a lagoon at Niue precludes the presence of small pelagic fishes normally associated with South Pacific islands. Thus there are no coastal stocks of herrings, sprats, sardines (Clupeidae) and anchovies (Engraulidae) around Niue. Small pelagic fishes found in the vicinity of the coast include the bigeye scad *(Selar crumenophthalmus,* round scads *(Decapterus* spp.) and flying fish (Exocoetidae). On the basis of collections made at Niue in 1989, four flying fish species were identified by Dr Bruce Collette of the Smithsonian Institute (R. Gillett, FAO Regional Fishery Support Programme, Suva, pers. comm.) A total of 25 species of deep slope bottom fishes was identified by SPC masterfishermen during three separate fishing surveys of Niue (Fusimalohi, 1978; Mead, 1980; Mead, in press).

To compensate for the lack of information on reef species, three officers of the Department of Agriculture who spearfished regularly on the reefs of Niue were asked to study pictures of reef fishes contained in the recently published *Micronesian reef fishes* (Myers, 1989). About 200 species of reef fish were identified from the colour plates as being present on the fringing reef of Niue. Some of these identifications were corroborated directly from the extensive underwater observations made during the clam surveys. These identifications and other records of fishes from the sources listed above have been used to compile a preliminary checklist of the fishes of Niue (Appendix I). This checklist is only for marine species and does not include the eels and small 'bullies' that are found in the freshwater caves on the island (Yaldwyn, 1970). It is not intended to be a complete list of the fishes of Niue, but to serve as an initial guide to what species may be found around the island. Most notable is the virtual absence of the common shallow-water Lethrinidae which are a feature of reef fish catches in the Western South Pacific.

Within the 200 nmi Exclusive Economic Zone (EEZ) of Niue is the partially emergent Beveridge Reef, which encloses an oval lagoon approximately 7.0 km long with an open sandy floor with areas free of coral heads. Accounts by Niueans who have dived on Beveridge Reef suggest that this area has a rich and varied reef fish fauna. Visual and hydroacoustic surveys of the lagoon by the SPC Skipjack Survey and Assessment Programme in 1980 (South Pacific Commission, 1984) revealed no concentrations of small pelagic fishes suitable for baitfish. Only a few schools of garfish (Hemiramphidae) and damselfish (Pomacentridae), which are not suitable for use as live bait, were sighted. Similarly, baitfish were seen at Beveridge Reef in late 1979, during an exploratory fishing cruise by the Tongan vessel *Takuo*, sponsored by the United Nations Development Programme on behalf of Niue (Mead, 1980). A total of 14 deep slope fishes was taken during the single SPC survey of the bottom-fish resources on Beveridge Reef (Mead, 1980).

3. PREVIOUS FISHERIES SURVEYS AND DEVELOPMENT WORK IN NIUE

The earliest mention of fishing on Niue in the archives of the South Pacific Commission is a report on the activities initiated in May 1962 by an SPC Fisheries Officer, which lasted until November 1964 (Devambez, 1968). Trials were carried out with several different fishing methods, including trolling, longlining', gillnetting and fish trapping. The document on file at SPC does not contain the appendices with the actual details of catches by these different methods, nor could they be found in the archives. However, it was clear from the project narrative that trolling was the most successful fishing method. Longlining was hampered by rough seas and bait shortages, whilst gillnetting for flying fish and round scads was found to be less successful than the traditional methods of scoopnetting and handlining.

A further visit by the SPC Fisheries Officer was made during August to September 1970 to advise on Government assistance for fishing and fish marketing ventures and to conduct fishing trials for tuna (Hinds, 1970). Investigations during this period focused on the operations of two privately owned fishing vessels that were monitored between 1969 and 1970. This visit resulted in the formulation of 25 recommendations to the Government of Niue, covering wharf-side construction, boat construction and design, appropriate propulsion units for the boats, financing new fishing ventures and fisherman training.

During 1977 an 8.5 m fishing boat and fishermen were sent to Niue from New Zealand as part of a bilateral aid scheme. A short summary of the findings of this project was made by Dryden (1978). Between July 1977 and May 1978, a total of 8 t of fish was caught by this fishing project. Dryden reports that fishing with a vessel of this design in Niuean waters was not very productive; 75 per cent of the fish were captured on the windward eastern coast but it was only possible to fish on this side of the island on 30 per cent of the fishing days. Dryden further stated that bottom fish were not present in sufficient quantities on the western coast of Niue to warrant extensive fishing effort. Fishing on the eastern coast was only possible for 1—3 hours a day in the slack water between tides.

Dryden's overall conclusion was that fishing in Niue was not very productive because of the limited fishing areas and the seasonality of the large pelagic fishes. Besides troll fishing and dropline fishing, trials were conducted with bottom and surface long lines, surface and bottom-set gill nets, lobster pots, prawn pots and poles and lines with dead bait. Dryden concluded that only trolling and dropline fishing were economically feasible around Niue.

The South Pacific Commission's Deep Sea Fisheries Development Project conducted three stock surveys of the deep slope bottom fish resources around Niue between 1978 and 1983 (Fusimalohi, 1978; Mead, 1980; Mead, in press). During the 1979 survey, a single visit was made to Beveridge Reef which lies 225 km south-east of Niue. The average catch rates at Niue and Beveridge Reef were 5.8 and 6.1 kg/line-hr respectively. The conclusion drawn from the different surveys was that Niuean fishermen could obtain good incomes through a combination of bottom fishing for deep slope species and trolling for large pelagic fish.

4. RESOURCE SURVEY METHODS

General fisheries resources survey

A questionnaire sampling survey of different households on Niue was carried out between 12 and 24 July 1980 to ascertain the patterns of exploitation of fisheries resources, the main methods of fishing and the commonest species in the catch. Data were collected on the investment made to go fishing (boats and outboard motors), and the dimensions of the different fishing gears employed. An example of the survey questionnaire is shown in Appendix II.

According to the 1989 mini-census, there are 522 households on Niue, spread between 13 villages, including the capital Alofi. In this survey we attempted to interview people belonging to 10 households in each village, giving a maximum number of 130 interviews and a sample size of 25 per cent. In reality it was difficult to collect 10 interviews from some villages, either because of the small population, or because much of the adult population commutes to Alofi during the day. The minimum number of households to be contacted was 102, which is 19.5 per cent of the total number of households on Niue.

A further consideration in the sampling programme was the separation of fishing activities between sexes. Fishing from boats is almost exclusively the preserve of men in Niue, but they are largely absent from their houses during the working day. Walking on the reef and collecting sedentary invertebrates is more the preserve of women, although both men and women fish from the shore to catch small reef fishes. Interviews with the different households had to ensure that all fishing/harvesting activity was recorded, either by leaving questionnaires to be filled in after working hours or by repeat sampling when both husband and wife were at home, usually in the evening.

Besides the island-wide survey through questionnaires, detailed interviews were conducted with selected individual fishermen to ascertain likely revenues from part-time and full-time fishing. Information was collected on the actual frequency of fishing, costs of each fishing trip (especially for petrol) and other associated costs for hooks, lures and fishing line. Some fishermen also keep detailed logs of their fishing trips and permission was sought to examine these for details of catches and catch composition.

Intensive stock survey of giant clams

This aspect of the Niue resources survey is the third population study on giant clam species in the South Pacific commissioned by FAO. The methods and procedures used in this survey were also used by Braley (1988 and 1989) for FAO-funded surveys in Tuvalu and Tokelau.

The tow method originally used by Munro (1988) to assess giant clam stocks in Kiribati was used in this survey. Two observers equipped with snorkels and masks were towed from the sides of a small boat. A length of pipe from which the observers could be towed was secured across the bow of the boat. The keel of the boat provided an artificial barrier between the observers, preventing replication of animal counts. This procedure was also used to count numbers of crown-of-thorns starfish *(Acanthaster planci)* and holothurians (beche-de-mer). The clarity and depth of water were the two major factors determining the width of the tow tracks. The combined tow width varied from 6 to 10 m. The tow speed ranged from 30 to 50 m/min. No intertidal tows were performed.

The distance travelled during each tow was determined by the method of Braley (1988, 1989). A buoyed rope was anchored at the starting point of each tow and observers towed in a straight line to a distance of between 90 and 500 m. The distance was measured in duplicate at the end of each tow by using an optical rangefinder (Rangefinder 1200 m, calibrated each day to maintain accuracy). After each tow the following data were collected for each diver: clam species and numbers, water depth, width of tow track, percentage of total coral cover, percentage of live coral, number of crown-of-thorns starfish and numbers of each beche-de-mer species. Single tows were conducted when the reef edge was narrow. Replicate tows were conducted when possible, with each new tow being parallel to and approximately 30 m from the original tow.

Besides observations on stock densities of clams around Niue, size frequency data were collected at a number of sites around the island. Measurements were made on *T. maxima* in situ using SCUBA gear and vernier callipers in depths ranging from 5 to 20 m. The maximum length of both valves of 50 live animals was taken to the nearest millimetre. No measurements were made on *T. squamosa* because of its scarcity.

Assessment of giant clam fishing intensity and socio-cultural attitudes

A questionnaire to assess the intensity of clam utilisation and social attitudes to conservation was administered during the period of this survey. Sampling of the population was stratified by both age and sex. The sample contained 60 people (30 males and 30 females) in three age classes (10—30 yrs, 30—50 yrs, 50 +). The same design of questionnaire was previously employed by Braley (1988, 1989). An example is shown in Appendix III. Samples were taken from different villages on Niue until ten completed forms were available for each age class by gender.

Preliminary stock survey of other reef invertebrate species

To assess holothurian (beche-de-mer) densities, counts were made during the tows used to assess clam densities. Specific transects were also laid across the reef flat at high tide to count densities of beche-de-mer in shallow water and to identify species. Transects were made from the base of the cliff wall across the reef flat, out to the reef crest. Two observers walked 3 m from each side of the transect line (30 m tape-measure) and counted all beche-de-mer of different species at 10 m intervals. Ten transects were made across the reef flats on the west coast of Niue, at Tuapa (5), Alofi (2) and Tamakautoga (3).

The species composition and relative abundance of tropical spiny lobster on the reefs of Niue was assessed by making three night dives on the reefs adjacent to Alofi and Avatele. Between four and six divers swam along the reef edge with torches, capturing lobsters by spearing. Also taken during these dives were other edible crustaceans such as crabs and slipper lobsters. The composition of the catch was determined and the carapace length (CL) of each specimen was measured with calipers to the nearest millimetre. Included with the data from the survey dives was the catch of two Niuean residents from Avatele.

5. FISHERIES OF NIUE

General

The rugged nature of the Niue coastline prohibits the widespread use of large fishing vessels, since they cannot be easily launched. The largest boats on Niue at the time of this survey were three 8.5 m Alia catamarans made from aluminium in Western Samoa. Two of these vessels are owned privately and the third belongs to the Department of Agriculture. The commonest type of fishing boat on Niue is a one-man outrigger canoe made especially light so that it can be carried by hand to the water on the steep slopes of the coastal tracks. These canoes are about 4 m in length. Larger, three-man canoes are built, but only for racing.

Crossland (1979) reported that in the early 1970s there were between 350 and 400 one-man fishing canoes on Niue. The mini-census and agricultural census held on Niue in October 1989 collected information on fishing activities by individual households on the island. In 1989 there were 241 canoes and 60 aluminium dinghies (ranging in length from 3.7 to 4.3 m), making a total fleet size of 301 vessels. This is somewhat lower than the fleet size quoted by Crossland and may reflect the attrition of the human population through migration to New Zealand. According to the census there were a total of 68 outboard motors on the island, which is similar to the total number of dinghies. Questions in the census on patterns of fishing activity referred to the month of September 1989.

Of the 522 households surveyed in September 1989, persons from 320 households performed some form of fishing activity. The greatest number of fishing trips (1,135) was conducted on the shore; this most likely refers to reef walking and gleaning. There was an almost equal number of fishing trips with canoes (1,121), while 485 were made in outboard-powered dinghies. Spear fishing and some fishing from the Government Alia catamaran accounted for 165 and 28 trips respectively. During September, therefore, a total of 2,934 fishing trips was made by the people of Niue.

Despite the relatively large amount of fishing activity, most Niueans do not derive their primary income from fishing. About 600 Niueans work in the Government public service and the private sector; thus nearly all households have some form of regular wage income. Fishing activity is either for additional income or to supplement food purchased in retail stores. Most Niueans also have gardens in the countryside surrounding the villages and these are an important source of fresh vegetables and fruits. At present only four men on Niue could be truly regarded as full-time fishermen. Two or three other individuals are serious part-time fishermen. The sale of catch makes a significant contribution to the household income.

Most fishing activity occurs around the western coast of the island, which is in the lea of the prevailing south-easterly winds. The villages between Avatele in the south-west corner of the island and Hikutavake in the north-west all have areas where canoes and dinghies can be launched. Each of these six villages and the town of Alofi are adjacent to the sea. The five villages of the other parts of the island, including the west coast, are situated several kilometres from the coast. They have few canoes and dinghies and their landing sites are remote.

Like many island nations of the South Pacific, Niue imports canned and frozen fish for retail sale through local stores. Canned fish and shellfish come from Japan and New Zealand, while frozen snapper, flounder, oysters and mussels are imported from New Zealand. The exact amount of the different preserved fish products imported into Niue was not available at the time this report was written. Hinds (1970) quotes a figure of 102, 621 lbs (46.6 t) of fish imported during 1970. This was at a time when the population was estimated at 5,300 people. Using simple proportionality, it is likely that present fish imports, mostly in cans, amount to about 20 t/yr.

Fisheries survey and resource utilisation

The responses to the resource survey questionnaire were given in July 1990 during a period when petrol was becoming increasingly scarce pending replenishment of stocks by a tanker vessel. The responses must, therefore, be seen in the light of these circumstances. Answers to the first question in the survey (Fig. 2) suggest that most fishing was carried out with handlines (36 per cent) and rods and lines (38.2 per cent). Also important was trolling (10.3 per cent) but this activity is limited to those fishermen with a dinghy and outboard motor. A variety of other gears was reported, including knives, hammers and axes, indicating the harvesting of reef invertebrates from the reef plateau and shallows. Only three respondents stated they used seine nets and only in one instance was this qualified as a gill net. In general netting is rarely practised on Niue and the commonest net employed by Niueans is the scoop net used to catch flying fish.

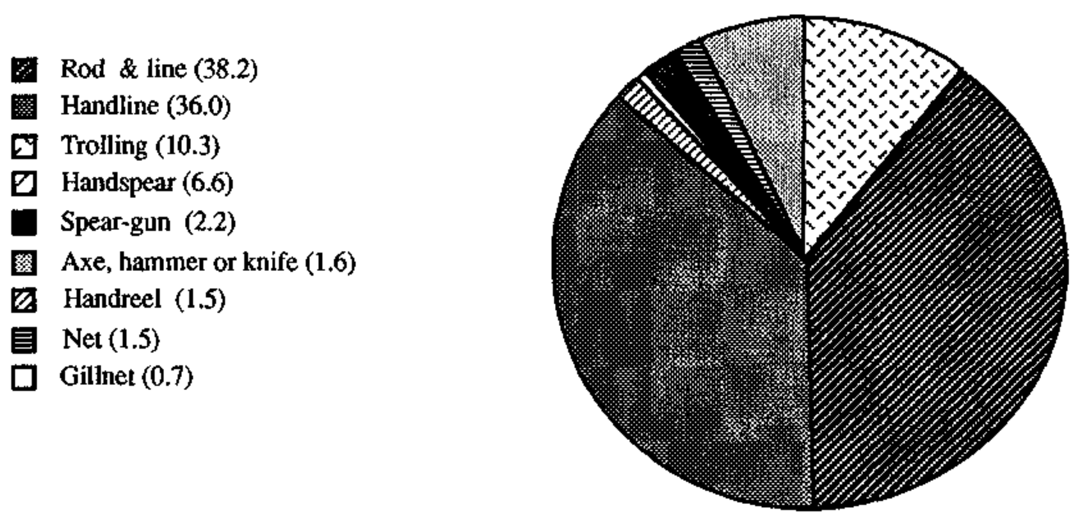

Figure 2. Percentage frequency distribution of types of fishing gear used by questionnaire respondents in their most recent fishing trip

The responses to Question 2 on the survey form indicate that the total household catch is taken almost equally from the reef (51.9 %) and from the waters beyond the reef (48.1 %). However, the catch from beyond the reef was not designated as coming from demersal or pelagic stocks. Most of the reef catch and harvests was for home consumption (80 per cent) with 15.6 per cent being shared and only 4 per cent sold elsewhere. Similarly, most of the beyond-reef catch (63.2 %) was kept for home consumption but greater proportions of this were shared (24.9 %) and sold (11.8 %) than of the reef catch (Fig. 3).

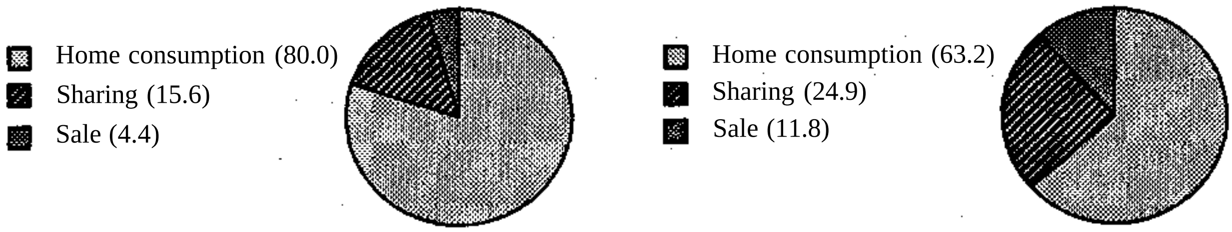

Figure 3. Destination of catch from shallow reef (left) and beyond the reef (right)

The frequency with which different gears were used on Niue was ascertained from Question 5 of the survey. The time periods 'often', 'sometimes' and 'never', although imprecise, were scaled respectively to represent weekly to monthly, quarterly, and once a year or less . The most frequent fishing activities (Table 1) are angling with rods and lines, handlining for shallow reef and deep slope species, trolling and collecting shells from the reef plateau. Fishing with gill nets and cast nets, collecting beche-de-mer, and poisoning of fishes are rarely carried out. The response to whether persons used dynamite to capture fish was unanimously negative.

Table 1: Frequency of different fishing activities on Niue based on questionnaire survey. 'Often' = weekly to monthly, 'sometimes' = quarterly, 'never' < once a year.

Method	Often	Sometimes	Never
Fish drives	4.9	29.4	65.7
Gill netting	2.9	8.8	88.3
Scoop netting	10.8	22.5	66.7
Cast netting	1.0	9.8	89.2
Handlining	28.4	41.2	30.4
Rod and line	46.1	48.0	5.9
Trolling	29.4	26.5	44.1
Deep slope fishing	27.5	26.5	46.0
Speargun	8.8	25.5	65.7
Hand-spear while walking	5.9	30.4	63.7
Collecting lobsters	3.9	44.1	52.0
Collecting beche-de-mer	3.9	12.7	83.4
Collecting shells	27.5	47.1	25.4
Collecting seaweed	3.9	31.4	64.7
General reef gleaning	4.9	52.0	43.1
Poisons	0.0	2.9	97.1
Dynamite	0.0	0.0	100.0

About 63 per cent of the sampled population of 105 households owned some form of small vessel, with nearly 40 per cent owning an outrigger canoe (Fig. 4). About 17 per cent of those questioned owned an aluminium dinghy with an outboard motor. Only seven per cent of the sampled population owned both a canoe and a motorised dinghy. Hooks and lines were the commonest type of fishing gears owned by the sampled population (Fig. 5), with about 60 per cent of the households contacted possessing some form of line. Spearguns and scoop nets were owned by just over a quarter of the households interviewed. Other fishing nets, such as seines or gill nets, were not common.

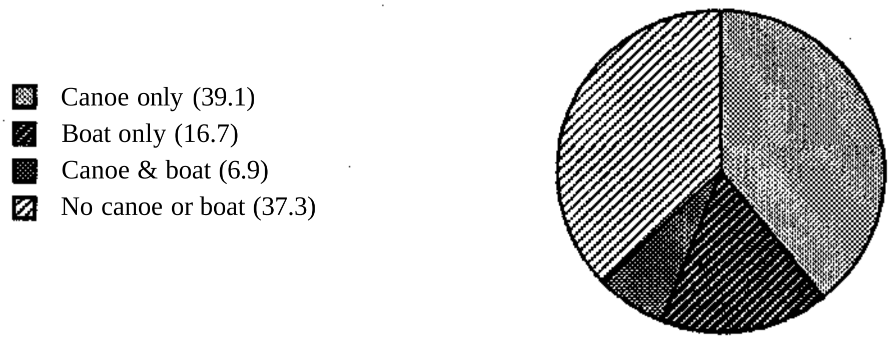

Figure 4. Percentage of households in questionnaire survey owning canoes and boats

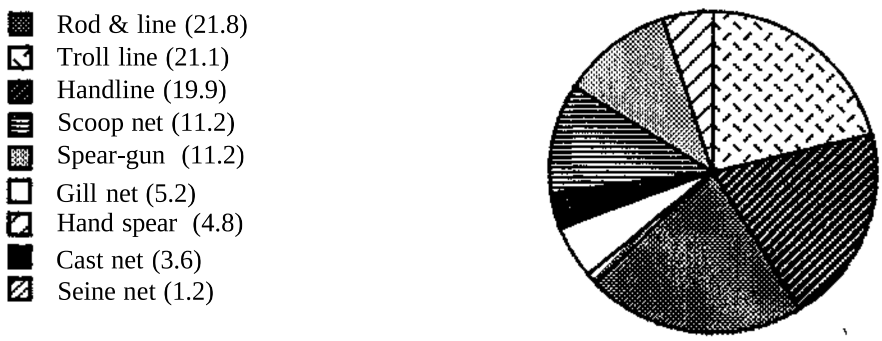

Figure 5. Percentage of households in questionnaire survey possessing different fishing gears

The species caught or collected by different fishing gears and activities as determined from the questionnaire are summarised in Appendix IV. On most occasions the species listed by the respondents were given in Niuean. These have been translated into the common English equivalent. In some instances the Niuean name refers to individual species but often a local name is a collective term for a group of similar species, for example, 'palu' for 'snappers' or members of the family Lutjanidae. Local names do exist for the different snapper species but these were only given by the full-time fishermen. Most persons catching a snapper, whether from the shallow reef or from the deep reef slope, simply termed it 'palu'. As there are very different demersal fish communities in the two habitats, snappers taken in a shallow fish-drive on the reef plateau are usually of different species from those taken from the deep slope by handlining.

The data in Appendix IV have been summarised further in Table 2. Each number in Appendix IV refers to the number of times a species was cited in the 105 questionnaire responses as being captured by a particular fishing gear. From this it was possible to rank the different species or species groups and determine the most important targets for each fishing activity.

Reef gleaning is concerned principally with the harvest of molluscs and other invertebrates such as annelid worms. Catching of octopus was also cited quite frequently under this category. Scoop netting refers almost exclusively to catching flying fish at night, using light attraction. Fish caught by fish drives, spear-gun and fish spear are the reef-associated fish such as surgeonfish (Acanthuridae), parrotfish (Scaridae) and soldierfish (Holocentridae). Handline fishing refers both to fishing in mid water for large pelagic species, such as wahoo and yellowfin, and for the large snappers and groupers of the deep reef slope, and to fishing for the smaller reef species in shallow water. The target species of trolling are invariably the large pelagic fish such as wahoo, tunas, barracudas and dolphins.

Table 2: Principal target species of different fishing activities on Niue, based on data in Appendix IV

Principal target species	Reef gleaning	Fish drive	Hand-line	Rod& line	Spear-gun	Fish spear	Trolling	Scoop net
Miscellaneous molluscs	X							
Octopus	X							
Beche-de-mer	X							
Giant clams	X							
Wrasse			X	X				
Rudderfish		X	X	X	X	X		
Mullets		X		X	X			
Surgeonfish		X			X			
Parrotfish		X			X	X		
Snappers		X	X		X			
Groupers			X					
Soldierfish			X	X	X			
Wahoo			X				X	
Yellowfin tuna			X				X	
Skipjack tuna							X	
Dolphin fish							X	
Dogtooth tuna							X	
Barracuda			X				X	
Jacks			X					
Unicorn fish				X				
Hawkfish				X				
Round scad				X				
Juvenile goatfish				X				
Threadfin				X				
Sweepers				X				
Bullseyes			X					
Bigeye scad				X				
Billfish							X	
Flying fish								X
Lobster					X			

6. FISHING METHODS, CATCH RATES AND CATCH COMPOSITION

Deep slope handline fishing

The deep reef slope area at Niue is very limited, as the shelf area descends precipitously within a few hundred metres of the shore. Bathymetric charts (e.g. Polovina et al., 1987) show that the 1000 m contour lies within 4 to 6 km of the coast. Along the west coast there is an undersea ridge that extends about 6 km off Halagigie Point. Along this ridge are three seamounts where the bottom rises to between 200 and 300 m of the surface. Bathymetric data for the northern, southern and eastern coasts are not sufficiently detailed to show if there are any other seamounts in proximity to the island. Off the northern side of the island is Toi Point with a slight submarine ridge running to the north of the

Point. On the southern side of Niue is Limufuafua Point with a submarine ridge extending several miles south. Within the Exclusive Economic Zone (EEZ) of Niue are the two submerged atolls of Beveridge Reef to the south-east and Antiope Reef to the north-west. These reefs are beyond the range of the small fishing craft employed on Niue but information on fishing at Beveridge Reef during an SPC survey is given in this report.

Deep slope fishing on Niue is practised by both full-time and part-time fishermen. They normally use aluminium dinghies and handreels based on the FAO/Western Samoa design and built on Niue. A New Zealand expatriate has designed a circular aluminium reel which has a clutch to prevent the line snapping when particularly large fish are caught. Flying fish, round scads and bigeye scads are all used for bait as well as being caught for food. Skipjack tuna, which is employed elsewhere in the region, is used occasionally, but is regarded as too valuable a food fish to waste as bottom fishing bait.

One full-time Niuean fisherman kept very detailed records of his catches of bottom fish, large pelagic fish and flying fish between October 1988 and July 1990 (Appendix V). Over this 22-month period, 92 fishing trips were made and 1,065 kg of bottom fish caught for an effort of 192 line-hours. Monthly average catch rates ranged from 2.1 to 8.5 kg/line-hr with a mean of 5.5 kg/line-hr. The average catch per trip was 11.6 kg. The composition of the catch was dominated by large snappers of the genera *Etelis* and *Pristopomoides,* which formed 61.5 per cent of the catch by numbers and 75.0 per cent by weight (Table 3). The other major feature of the catch was the groupers or rock cods (Serranidae), which comprised between 20 and 30 per cent of the catch by numbers and weight.

Table 3: Composition of bottom fish catches by a Niuean fisherman, 1988-1989

Species group	No.	%No.	Wt. (kg)	%wt.
Etelinae/Apsilinae	646	61.5	798.3	75.0
Lutjanidae	5	0.5	2.5	0.2
Lethrinidae	4	0.4	6.6	0.6
Serranidae	288	27.4	198.7	18.7
Carangidae/Scombridae	38	3.6	42.5	4.0
Gempylidae	1	0.1	5.0	0.5
Others	68	6.5	11.0	1.0
Total	1,050	100.0	1,064.6	100.0

Average monthly catch rates for the bottom fish operation were computed from raw data (Appendix V) and then plotted over a 12-month calendar period (January to December) and smoothed with a running average of three (Fig. 6). There was no striking seasonality in the data but there is a suggestion that catches are higher in the latter half of the year. Other records of fishing on the deep slopes of Niue were not as detailed as those presented here and in general the majority of other fishermen concentrate on pelagic stocks. Indeed the records analysed here also contain details of pelagic fish landings made during the same trips and amounting to just over 1,100 kg (see further below). A few bottom fish catches (amounting to nearly 30 hours of fishing) were, however, reported in detail by a canoe fisherman. The mean CPUE experienced by this fisherman was 4.2 kg/line-hr and his catch comprised eteline snappers (65.6 per cent), groupers (28.4 per cent) and trevallies (6.0 per cent).

The South Pacific Commission's Deep Sea Fisheries Development Project visited Niue on three occasions, fishing on the deep slope around Niue and, on one trip, at Beveridge Reef. Wooden handreels based on an FAO design from Western Samoa were used. Average catches off Niue Island ranged from 2.8 to 8.5 kg/line-hr, with an average of 5.8 kg/line-hr. Over the period of eight days spent fishing on Beveridge Reef in 1979 the average CPUE was 6.1 kg/line-hr.

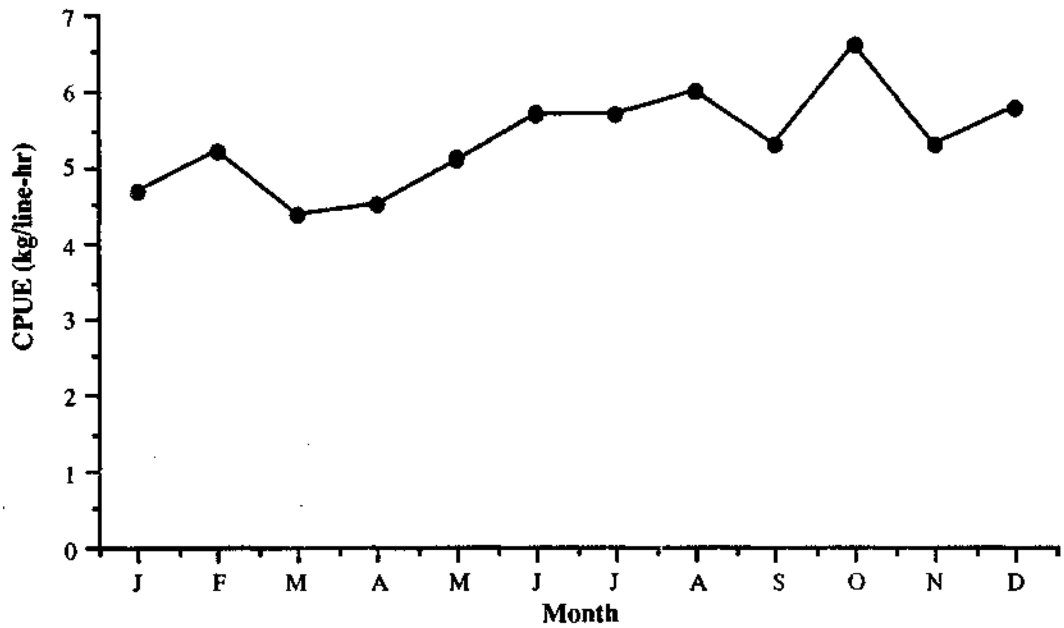

Figure 6. Mean monthly catch rates of bottom fish caught by **droplining, 1988—1990**

Deep slope catches at Niue Island during the first survey in 1978 consisted mainly of snappers (Lutjanidae) emperors (Lethrinidae) and groupers (Serranidae). The snapper catch comprised both the deep slope species (Etelinae and Apsilinae = 'etelines') and the shallow water species (Lutjaninae). The only information on the species of snapper in the report of the first visit (Fusimalohi, 1978) consists of details on catches of *Lutjanus bohar*. During the two subsequent visits, between 55 and 60 per cent of the catch by weight comprised eteline snappers, with other major contributions from the oilfish and snake mackerels (Gempylidae), shallow water snappers (Lutjanidae), and groupers. Catches of deep slope fishes on Beveridge Reef consisted mainly of snappers, with *L. bohar* forming nearly 60 per cent of the total catch.

No estimates are available for the unexploited biomass of deep slope species around Niue or Beveridge Reef. Dalzell and Preston (1992) have suggested that for small islands and seamounts the following equation, based on data in Polovina et al. (1990), gives a reasonable empirical estimate of the unexploited or virgin biomass (B_o):

$$LnB_o = 1.27 - 0.03552H$$

where H is the size of the habitat area expressed as nautical miles (nmi) of the 200 m isobath. For Niue island the virgin biomass was estimated at 36 t or 1.03 t/nmi, whilst at Beveridge Reef the empirical virgin biomass was 33.8 t or 1.87 t/nmi. Polovina et al. have suggested that the annual maximum sustainable yield (MSY) from deep slope fishing lies in the range of one tenth to one third of the virgin biomass. Based on this, MSY from deep slope stocks around Niue would be expected to lie between 3.6 and 10.8 t/yr, and for Beveridge Reef between 3.4 and 10.0 t/yr.

Pelagic fishing

On Niue, catches of large pelagic fishes were traditionally made from canoes, using handlines and live and dead bait. Some areas of the coast, particularly around the tips of headlands, are known to be sites where tuna and wahoo aggregate. The introduction of small aluminium dinghies and outboard motors to Niue during the early 1970s led to an increase in troll fishing for large pelagic fishes. Canoe fishermen still fish for large pelagic fishes in the traditional manner, by handline fishing in open water and around payaos, using round scads, bigeye scads and flying fish for bait. Troll fishermen use a variety of commercial lures and rigged bait. Attrition rates of lures are unknown, but are severe during the wahoo season.

As Niueans concentrate mainly on catching large pelagic fish, there was more information on catch rates and catch composition of these species. Catch data records were available for the operations of the Fisheries Division 8.5 m catamaran in 1986 (Table 4). Fishing trips lasted on average for ten hours, commencing around dawn and finishing in the late afternoon. The catch per trip ranged from 25.5 kg to 117.3 kg, with an average of 75 kg/trip. Five trolling lines were used on each fishing trip and the CPUE ranged between 0.66 and 2.2 kg/line-hr, with an average of 1.64 kg/line-hr.

Table 4: Catch and fishing effort for troll fishing by the Niue Fisheries Division catamaran, 1986

Month	No. of trips	Trip hours	Catch (kg)	Catch of individual species (kg)					
				Wahoo	Yellowfin tuna	Skipjack tuna	Dolphin	Billfish	Others
J	13	133.5	1,119.0	433.0	462.0	209.0	15.0	0.0	0.0
F	9	83.0	689.0	512.0	95.0	28.0	0.0	28.0	26.0
M	14	108.5	357.0	160.5	53.5	3.0	0.0	0.0	140.0
A	2	21.0	102.0	32.0	50.0	0.0	0.0	0.0	20.0
M	13	131.5	1,041.0	395.0	327.0	36.0	47.0	230.0	6.0
J	19	204.0	2,228.0	1,592.5	515.0	13.0	13.5	0.0	94.0
J	15	132.0	946.5	516.5	280.0	119.0	18.0	0.0	13.0
A	21	182.0	1,267.0	1,012.5	55.0	68.0	20.5	0.0	111.0
S	30	276.0	2,673.7	2,104.5	122.0	11.0	159.0	124.0	153.2
O	19	167.5	1,368.5	758.0	62.0	278.0	7.0	0.0	263.5
N	1	10,0	220.0	55.0	120.0	45.0	0.0	0.0	0.0
D	13	101.0	666.0	275.0	45.0	246.0	0.0	0.0	100.0
Total	169	1,550.0	12,677.7	7,846.5	2,186.5	1,056.0	280.0	382.0	926.7

Catch data were also available from the log books of four private fishermen, who between them operated three dinghies and two canoes. Average catch rates for trolling from two of the dinghies were 2.8 and 3.8 kg/line-hr. For the first of these dinghies, troll records extend over 22 months and refer to catches made during transit time between shore and bottom fishing grounds. Catch rates in this instance ranged from 0 to 5.9 kg/line-hr. Where exact CPUE data were not available, catch per trip was computed. For the three dinghies in this survey it ranged from 12.4 to 41.4 kg. The average catch rates for two canoes fishing with vertical longlines for large pelagic fish were 7.6 and 8.0 kg/line-hr.

The catch composition of large pelagic fishes taken by the three dinghies, two canoes and the Fisheries Division catamaran, based on the log-book and data records, is summarised in Table 5. The most important large pelagic species taken by dinghy fishermen are wahoo and yellowfin tuna, which together accounted for about 80 per cent of landings. The other major catch component of the dinghy fishermen is skipjack tuna. Catches of large pelagic fish by canoe fishermen are dominated by yellowfin tuna, which comprised between 60 and 80 per cent of the catch. The differences in the catches are a reflection of the different fishing methods used by dinghy and canoe fishermen.

Table 5: Percentage catch composition of large pelagic fishes taken by canoes, dinghies and catamaran

Species	Dinghy A	Dinghy B	Dinghy C	Canoe A	Canoe B	Catamaran
Skipjack	18.3		3.4			8.3
Yellowfin	15.9	8.7	43.4	89.8	56.5	17.2
Wahoo	63.0	69.8	33.5		10.6	61.9
Barracuda			5.4	10.2		
Trevallies						
Dolphin	1.9		1.9			2.2
Albacore					2.7	
Others		21.5	12.5		30.2	10.3
Weight of fish (kg)	1,143.5	1,111.0	786.5	128.0	850.0	12,677.0

Fishing for large and small pelagic species is seasonal. Table 6, which is based on the accounts given to the survey by fishermen on Niue, summarises the different fishing seasons. The seasonality of large pelagic fishing was evident from the catch records of the Fisheries Division catamaran in 1986 and the data provided by one Niuean fisherman trolling from a dinghy between 1988 and 1990 (Appendix V and Table 7).

Table 6: Catch seasons for large and small pelagic fishes in Niue

Species	J	F	M	A	M	J	J	A	S	O	N	D
A. solandri						+	X	X	X	+	+	+
K. pelamis	X	X	X	+	+	+	+	+	+		X	X
T. albacares	+	+	+	X	X	X	X	+	+	+	+	+
S. crumenopthalmus	+	X	+									
Decapterus spp.	+	+	+							+	X	X
Barracuda spp.						+	+	+	+	+	+	+
Flying fish	+	+	+	+	+	+	+	+	+	+	+	+

\+ = fishing season
X = peak catch period

These data were used to compute average monthly CPUE for the total troll catch for the main component species—wahoo, skipjack and yellowfin tuna (Fig. 7). In the case of the data for the catamaran, the single trip record for November was excluded and averages of the October and December trips were used.

Table 7: Mean monthly catch rates for demersal and troll fishing at Niue, based on data from a single fisherman collected over 22 months

Month	CPUE (kg/line-hr)				
	Demersal	Troll	Wahoo	Yellowfin	Skipjack
J	4.7	1.3	0.8	0.1	0.6
F	5.2	1.3	1.3	0.4	0.8
M	4.4	1.3	0.9	0.4	0.6
A	4.5	1.6	1.3	1.1	0.3
M	5.1	1.7	1.4	1.4	0.1
J	5.7	2.3	2.8	1.7	0.1
J	5.7	3.5	2.9	1.3	0.1
A	6.0	3.8	2.7	1.0	0.1
S	5.3	3.6	1.4	1.0	0.4
O	6.6	3.1	1.1	0.6	0.8
N	5.3	2.8	0.6	0.3	0.9
D	5.8	2.3	0.7	0.1	0.8

Figure 7 suggests that troll catches of large pelagic fishes are greatest during the middle and latter half of the year. This is particularly true of the data set covering 1988—1990, when overall catch rates increased markedly after May to a peak in August and then declined. Between 1988 and 1990 both yellowfin tuna and wahoo had seasonal peaks of abundance during the middle of the year with low catch rates between October and April.

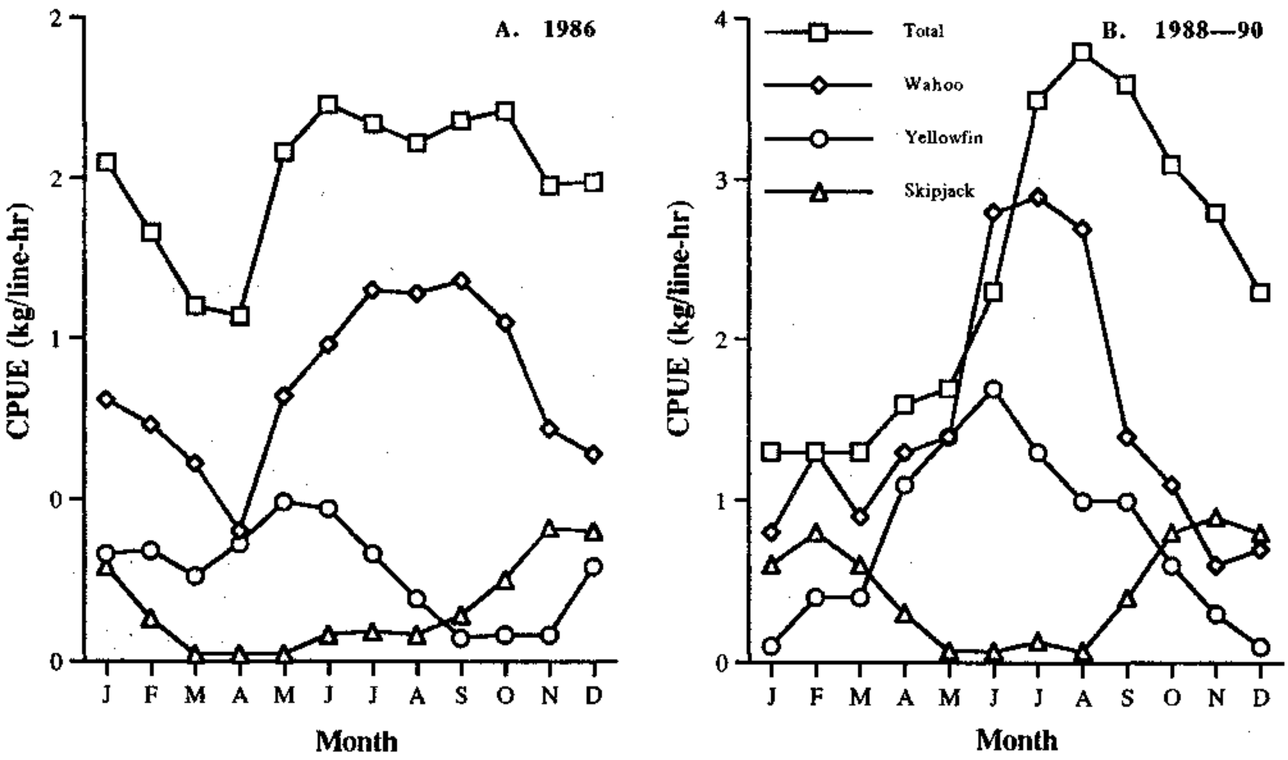

Figure 7. Mean monthly catch rates of large pelagic fishes caught by trolling at Niue

By contrast, the CPUE of skipjack tuna peaked between October and February, with low catch rates experienced during the middle of the year. During 1986 the peak in CPUE for the total catch and for the wahoo catches was broader and extended from May to November, whilst for yellowfin the mid-year peak was not as pronounced. The monthly changes in CPUE of skipjack did not differ markedly between the two data sets.

Niue's exclusive economic zone (EEZ) encompasses 390,000 km^2 of sea. Presently, Niue has no access agreements with foreign fishing fleets so that large pelagic fish are not (legally) being harvested from this area of the South Pacific by purse seine or longline fishing. Moreover, Niue is in the strong trade-wind belt and too far to the south for the safe operation of a conventional purse seiner. Longliners do operate near the Niue EEZ, as recorded in the *SPC Regional Tuna Bulletin,* and historical records (South Pacific Commission, 1981) show that both Japanese and Taiwanese longliners operated within the Niue EEZ during the 1960s and 1970s.

The main target of these operations in Niue waters was albacore *(Thunnus alalunga),* which accounted for between 82 and 87 per cent of the total catch in numbers by both fleets. Yellowfin and bigeye tunas made up most of the remainder of the catch, with the balance comprised of other scombrids and billfish (Table 8, Fig.8).

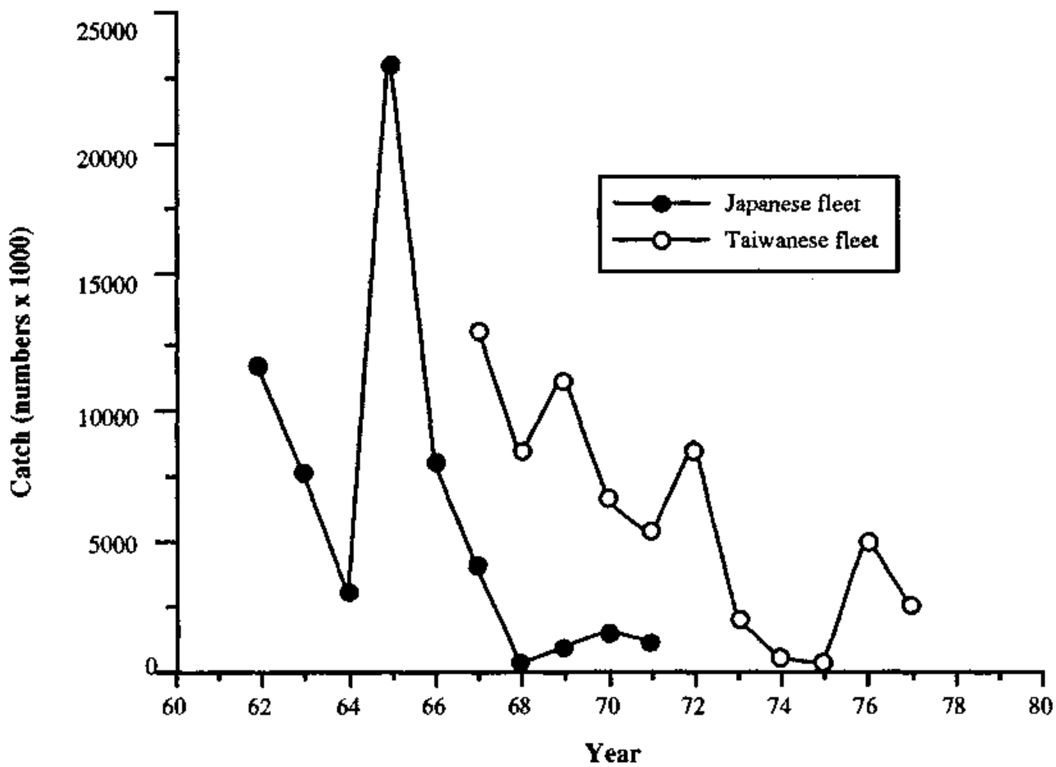

Figure 8. Annual catches of tunas and other large pelagic fishes in the Niue EEZ by Taiwanese and Japanese longliners, 1962—1979

The termination of the records for each fleet marks the approximate date when fishing activity in Niue's EEZ ceased. The Japanese longline fleet stopped fishing in the South Pacific to the east of Australia during the early 1970s, probably because of a decline in the market for high-quality albacore for the Japanese sashimi trade.

The Taiwanese fleet still operates in the vicinity of Niue as, with Korean longliners, it is based in American Samoa and supplies albacore to the canneries there. The establishment of the EEZs in the Pacific in the early 1980s obliged the distant water fishing nations (DWFNs) to negotiate access agreements to exploit tuna stocks.

Table 8: Summary of catch **(in numbers) and effort data from** Japanese **and** Taiwanese Iongiiners operating in **the** Niue EEZ, 1962-1977

A. Japanese Iongiiners

Year	62	63	64	65	66	67	68	69	70	71	**Total**	%
Bluefin tuna	3	0	0	9	0	0	0	0	0	0	12	0.02
Albacore tuna	9,184	6,040	2,233	18,773	6,027	2,093	219	778	1,107	842	48,106	82.44
Bigeye tuna	443	231	86	717	363	205	14	13	48	42	2,162	3.70
Yellowfin tuna	666	551	303	1,573	761	298	47	10	211	132	4,552	7.79
Broadbill swordfish	44	30	6	98	62	32	0	0	0	6	278	0.48
Striped marlin	445	154	67	435	144	48	4	12	38	30	1,377	2.36
Blue martin	63	102	29	504	140	58	9	0	29	30	964	1.65
Black marlin	9	5	0	15	13	4	0	0	0	0	46	0.08
Sailfish	93	42	8	127	119	99	0	0	8	3	499	0.86
Skipjack	2	22	7	166	75	68	0	0	19	5	364	0.62
Small tunas	0	0	0	0	0	0	0	0	0	0	0	0.00
Total	10,952	7,177	2,739	22,417	7,704	3,715	293	813	1,460	1,090	58,360	100.00
Effort (hooks x l000)	248	167	64	533	220	118	10	13	45	39		
CPUE (No./l000 hooks)	44	43	43	43	35	31	29	63	32	28		

B. Taiwanese longliners

Year	67	68	69	70	71	72	73	74	75	76	77	**Total**	%
Bluefin tuna	0	5	94	0	0	0	0	0	0	0	0	99	0.16
Albacore tuna	11,278	6,697	10,386	5,092	4,226	6,894	1,534	356	258	4.156	1,817	52,649	86.90
Bigeye tuna	398	557	118	116	159	234	28	14	9	187	76	1,896	3.13
Yellowfin tuna	683	390	179	507	440	1,056	151	65	15	340	211	4,037	6.66
Broadbill swordfish	2	4	25	2	1	11	6	0	0	9	0	60	0.10
Striped marlin	76	13	65	44	28	69	5	0	1	52	14	367	0.61
Blue marlin	207	142	9	64	61	208	70	5	20	138	65	989	1.63
Black marlin	15	2	1	1	3	2	3	2	0	0	1	30	0.05
Sailfish	0	1	10	2	7	2	0	0	0	0	0	22	0.04
Skipjack	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Small tunas	0	14	0	419	0	0	1	0	0	0	0	434	0.72
Total	12,659	7,825	10,887	6,247	4,925	8,341	1,798	442	303	4,882	2,184	60,583	100.00
Effort (hooks x 1000)	304	136	152	107	116	248	72	27	24	234	98		
CPUE (No./lOOO hooks)	42	58	72	58	42	34	25	16	13	21	22		

The Taiwanese fleet has such access agreements with the Governments of the Cook Islands and French Polynesia, authorising it to fish in 6.9 million km^2 of ocean. Further, there is a large body of international water immediately to the south of French Polynesia where longline vessels can fish freely, without the need to negotiate access agreements. The relatively small EEZ of Niue has not therefore attracted much attention from the resident DWFN fleets and thus remains unexploited at present.

Flying-fish fishing

Flying-fish fishing in Niue is carried out mainly from dinghies, normally with a two-man crew. One man catches the fish while the other operates the outboard motor and steers the boat. Surface illumination is used at night to attract the flying fish. Most fishermen use a kerosene pressure lantern mounted on a pole at the front of the boat. Recently some have switched to small but powerful quartz halogen bulbs powered from a car battery but mounted in the same way as the kerosene lanterns. Fish are caught with a large oval scoop net with a maximum diameter of about one metre. Catching the flying fish as they float quiescent on the surface involves a certain amount of skill since, if alarmed, they will readily take flight. An experienced fisherman can catch up to five flying fish, one after another, in a scoop net before it is emptied.

Flying fish can be caught all the year round, but according to Niuean fishermen, the peak season for flying-fish extends from August to March. Fishing data in Appendix V suggest that are two seasonal peaks of abundance during the year, between March and May and October and December (Fig. 9). This may in fact be one single seasonal peak. The data in Appendix V indicate that the CPUE for flying-fish fishing at Niue ranges from 5 to 15 kg/hr, an average of 12.0 kg, or about 40 fish per hour.

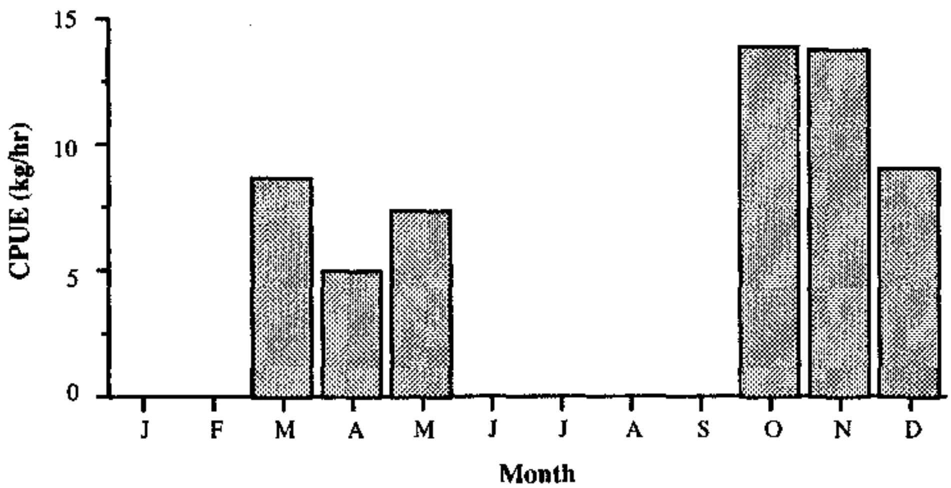

Figure 9. Mean monthly catch rates of flying fish caught by scoop netting, 1988—1990

Small pelagic fishing

Two other small pelagic fish, round scads *(Decapterus* spp.) and bigeye scads (*Selar crumenophthalmus)*, are captured regularly in Niue, for both food and bait. Fishing for round scads is seasonal, with catches being made between October and April, the period of the highest water temperatures. Round scads are captured both along the shore and out in the open sea by rod and lines with coconut bait. Shore catches are made with a conventional fishing rod, but round scads in open water are captured on a bifurcated light rod from which two lines are hung. Canoe fishermen chum for round scads with coconut flesh which they first chew into a pulp. The pulped flesh is then put on the paddle blade and stirred into the water, thus concentrating it in an eddy. As the round scads feed on this chum, the baited hooks are lowered into the bait cloud to catch the fish.

Bigeye scads *(Selar* spp.) are normally captured at night. The fish are aggregated under a lamp and then caught on handlines with small feather lures. Recently the Department of Agriculture has deployed several fish aggregation devices (FADs) around Niue in an effort to assist local fishermen. The fishermen have reported that the FADs appear to have resident populations of both bigeye scads and round scads throughout the year. None of the fishermen interviewed in this study kept records of their scad catches, since their main fishing operations do not involve scads.

Gillett (1987) demonstrated that a hoop net developed for round scad fishing in Hawaii functioned equally well in the waters around Niue. Over a four-week period (March to April 1987) 75 hauls of the hoop net captured 2,579 scads weighing a total of 526 kg. The average catch by the hoop net was 7 kg or about 34 fish per haul. Gillett suggested that this figure could be increased given that the initial operations were of an exploratory and teaching nature. The hoop net is highly selective and round scads were the only fish taken in the hauls. However, barracuda will follow the round scads to the net and can be taken on handlines before the net is hauled. Despite these encouraging results with the hoop net, the use of nets to catch round scads in Niue is forbidden under the Niue Fish Protection Ordinance, which limits their capture to hooks and lines baited with coconut meat.

Little other information is available on the small pelagic resources of Niue. During the visit of the South Pacific Commission Skipjack Programme's tagging vessel in 1980, no bait fishing was attempted at Niue. The vessel did, however, visit Beveridge Reef and surveyed the lagoon for baitfish there. The results were disappointing. Only a few schools of garfish (Hemiramphidae) and damsel fish (Pomacentridae) were sighted.

Reef fishing and gleaning

The shallow-water reef fish stocks on Niue are captured mainly by hook and line and by spearing. A few individuals also employ gill nets to catch small surgeon fishes such as *Acanthurus triostegus* and A *lineatus.* A variety of reef fishes are taken, but the most sought-after species from the shallow waters are soldier fishes (Holocentridae). These are caught mainly by canoe fishermen, who troll very slowly along the reef edge with handlines and feather jigs. Both men and women fish on the reef plateau with light home-made fishing poles with a fixed length of line. These are used to cast on the reef plateau and reef edge and baited with coconut flesh and fish flesh to catch (depending on season) round scads, drummers (Kyphosidae) and mullets (Mugilidae). Juvenile goatfish *(Mulloides flavolineatus)* school in shallow reef areas between November and March. These fishes, known locally as 'kaloama', are also caught on rod and line with coconut-flesh bait and are considered a delicacy.

None of the fishermen interviewed in this survey kept log books relating to reef fish catches. Thus there is no information on catch rates or catch composition. About 30 of the respondents in the resource utilisation survey gave details of catches from the reef with pole-and-line gear. These ranged from 0 to 50 kg, with a mean of 10 kg. Few of the respondents described the dominant species in the catch, but those who did included hawkfishes (Cirrhitidae), jacks (Carangidae), drummers (Kyphosidae) and mullets (Mugilidae). Three respondents gave details of spear fishing that included catch weights, which ranged from 5 to 50 kg, with an average of 24 kg. Spear-fishing catches were cited as 'reef fish' but one respondent mentioned that *Acanthurus achilles* was dominant in the catch.

Reef gleaning for shallow-water invertebrates is carried out mainly by women and children on Niue. The main species collected from the reef plateau is the gastropod mollusc, *Turbo chrysostomus,* which is commonly eaten. Also collected are giant clams *(Tridacna maxima),* other invertebrates, such as beche-de-mer, and seaweed. A variety of polychaete worms living amongst the coral and the rocks of the reef is gleaned. Some are collected simply by smashing open their calcareous burrows, whilst others have to be extracted with a piece of wire. These worms are not a staple of the Niuean diet, but a condiment that is eaten occasionally. Seven respondents gave details of reef gleaning for shellfish, etc. but some of these recorded the harvests in baskets. Amounts of shellfish ranged from 2 to 20 kg, with an average of 10 kg.

7. GIANT CLAMS

Giant clam classification and biology

Fossil evidence indicates that giant clams have existed since the Eocene era (65 million years ago). Seven species of giant clam are present today in tropical waters. The species, listed from smallest to largest in size, are: *Tridacna crocea, Tridacna maxima, Hippopus porcellanus, Hippopus hippopus, Tridacna squamosa, Tridacna derasa and Tridacna gigas.*

All species of giant clam share an unique symbiotic relationship with the microscopic dinoflagellate, *Symbiodinium microadriaticum,* also known as zooxanthellae. Zooxanthellae live freely inside the haemal sinuses (blood passages) which are located under the surface of the mantle tissue of the clam (Braley, 1989). The photosynthetic products from zooxanthellae are used directly by the clam and many of the nutritional requirements of clams are met by this relationship (Braley, 1989). Hence, availability of light is the most important environmental factor for determining clam growth and survival. Clams occur from the intertidal zone down to approximately 20 m, this lower depth being dependent on the clarity of the water. *T. squamosa* and *T. derasa* may be located at greater depths in very clear water. The recent monograph by Copland and Lucas (1988), which reviews clam biology, status of natural stocks in various Pacific countries and aquaculture technology should be referred to for further information.

Stephenson (1934) and Wada (1954) were the first to investigate reproduction in giant clams. Since then a considerable amount of information has been gathered on reproduction and larval biology of giant clams (see for example Gwyther and Munro, 1981; Heslinga et al., 1984; Braley, 1986; Crawford et al., 1986). All giant clam species are protandrous simultaneous hermaphrodites, generally releasing sperm before eggs (Nash et al., 1988). Breeding may be continuous in low latitudes, while distinctive seasonal breeding periods occur in higher latitudes, resulting in summer spawnings. Gamete release occurs through the excurrent siphon and in both natural and artificial conditions may stimulate other clams in close proximity to release gametes (Braley, 1986; Lindsay, unpublished data).

Eggs produced by the smaller species of clam may number 5—30 million, while *T. gigas*, the largest species, may spawn more than 500 million eggs per animal. The average size of giant clam eggs is 100 μm (0.1mm) in diameter. Embryonic development results in a motile trochophore (12—20 hrs) which has no shell and does not feed. This then develops (40—48 hrs) into the next larval stage, the veliger. The veliger possesses a bivalved shell and a swimming organ, termed the velum, which also functions in feeding. The veliger is approximately 160-200 µm in shell length and feeds on single-celled algae (phytoplankton). The swimming period lasts about one week, after which the larvae settle to the bottom.

The late larva possesses a foot which it uses to seek a suitable site, where it settles and metamorphoses into a juvenile clam. Gills and a mantle are developed, and it is at this stage that ingested symbiotic algae (zooxanthellae) are incorporated into the mantle tissue. Growth rates in the first six months after settlement are slow for all clam species. *T. gigas* grows relatively rapidly after this, reaching a shell length of 10 cm at 18 months and 22 cm in 3 years. It has been estimated that *T. gigas* may reach a shell length of 70 cm in 15 years (Gwyther and Munro, 1981). The smaller species reach shell lengths of 25 cm in 5—10 years.

Utilisation of giant clams

Giant clams have always been an important food source for Pacific Islanders and are prepared in various ways. In Asian markets, giant clam meat is also highly valued. Fresh *T. squamosa* meat was sold in Japan (January 1990) for US$ 13.80/kg. Dried clam adductor meat is highly prized and may be worth USS 100/kg. Pearson (1977) and Dawson (1980) expressed concern over depletion of stocks of the two largest species of giant clam *(T. derasa* and *T. gigas)* by Taiwanese fisherman. Depletion of clam stocks in the Pacific has been attributed to overfishing as human populations increase and advanced technology becomes available. The extinction of *Hippopus hippopus* in Tonga in recent times is an example (McKoy, 1980). Over the past decade there have been notable advances in the breeding, culturing and propagation of giant clams. All species of giant clam are presently being cultured at various centres in the Pacific Island region.

Survey results

The reef surrounding Niue is devoid of the complex coral patches and coral pinnacles that are associated with a true hermatypic reef. A total of 42 tows was conducted, from Tepa Point in the south-west to Vaigata in the east. The location of each tow and of sites where clams were measured is shown in Figure 10. A total of 9.2 hectares was covered by the tows (from the reef crest down to 18 metres water depth). This represents about 3 per cent of the estimated total subtidal reef area for the entire island (down to 25 m) of 272.5 hectares. The field survey tow records for the entire island are given in Appendix VI. Only two giant clam species were located during the survey: *Tridacna squamosa* and *T. maxima*. Both are referred to by Niueans as 'gege'.

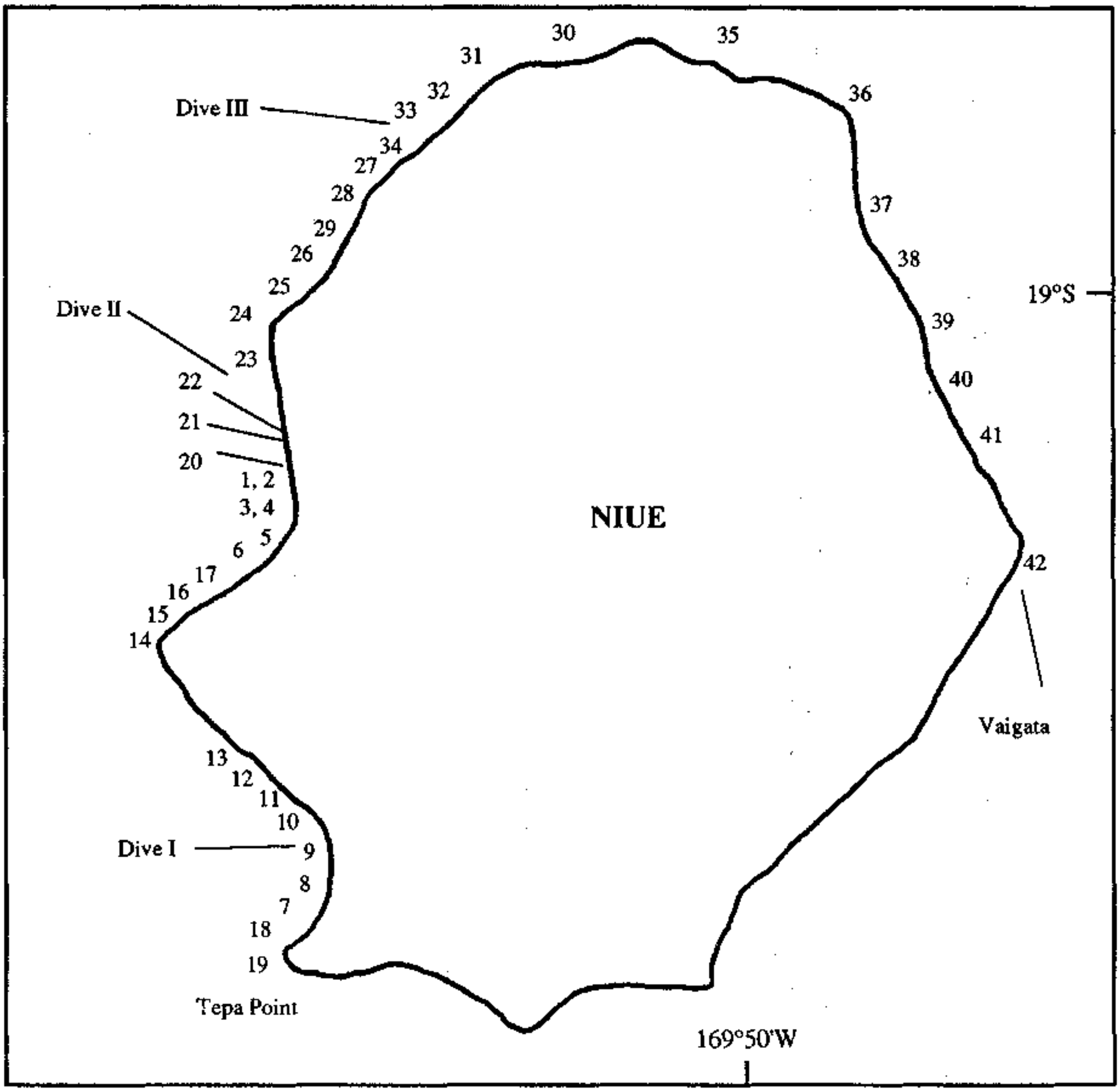

Figure 10. Location of tow transect sites for the estimation of clam abundance, coral cover and abundance of other sessile reef invertebtrates. (Arabic numerals refer to the site of each tow while the sites of dives to measure clams are marked in Roman numerals. For further information see Appendix VI.)

Table 9: Density of giant clams from tow transects, Niue, July 1990

A. West coast

Tow number	Area covered (ha)	No./ha		
		T. maxima	***T. squamosa***	**Total**
1	0.500	0.0	0.0	0.0
2	0.400	7.5	2.5	10.0
3	0.350	60.0	0.0	60.0
4	0.280	28.5	0.0	28.5
5	0.240	87.5	0.0	87.5
6	0.240	37.5	0.0	37.5
7	0.200	155.0	110.0	265.0
8	0.160	62.5	18.8	81.3
9	0.072	416.6	277.7	694.3
10	0.140	271.4	14.3	285.7
11	0.112	196.4	0.0	196.4
12	0.160	81.3	0.0	81.3
13	0.160	62.5	12.5	75.0
14	0.180	0.0	0.0	0.0
15	0.120	8.3	0.0	8.3
16	0.200	20.0	0.0	20.0
17	0.130	300.0	0.0	300.0
18	0.160	87.5	0.0	87.5
19	0.240	158.3	8.3	166.6
20	0.380	23.6	0.0	23.6
21	0.140	71.4	0.0	71.4
22	0.280	110.7	0.0	110.7
23	0.216	282.4	0.0	282.4
24	0.096	208.3	0.0	208.3
25	0.172	46.5	0.0	46.5
27	0.430	44.1	0.0	44.1
28	0.216	41.6	0.0	41.6
29	0.112	17.8	0.0	17.8
30	0.210	95.2	0.0	95.2
31	0.140	28.5	0.0	28.5
32	0.280	35.7	0.0	35.7
33	0.152	157.8	0.0	157.8
34	0.150	313.0	0.0	313.0
Total	7.190	3,535.20	444.1	3,979.3
Mean	0.210	104.0	13.1	117.1

B. East coast

Tow number	Area covered (ha)	No./ha 71 *maxima*	71 *squamosa*	Total
35	0.330	9.1	0.0	9.1
36	0.180	11.1	0.0	11.1
37	0.300	16.6	10.0	26.6
38	0.450	28.8	11.1	39.9
39	0.350	48.6	8.6	57.2
40	0.200	15.0	35.0	50.0
41	0.120	33.0	58.3	91.3
42	0.120	41.6	25.0	66.6
Total	2.050	203.8	148.0	351.8
Mean	0.260	25.5	18.5	44.0

Estimated stock densities per hectare for both giant clam species from all tows are given in Table 9. Mean stock densities were 89.0 clams/ha for 71 *maxima* and 14.0 clams/ha for 71 *squamosa.* These density estimates indicate that there are standing stocks of 24,252 71 *maxima* and 3,815 71 *squamosa* on the subtidal reefs of Niue. 71 *maxima* was found in 95 percent of the tows and its abundance, although low, varied considerably between tow sites. The highest density was 416/ha. 71 *squamosa* was less abundant than *T. maxima.* It was found in only 30 per cent of the tows and the highest recorded density was 278/ha.

The reef from Tepa Point in the south-west to Liha Point in the north-east (tows 1—32) had a very low percentage of coral cover. This was attributable to the destructive effects of Cyclone Ofa in January 1990. The total coral cover for this area of coast ranged from 5 to 50 per cent (Appendix VI) with a mean of 14.1 per cent. The total live coral cover for the same area ranged from <5 to 35 per cent, with a mean of 8.9 per cent.

The reef areas that could be surveyed south of Liha Point (tows 37—42), had a much higher percentage of coral cover. This reef region appears not to have been greatly affected by Cyclone Ofa. The mean coral cover for these tows was 73.3 per cent (range 60—80 per cent) and the total of live coral ranged from 40—70 per cent with a mean of 57.5 per cent.

Logistical problems (petrol shortages and weather) made it impossible to carry out tow surveys between Vaigata in the east and Tepa Point in the south-west. Thus standing stock estimates of both giant clams have been calculated for all of Niue without any observations from this section of the reef. Although the mean densities of *T. maxima* appear to be quite different between the east and west coasts, this is not significant ($t = 1.564$, $p<0.1$, $n = 40$).

A similar result was also obtained for *T. squamosa* when average densities were compared between the two coasts ($t = 0.619$, $p<0.1$, $n = 40$). Clearly, however, the statistical comparison suffers here from an imbalance in the sample size from the east coast, when the variance of the mean densities is naturally very high.

The gonad conditions of several *T. maxima* were examined visually after they had been killed. All clams revealed developing stages of gametogenesis. Eggs were present in all clams, but, the gonad itself was not fully developed. Stages of gametogenesis in *T. squamosa* were not examined because of the limited availability of this species.

During the beche-de-mer reef transects only two *T. maxima* and no *T. squamosa* were found on the reef plateau. These very low numbers are explainable by the daily gleaning for edible shellfish by women and men and the limited area and habitats for giant clams on this plateau. Natural stock densities of *T. maxima* and *T. squamosa* have been recorded from other Pacific regions. High densities of *T. maxima* have been reported from the Tuamotu Archipelago (French Polynesia), where standing stocks ranged from 12,800 to 60,000 clams/ha (Richard, 1978); and from the Great Barrier Reef, with 8,000 clams/ha from One Tree Island (McMichael, 1975). Low densities similar to those found in Niue have been reported from Abaiang Atoll (Kiribati): 100 clams/ha (Munro, 1988) and from three atolls of Tuvalu: 63—101 clams/ha (Braley, 1988). Extremely low stock densities of *T. squamosa* have been reported from both Tuvalu: 0.68-1.4 clams/ha (Braley, 1988) and Tokelau: <6 clams/ha (Braley, 1989).

The absence of a true hermatypic reef and its associated lagoon at Niue may account for the general low stock densities of both giant clam species. Furthermore, this natural low density may have been further reduced by local fishing pressure. Cyclone Ofa devastated the reef on the western side of Niue. Although no written information on clam stocks existed before this time, it is likely that some clams were killed. The cyclone may also have contributed to the low stock densities recorded on the eastern side, although the difference in coral cover between the two coasts suggests that its physical effects were much less severe on that side of the island.

Although the stock density of *T. maxima* is low, this does not imply that the stocks need immediate conservation at current levels of fishing. The consumption rate of *T. maxima* in Niue is not high enough at present to seriously threaten resident stocks (see below). However, the consumption rate of *T. squamosa* is high enough to suggest that there is a need for some form of conservative measures that will allow the natural populations to re-establish. Only 20 people actively collect clams and most of these are not Niueans. However, the small size of the clam stocks and their visibility on the limited reef area are such that greatly increased fishing pressure could seriously deplete the giant clam stocks on the western coast of Niue. Because the eastern side of the island is inaccessible for most of the year we feel that marine reserves are not warranted on the reefs of Niue. The natural inaccessibility of the eastern coast will prevent over-exploitation at current fishing levels.

Clam size frequencies

Fifty *T. maxima* were measured at each of three sites along the west coast of Niue. The weather and sea conditions made it impossible to dive on the east coast of the island. The results for the three sites are summarised in Figure 11, while the original data are contained in Appendix VII. The average size of clams at each location ranged between 11.9 and 13.1 cm. The mean size of *T. maxima* measured adjacent to Alofi was significantly different from that of the same species at Avatele ($t = 2.26$, $p < 0.05$, 105 df). Comparisons of the mean sizes of clams between the populations at Alofi and Namukulu and Namukulu and Avatele showed no significant differences.

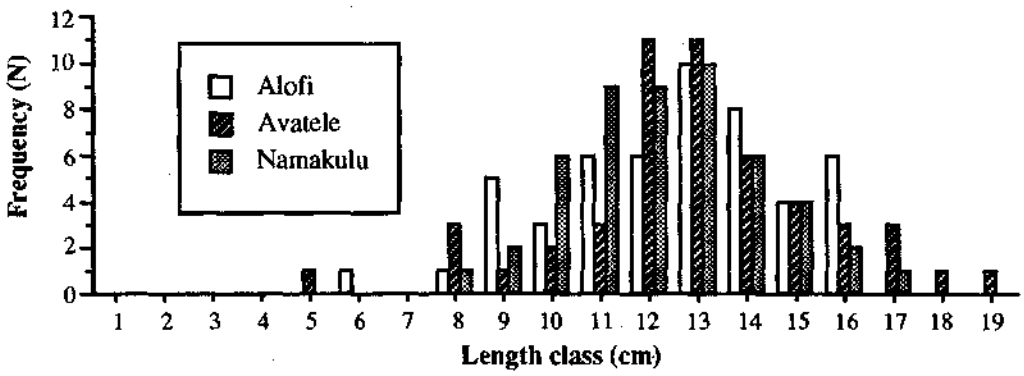

Figure 11. Size frequency distributions of *T. maxima* from three locations along the west coast of Niue

Potential for clam mariculture

The potential for clam culture in Niue appears to be limited. The lack of a lagoon, and hence of suitable safe protected regions for growout phases of the juvenile clams, and the limited number of sites suitable for a hatchery, limit the potential for such a venture. The limited number and training of staff in hatchery technology also preclude the establishment of a clam hatchery. The clear waters around the island would allow subtidal culture of juvenile clams. However, all subtidal areas are subjected to the full force of storms such as Cyclone Ofa. Strong wave action in the intertidal zone and the very limited area available exclude any clam culturing in this zone.

Tonga presently has a giant clam hatchery facility which is capable of small-scale production and the Cook Islands will have one soon. In time these hatcheries will probably produce animals that may be sold or given to other interested countries. We would suggest that the Niue Department of Agriculture and Fisheries limit its efforts to obtaining some cultured juvenile clams and conducting small-scale experiments on the suitability of clam culture in subtidal protected areas.

Socio-cultural attitudes to clam exploitation

Summaries of the replies to the clam questionnaire are shown in Appendix III. Initially the data were simply summarised only by sex of the respondents. Clams are viewed by Niueans as luxury food rather than a staple. No respondent ate clams daily and only 8.8 per cent of men and 13.3 per cent of women ate clams weekly. Ten per cent of women in the survey never ate clams, possibly for religious reasons, and roughly 50 per cent of men and women only consumed them yearly. About 60 per cent of both men and women collected clams themselves, while most of the others purchased clams, either from the produce market or from fishermen. The size of clams eaten by the respondents ranged from 3 to 18 cm, and prices ranged from 0.5 to 12.0 dollars per clam. There is a linear relationship between clam size and price (see Figure 12) although there is some variation in price for a given size of clam. On average the price per clam increases by $ NZ 0.50/cm of clam size.

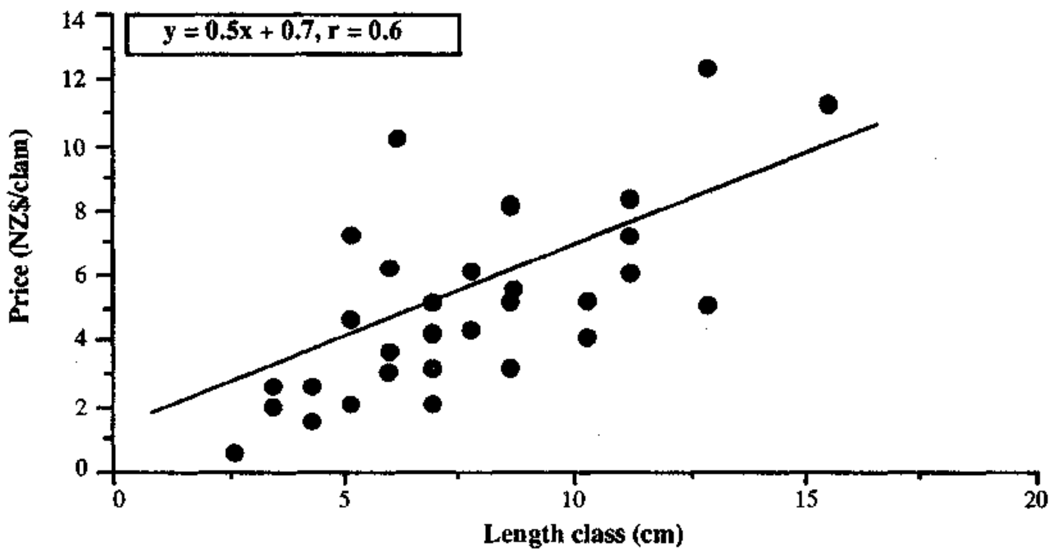

Figure 12. Price per giant clam by size, as reported from clam questionnaire survey at Niue, July 1990

Three quarters of both men and women surveyed suggested that clams are becoming scarce. Ten per cent of women did not whether they were becoming scarce, while 24 per cent of men and 17 per cent of women thought that there were no changes in clam stock densities. The most commonly cited reason for declines in clam stocks was Cyclone Ofa (January 1990). About 70 per cent of respondents stated that there were no customary taboos on the collection and consumption of giant clams. The 20 per cent of respondents who did know of such customary taboos cited the following examples:

— The death of a person in a village usually results in a ban on all fishing on the adjacent reef as a mark of respect for the deceased and his/her family;

— Clam collecting and all other fishing activity are forbidden on some reefs during the 'small fish season' (January to March, when 'kaloama' (*Mulloides flavolineatus)* is plentiful in the shallow waters over the reef plateau and can be captured on rod and line);

— At one village (Tamakautoga) a one-year ban has been instituted on reef fishing and harvesting to let stocks recover after cyclone damage;

— Five male respondents also stated that clams are never eaten in the water during the period of collection.

About 65 per cent of men and women see a need to limit harvesting of giant clams to preserve stocks. Nearly 60 per cent of men thought that reduction in clam stocks affected subsequent recruitment, while the remainder thought that there was no relationship. Interestingly, although 48 per cent of women agreed that stock depletion affects recruitment, 41 per cent did not know. Between 75 and 80 per cent of men and women thought that laws restricting the harvesting of giant clams would be gradually accepted. The desire of both men and women to see the Niue Government culture clams was almost unanimous. Similarly, nearly all men and women thought that it would be safe to leave experimental populations of clams on the reef flat. Finally, Niueans eat clams prepared in the following ways: raw, raw with lime juice and/or coconut and cooked, simply by boiling or frying.

8. TROCHUS

The top shell or trochus (*Trochus niloticus)* is a reef-associated marine snail which occurs naturally over a wide area of the Indo-Pacific. It has also been introduced to many islands outside its natural range, e.g. Micronesia, French Polynesia, Cook Islands, Tokelau and Tuvalu (Gillett, 1988). This species does not occur naturally on Niue but may be introduced to provide an additional source of revenue.

Trochus are found on the reef flat, especially where there is a good growth of the calcareous algae on which they feed, or back-reef lagoon areas and also in surge channels along the reef front. They are most abundant on the windward reef and are rarely seen below 8 m. Although most active at night, trochus are quite conspicuous and relatively easily collected at any time. They attain a maximum size of approximately 15 cm at about 15 years of age. Maturity is normally attained at a size of 6 to 7 cm (age 3 yrs), after which growth slows appreciably. In the southern hemisphere spawning occurs in the summer months (November to April), or at just after the full moon (Lindsay, unpublished data).

Trochus is collected for the nacreous (mother-of-pearl) inner layer which is made into quality buttons and for ornamental purposes. Collection is by hand, usually when walking the reef flat at low tide, or by free diving. The shell is usually boiled to extract the meat, which generally comprises 15 per cent of the live weight. The meat can be eaten, but is often discarded. It does, however, command good prices on the international markets in fresh, frozen or canned form. The texture of the large foot muscle is similar to abalone. In the manufacture of buttons, blanks are cut from the shell, following the whorls around, and later buffed and polished. The residual shell still has value and can be further processed to produce mother-of-pearl chips.

As part of this survey the reefs of Niue were assessed for suitability for trochus introduction. Within the Niue reef plateau are a large number of deep channels and crenellations with growths of calcareous algae which would probably support populations of trochus if they were introduced from elsewhere. The successful introduction of trochus to the reefs of Aitutaki in the Cook Islands was accomplished with only 40 specimens. However, this limited seed-stock has resulted in a limited gene pool in the descendants. Although in this instance this does not appear to be a problem, an introduction of this species to Niue, if it is ever approved, should be made with a larger number of individuals and possibly with seed-stock from different islands. Any introduction of trochus will need to be properly managed and monitored, in conjunction with an agency such as the UNDP/FAO Regional Fisheries Support Programme or the South Pacific Commission.

Assuming that trochus could be successfully introduced to Niue, it is important to estimate what yield might be expected from the island's reef areas. Clearly such estimates can only be informed guesses, and in the case of Niue, such an introduction would be somewhat unusual given the lack of lagoon and true hermatypic reef. Sims (1984a & b) reports that trochus harvests in Aitutaki during 1981 and 1983—84 yielded approximately 5 t and 0.9 tonnes respectively per kilometre of reef. According to Sims (1984a) a fishing mortality of about 31 per cent of the standing stock could probably be sustained. McGowan (1958), considering historical data from Micronesia, stated that 1.2 to 1.4 t/km/yr is the probable maximum average tonnage which can be expected from a large reef area. Contemporary trochus harvests from the reefs surrounding Pohnpei amount to about 80 t/yr and appear to be sustainable in the long term.

Given an average sustainable yield of about 1.0 t/km/yr, the expected sustainable yield from Niue's reef would be about 65 t/yr. This assumes that the yields of trochus from Niue's narrow rocky fringing reef would be similar to those of the hermatypic lagoon reefs from elsewhere in the South Pacific. Further, the reefs of the east coast of Niue are inaccessible for much of the year, which might mean that the true expected yield would not be realised. Another constraint might be the small number of persons living on Niue and the limited number capable of diving for trochus, which would affect the harvest potential.

9. BECHE-DE-MER

Sea cucumbers or beche-de-mer have been consumed as a traditional food in China and other parts of South-East Asia for many centuries. Intensive exploitation of beche-de-mer stocks in the South Pacific islands commenced with the advent of European colonisation during the 18th and 19th centuries (Ward, 1972). Harvests were so large in some locations, such as Fiji, that reefs were severely depleted by the 1830s, leading to a period of decline in the industry. In the past decade beche-de-mer fisheries throughout the South Pacific have revived and expanded because of increasing demand from Asian markets.

In 1988 annual production of beche-de-mer in Fiji exceeded the total coastal fisheries production of all fin fish and other marine organisms. The high levels of exploitation, and in some areas the noticeable decline in the mean size of the animals harvested, led the Fiji Government to impose a moratorium on the export of beche-de-mer.

Only five species of beche-de-mer *(Holothuria atra, Microthele nobilis, Thelenota ananas, Actinopyga mauritiana* and *Bohadschia* sp.) were observed on the reefs of Niue. The densities of the different species on the subtidal reef (Appendix VI) and intertidal reef flat (Appendix VIII), based on transect and tow counts, are given in Table 10. Apart from two instances, all the beche-de-mer counted in the reef plateau transects were the generally non-commercial *Holothuria atra.* Densities of *H. atra* on the reef plateau ranged from 0.0/ha to 1400/ha with a mean of 347/ha.

The species were not evenly distributed across the reef flat. The mean number in each 10 m increment from all the transects is shown in Figure 13. Densities of beche-de-mer were greatest at 0—20, 60—110 and 140—150 m from the shore. Conand (1989) states that *H. atra* was the commonest of the beche-de-mer species in the lagoon of New Caledonia, with a mean density of 545 specimens and a maximum of 7,270 per hectare.

Table 10: Density of beche-de-mer, Niue, July 1990

A. West coast

Tow number	**Area covered (ha)**	**No./ha**			
		H. atra	***T. ananas***	**Other spp.**	**Total**
1	0.500	2.0	0.0	0.0	2.0
2	0.400	**7.5**	5.0	0.0	12.5
3	0.350	**2.8**	5.7	0.0	8.3
4	0.280	0.0	25.0	0.0	25.0
5	0.240	4.1	4.1	0.0	8.2
6	0.240	0.0	70.8	0.0	70.8
7	0.200	5.0	10.0	0.0	15.0
8	0.160	6.3	43.7	**6.3**	56.3
9	0.072	13.8	13.8	0.0	27.6
10	.0.140	0.0	0.0	7.1	7.1
11	0.112	26.7	26.7	17.8	71.6
12	0.160	6.3	0.0	6.3	12.2
13	0.160	0.0	0.0	0.0	0.0
14	0.180	5.5	0.0	0.0	5.5
15	0.120	8.3	0.0	0.0	8.3
16	0.200	0.0	0.0	0.0	0.0
17	0.130	0.0	84.6	0.0	84.6
18	0.160	25.0	62.5	0.0	87.5
19	0.240	12.5	58.3	0.0	70.8
20	0.380	**2.6**	18.4	0.0	21.0
21	0.140	7.1	28.5	14.2	49.8
23	0.216	37.0	18.5	13.8	69.3
24	0.096	20.8	10.4	0.0	31.2
25	0.172	5.8	11.6	0.0	17.4
26	0.168	29.7	23.8	0.0	53.5
27	0.430	0.0	,0.0	0.0	0.0
28	0.216	41.6	37.0	0.0	78.6
29	0.112	71.4	8.9	0.0	80.3
30	0.210	19.0	0.0	0.0	19.0
32	0.280	21.4	0.0	0.0	21.4
33	0.152	72.3	6.5	13.1	91.9
34	0.150	33.3	0.0	0.0	33.3
Total	7.190	548.5	595.2	82.1	1,225.8
Mean	0.210	16.1	17.5	2.4	35.9

B. East coast

Tow number	Area covered (ha)	No./ha			
		H. atra	*T. ananas*	**Other spp.**	**Total**
35	0.330	3.0	3.0	0.0	6.0
36	0.180	0.0	0.0	0.0	0.0
37	0.300	13.3	13.3	0.0	26.6
38	0.450	31.1	22.2	8.8	62.1
39	0.350	48.5	31.4	17.1	97.0
40	0.200	15.0	10.0	5.0	30.0
41	0.120	25.0	25.0	0.0	50.0
42	0.120	8.3	8.3	0.0	16.6
Total	2.050	144.2	113.2	30.9	288.3
Mean	0.260	18.0	14.2	**3.9**	36.0

C. **Intertidal and subtidal reefs**

Species	Intertidal reef (No./ha)	Subtidal reef (No./ha)
Holothuria atra	347.0	16.8
Thelenota ananas	3.9	17.5
Other beche-de-mer[1]	0.0	2.4

1. Other species observed were *Actinopyga mauritiana, Holothuria nobilis, Stichopus horrens* and *Bohadschia* sp.

The total standing stock of beche-de-mer on the intertidal reef was estimated to be about 95,620 animals (94,557 *H. atra,* 1,063 *T. ananas)* using a figure of 272.5 ha for the area of reef plateau. All five beche-de-mer species were observed on the subtidal reef of the west coast, but the dominant species were *H. atra* and the prickly redfish, *T. ananas.* The densities of *H. atra* and *T. ananas* on the submerged reef were 16.8 animals/ha and 17.5 animals/ha respectively, while the density of other beche-de-mer was 2.4 animals/ha. This is equivalent to a total standing stock of about 4,600 beche-de-mer, or 2,100, 2,188 and 300 specimens of *H. atra, T. ananas* and other species respectively.

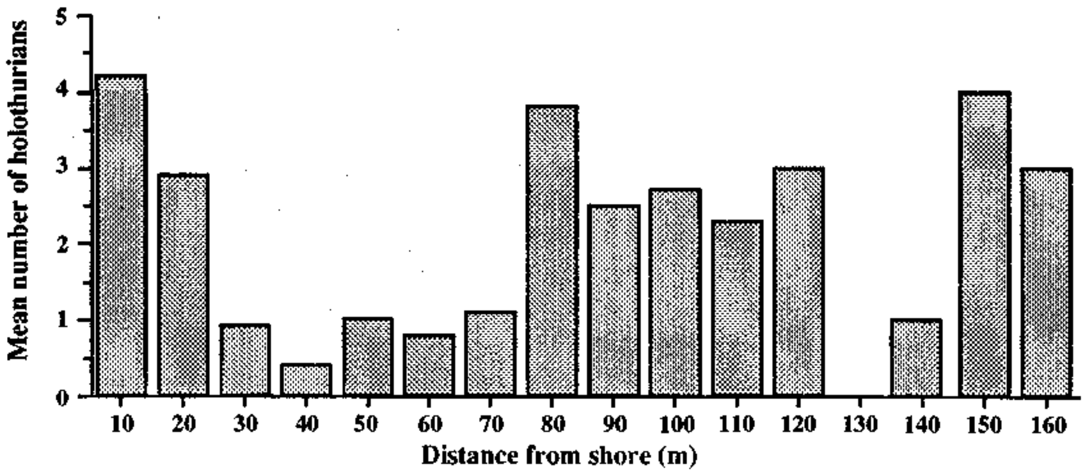

Figure 13. Mean number of beche-de-mer in each 10 m (60 m²) transect across the intertidal reef at Niue, July 1990

Conand (1989) has summarised data on commercial exploitation of beche-de-mer in the South Pacific. The most desirable species for processing are *Holothuria scabra, H. nobilis, Actinopyga miliaris, A. echinites* and *Thelenota ananas.* Species that are considered to be of little commercial value include *Holothuria atra, Actinopyga mauritiana* and *Bohadschia* spp. Beche-de-mer stocks at Niue consist mainly of low-value species. The prickly red fish, *T. ananas*, and the teat fish, *H. nobilis,* are present, but stock sizes are too low to warrant commercial exploitation.

Quantitative data on commercially valuable beche-de-mer are generally lacking for the South Pacific, but Conand (1989) quotes stock densities of 430 animals/ha and 50 animals/ha for commercial beche-de-mer stocks in Australia and New Caledonia. Beche-de-mer processing is thus not likely to be economically viable in Niue unless there is a shift of the market to processing *H. atra.* Beche-de-mer fisheries tend to be be short-term enterprises in the South Pacific because specimens are easily collected and this leads to over-harvesting.

10. OCCURRENCE OF CROWN-OF-THORNS STARFISH

The crown-of-thorns starfish, *Acanthaster planci,* is found on the reefs of Niue. Because of the large population explosions of this coral predator on the Great Barrier Reef during the late 1970s and early 1980s, interest in the biology of these starfish has increased, particularly in relation to the potential damage they can do to a reef. During the tows over the subtidal reefs of Niue only nine adult crown of thorns were observed in the 9.2 ha covered (Appendix VI). This indicates a standing stock density of about 0.98 animals/ha, although the true densities are probably higher since small juveniles are likely to have been missed by the towed observers. Population densities of >100 starfish/ha are considered high and at similar levels to those encountered during outbreaks on the Great Barrier Reef that have led to major reef destruction (Birkeland & Lucas, in press)

11. LOBSTERS AND OTHER REEF CRUSTACEANS

Three species of tropical spiny lobsters, *Panulirus penicillatus, P. longipes (femoristriga ?)* and *P. versicolor,* were found on the reefs of Niue during this survey A total of 37 *P. penicillatus* was captured, with carapace lengths (CL) ranging from 6.4 to 11.5 cm (Appendix IX). The sample comprised 18 females and 19 males, giving a sex ratio of 1 : 1.05. The 13 specimens of P. *longipes* consisted entirely of males ranging in size from 6.9 to 9.9 cm CL, while the single *P. versicolor* was a female. Eight of the *P. penicillatus* females were berried with eggs, while four further specimens each had a spermatophore present. One fisherman on Niue, who concentrates almost exclusively on the capture of lobsters, stated that *P. penicillatus* is the commonest lobster seen on the reef of Niue, which agrees with our limited observations from diving. He also stated that lobsters can be found in a spawning condition throughout the year, without specifying which species are ripe in particular seasons of the year. Prices of lobsters range from NZ $ 10.00 for a small specimen (6—8 cm CL) to $ 30.00 for a large 15—16 cm CL specimen.

Also taken on night dives and by the Niuean fisherman are the large red reef crab, *Etisus splendidus*, the three-spot reef crab, *Carpilius maculatus,* and the small slipper lobster, *Parribacus caledonicus.* All three species are commercially valuable, especially the three-spot reef crab which is esteemed by Niueans. Four specimens of *E. splendidus* were captured during the period of the survey, along with five *C. maculatus* and eight *P. caledonicus* (Appendix IX). Although we do not have any accurate information on lobster and crab population densities, the present levels of exploitation are low enough to suggest that stocks could withstand modest increases in harvests, but only for the local market.

12. COCONUT CRABS AND OTHER LAND CRABS

A preliminary study of the coconut crab, *Birgus latro,* population of Niue was carried out by Schiller (1989) in response to concern by the Niue Government over the levels of exploitation of this resource.

Schiller found that coconut crabs are not abundant, because of over-harvesting and the destruction of their habitat when forest land is turned over to agriculture. Schiller suggested that the majority of the coconut crabs on Niue occur in coastal forest covering less than 10 per cent of the island.

As well as the demand for coconut crabs on Niue itself, there is also a demand generated by the large Niuean expatriate population in New Zealand, which now numbers about 10,000 people (Schiller, 1989). The establishment of direct flights from Niue made it easier to export coconut crabs to expatriate Niueans in New Zealand, for whom they remain a desirable traditional food. This is also true of locally caught fish (discussed further below). Schiller estimated that between 3,200 and 5,900 coconut crabs were exported from Niue between June 1987 and March 1988. Quarantine records of the Department of Agriculture list the export of 210 cartons and other containers (handbags, suitcases, chillybins) of coconut crabs from Niue in 1987. Using the conversion factors given below for these containers, this amounts to a net export of about 2 t/yr.

The common Indo-Pacific land crab, *Cardisoma carnifex,* is also captured on Niue, both for food and for fish bait. Niueans walk along the roadside at night and pick them up by hand. There is no information on the level of harvests of this small land crab on Niue, but it is not thought to be sufficient to warrant concern.

13. PER CAPITA FISH CONSUMPTION AND TOTAL ISLAND PRODUCTION

A nutrition survey conducted by the South Pacific Commission in 1987 (Badcock et al., 1993) determined the percentage of different age groups in the population eating animal protein of Niuean origin at breakfast, lunch and dinner on a given day. From the nutrition survey data it was determined that about 57 per cent of meals containing Niuean animal protein consisted of fish and other marine organisms. The original percentages of Niueans eating a meal containing Niuean animal protein could thus be adjusted to account separately for the percentage in each age class eating fish or other marine organisms at breakfast lunch and dinner (Table 11).

Table 11: Percentage of Niuean women, men and children eating a meal containing fish during the day

Time	Women	Men	Children (5-14 yrs)	Infants (<5 yrs)
Morning	9.0	10.0	4.9	9.4
Afternoon	28.9	28.2	14,1	26.6
Evening	29.3	31.5	26.9	27.8

Assuming an average size portion of about 200 g for adults (15+ yrs) 150 g for children and adolescents (5—14 yrs) and 100 g for infants (<5 yrs), daily consumption of fish on Niue was 197.0 kg of fish for adults, 37.4 kg for children and adolescents, and 18.4 kg for infants, or a total of 252.8 kg for the whole population (Table 12). On an annual basis this represents a total consumption by the Niuean population of about 92.3 t/yr or a per capita consumption of about 40.8 kg/yr. Niueans gut and gill their fish but tend to eat most of the remainder, including the head. The loss in weight caused by gutting and gilling usually amounts to about 20 per cent of the total body weight. If the per capita consumption figure is adjusted to account for this, the estimated annual fish production for Niue amounts to 115.4 t.

The above calculations do not take into account the exports of fish from Niue, when Air Nauru was operating direct flights to New Zealand between 1982 and 1988 and fresh, frozen and cooked fish and coconut crabs were taken by Niuean passengers to relatives and friends. Records of these exports are somewhat fragmentary and record only the type of container used to transport fish (cartons, handbags, suitcases, chillybins, plastic containers, sacks). The records of the Department of Agriculture and Fisheries Quarantine Service indicate that between 1987 and 1988, 643 cartons and 283 other containers of fish were exported from Niue to New Zealand. According to the quarantine officers, the cartons weighed between 5 and 10 kg, while the other containers contained between 15 and 20 kg of fish. Taking simple averages for carton and container weights, an estimated total weight of 9,775 kg or about 4.9 t/yr was exported from Niue during this period.

Table 12: Daily amounts (in kg) of fish from Niue eaten by all Niueans

Time	Women	Men	Children (5-14 yrs)	Infants (<5yrs)
Morning	12.6	19.8	4.1	2.2
Afternoon	40.6	41.6	11.4	7:7
Evening	41.0	46.4	21.9	8.0
Total	94.2	102.8	37.4	18.4

During 1989 and 1990 exports of fish were limited by the smaller aircraft serving Niue from American Samoa. Data from the Quarantine Service indicate that about 190 kg of fish left Niue during that period. The net exports of fish with departing passengers would then be less than one fifth of the volume leaving the island when Air Nauru was flying between Niue and Auckland. The commencement of direct flights to Auckland by Solomon Airlines/Air Niue means that a substantial volume of fish will again be exported to New Zealand. This also applies to exports of coconut crabs (see above).

14. REEF YIELDS

Responses to the survey questionnaire indicate that the population of Niue catches fish equally from the reef and from the waters outside the reef. The total production of fish from the waters around Niue is 115.4 t/yr or 57.7 t/yr from the reef areas. Given a total reef area of 620 ha, this harvest represents a yield of 93.1 kg/ha or 9.3 t/km^2/yr. Munro & Williams (1985), summarising yields from a variety of coral reef fisheries, found average yields ranging from 0.5 to 26.6 t/km^2/yr. The estimated yield from Niue's reef is comparable to yields of reef fish and other organisms from a reef surrounding Daugo Island on the South Papuan Barrier Reef in Papua New Guinea, which ranged from 5.5 to 8.3 t/km^2/yr (mean = 7.2 t/km^2/yr) (Lock, 1986) and from small island fringing reefs in the Philippines of 8.3 to 19.6 t/km^2/yr (mean = 14 t/km^2/yr) (Alcala, 1981; Alcala & Luchavez, 1982) The high values for Niue not only reflect the extent of fishing and harvesting on the reef but also the concentration of effort in such a limited reef area.

15. FISHING AND THE NIUEAN ECONOMY

Using an average price per kilogramme of NZ $ 8.00, Niue's estimated total fisheries production of 115 t/yr, is worth about NZ$ 920,000 using an average price per kilogram of NZ$ 8.00. Most of this catch is used for food for the household and therefore does not enter the economy. As discussed above, it is estimated that 5 t of fish and 2 t of coconut crabs were exported from the island in the form of passenger luggage when a direct air connection was between Niue and New Zealand was available. Using the same average price these esports would be worth NZ$ 56,000. Using the 1981 figure (Anon, 1990b) and inflated to 1990 values, the gross national product (GNP) of Niue was estimated to be about NZ$ 8,000,000. The value of fish production in Niue thus represents about 12.2 per cent of the GNP.

The total production of all fishermen who sell fish is unknown. However, as there are only four or five-full time fishermen and two or three serious part-time fishermen, it should be possible to make some preliminary estimate of this sector of the Niuean economy. Data from fishermen's records indicate that both full-time and part-time fishermen are probably landing about 1.5 to 2.0 t/fisherman/yr. This suggests that commercial landings of fish in Niue amount to between 10 and 14 t/yr, with a value of NZ$ 80,000 to 112,000, or between 1.0 and 1.4 per cent of the GNP.

The average annual income on Niue during 1990 was estimated to be approximately NZ$ 2,400. This was based on the average income determined during the 1981 census (Anon, 1988) inflated to the equivalent value in 1990, using the weekly wages index for New Zealand (Anon, 1990b). Clearly, the present professional fishing community on Niue can expect a much better income than average, with an estimated annual gross revenue for professional fishing of about $14,000. This represents a substantial supplement for those part-time fishermen who are also hold other jobs and a reasonable income for full-time fishermen.

Capital investment for professional fishing involves a 3.7 or 4.3 m aluminium dinghy, and a 15 hp outboard motor costing between NZ$ 3,500 and 4,000. Other expenditure includes fishing gear; while exact costs were not recorded, they are not prohibitive. Further, fishermen may also make their own trolling lures or catch their own bait such as flying fish or round scads and bigeye scads. Costs per trip for professional fishing (based on 20 1 of fuel at NZ$ 1.34/1) are estimated to be between NZ$ 20.00 and 25.00. On the basis of the operating costs alone, the professional fisherman can expect to realise between 85 and 90 per cent of the gross revenues from fishing. An aluminium dinghy might reasonably be expected to have a life span of > 10 yrs, while outboard engines need replacing after 2—3 years of constant use, so capital replacement costs will not be too heavy.

Some further expansion of professional fishing in Niue is possible, given the high demand for fish and the revenues that can be earned. However, the limited market could soon be saturated if the number of full-time and part-time professional fishermen is increased.

Records covering 18 months of both demersal and pelagic fishing were available for one non-professional canoe fisherman. The estimated annual landings from his operation amounted to about 530 kg/yr, with a value of NZ$ 4,240/yr. It is difficult to extrapolate from a single set of records to the rest of the population owning canoes and dinghies. If an extrapolation is made, however, it suggests that the fleet of 56 dinghies and 239 canoes involved in subsistence or supplementary fishing produces 158 t/yr with a net value of NZ$ 1,264,000. However, the total fisheries production by professional and non-professional fishermen estimated in this way amounts to about 170 t/yr, which is about half as much again as the estimate of about 115 t/yr based on nutrition survey data. Collection of more records of fishing by non-professional fishermen should help to resolve this discrepancy.

16. DISCUSSION AND RECOMMENDATIONS

Initial observations on crustaceans suggest that there are moderate stocks of lobsters and crabs and that these are not heavily exploited. Since the number of individual people collecting crustaceans is limited, it should be relatively easy to monitor their catches. We recommend that one person in the Fisheries Division be trained to record catches and fishing effort, and to collect basic biological data such as species composition, length and weight data and simple observations on the reproductive condition of the females.

Given the depleted nature of *T. squamosa* stocks on the reefs around Niue, there is a need for some form of active conservation measure. The most simple action that can be taken (other than an outright ban) is the collection and arrangement of adult clams in a circle to increase the chances of successful fertilisation and recruitment. The clams should be placed in relatively sheltered areas at depths of 20 to 25 m, which is too deep for them to be collected by free diving. They should be arranged so that the excurrent siphon faces towards the centre of the ring. A ring should consist of 20 to 25 clams arranged in a circle of 5 m diameter. We suggest that initially three to six rings be established in sheltered bays. The rings should be monitored once every two months by Fisheries staff.

The clam survey was carried out six months after Cyclone Ofa had caused extensive damage to the reefs of Niue. From the clam questionnaire survey, it was clear that a substantial number of people felt that Ofa was responsible for a decline in clam stocks along the west coast. It is recommended that the clam survey be repeated within the next three to five years, assuming no further cyclones take place, to compare stock densities under more normal conditions. This recommendation also assumes that patterns of clam exploitation will not change greatly over this time-period.

A limited number of fishermen are involved in commercial full-time and part-time fishing. Most keep some form of log book as a means of monitoring their own production and economic efficiency. Some have adopted the SPC fishing record and the others should be encouraged to follow suit. However, Fisheries Division staff should make every effort to monitor actual landings by fishermen, not only to ascertain the veracity of reporting, but to help in the data recording and to collect information such as length, weight and gonad maturation data.

Fisheries Division staff should also try to improve the estimate of total fisheries production on Niue given in this report. Empirical methods using census data and nutrition data will probably be the only way to do this, but greater stratification by age, sex and even village of amounts consumed will improve the estimated total. The Fisheries Division should also work closely with the Quarantine Service to monitor the amounts of fish and coconut crabs exported in passenger luggage to New Zealand. While fish stocks on Niue are probably in no real danger of over-exploitation, the export of coconut crabs may represent a real threat to the stocks of this species. This is particularly true at present due to the recommencement of direct flights between Niue and Auckland.

The following equipment is considered essential for the efficient functioning of the Fisheries Division in Niue:

— 14 ft aluminium dinghy,
— 25 hp outboard engine,
— 3 sets of snorkelling equipment (face masks, snorkels and fins),
— 2 regulators,
— 2 backpacks,
— 3 wet suits,
— 2 sets of calipers,
— 30 m tape-measure,
— 0.5 and 1.0 m measuring boards,
— Scales suitable for weighing both fish and invertebrates,
— IBM-compatible computer with twin floppy ports and 40k hard disk,
— Printer,
— Software.

We also recommend that one or more of the Fisheries Division staff receive training in the commonly used software, probably through SPC and/or FFA. Further training in methods of fisheries data collection and simple techniques of data summarisation is also recommended.

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APPENDICES

Appendix I

PRELIMINARY CHECKLIST OF THE MARINE FISHES OF NIUE[1]

Family and species	**English name**	**Niuean name**
CARCHARHINIDAE		
*Carcharhinus amblyrhynchos**	Grey reef shark	Mago
C. amelanopterus	Black tip reef shark	Mago
Isurus oxyrhincus	Mako shark	Mago paala
Sphyrna sp.	Hammerhead shark	Mago
*Triaenodon obesus**	White tip reef shark	Mago
ACANTHURIDAE		
Acanthurus achilles	Achilles tang	Kolala
A. blochii	Ringtail surgeonfish	
A. dussumieri	Eye-stripe surgeonfish	
A. guttatus	Whitespotted surgeonfish	Hapi
A. leucocheilus	Pale-lipped surgeonfish	
A. lineatus	Blue-banded surgeon fish	
A. nigricans	Whitecheek surgeonfish	
A. nigrofuscus	Brown surgeonfish	
A. nigroris	Bluelined surgeonfish	Meito
A. olivaceus	Orange band surgeonfish	
A. triostegus	Convict tang	Tukutea
A. xanthopterus	Yellowfin surgeonfish	
Ctenochaetus striatus	Striped bristletooth	
Naso tuberosus	Humpnose unicornfish	
N. hexacanlhus	Blacktongue unicornfish	
N. lituratus	Orangespine unicornfish	
N. unicornis	Bluespine unicornfish	Humu
Zebrasoma scopas	Brown tang	
ZANCLIDAE		
Zanculus cornutus	Moorish idol	
SIGANIDAE		
Siganus spinus	Scribbled rabbitfish	Sikava
HOLOCENTRIDAE		
Myripristis amaena	Brick soldierfish	
M. berndti	Bigscale soldierfish	Selekihi matapulu
M. hexagona	Double tooth soldierfish	
M. kuntee	Pearly soldierfish	
M. murdjan	Red soldierfish	
M. pralinia	Soldierfish	
M. woodsi	White-spot soldierfish	
Neoniphon opercularis	Blackfin squirrelfish	
Plectrypops lima	Cardinal soldierfish	
Sargocentron cornutus	Squirrelfish	Ika ta
S. microstoma	Finelined squirrelfish	
S. spiniferum	Long-jawed squirrelfish	Ta gutoloa
S. tiere	Blue-lined squirrelfish	

1. Fishes marked with an asterisk were also recorded at Beveridge Reef.

POLYMIXIDAE		
Polymixia japonica	Beardfish	Kokio
FISTULARIIDAE		
Fistularia commersonii	Cornetfish	
PEMPHERIDIDAE		
Pempheris oualensis	Bronze sweeper	
KYPHOSIDAE		
Kyphosus cinerascens	Highfin rudderfish	Pake nue
K. bigibbus	Insular rudderfish	Nue
CHAETODONTIDAE		
Chaetodon auriga	Threadfin butterflyfish	
C. citrinellus	Speckled butterflyfish	
C. ephippium	Saddled butterflyfish	
C. lunula	Racoon butterflyfish	
C. melannotus	Black-backed butterflyfish	
C. quadrimaculatus	Fourspot butterflyfish	
Forcipigerlongirostris	Big long-nosed butterflyfish	
Heniochus acuminatus	Long-fin bannerfish	
H. singularis	Singular bannerfish	
POMACANTHIDAE		
Centropyge flavissimus	Lemonpeel angelfish	
Pomacanthus imperator	Emperor angelfish	Sifisifi
Pygoplites diacanthus	Regal angelfish	
POMACENTRIDAE		
Abudefduf septemfasciatus	Banded sergeant	
Amphiprion chrysoptenis	Orangefin anemonefish	
Chromis delta	Deep reef chromis	
C. xanthura	Black chromis	
Chrysipteraglauca	Grey demoiselle	
C. caeruleolineata	Blue-line demoiselle	
Dascyllus trimaculatus	Three spot dascyllus	
SCORPAENIDAE		
Pontinus macrocephalus	Scorpionfish	
Pterois antennata	Spotfin lionfish	
Synanceia vernicosa	Stonefish	
ANOMALOPIDAE		
Anomalops katoptron	Flashlightfish	
CARANGIDAE		
Carangoides orthogrammus	Yellow spotted trevally	Aheu
Caranx ignobilis	Giant trevally	Ulua
*C. lugubris**	Black jack	Tafauli
C. melampygus	Bluefin trevally	Malau tea
C. sexfasciatus	Bigeye trevally	Aheu
Decapterus macrosoma	Round scad	Ulihega
Elegatis bipinnulatus	Rainbow runner	Samani

Gnathonodon speciosus	Golden trevally	Aheu
Scomberoides lysan	Leatherback	Lai loa
Selar crumenophthalmus	Bigeye scad	Atule
*Seriola rivoliana**	Greater amberjack	Palu sikava
Trichinotus bailloni	Silver pompano	Lai
BOTHIDAE		
Bothus mancus	Peacock flounder	
MURAENIDAE		
Gymnothorax javanicus	Giant moray	Toke
G. meleagris	Whitemouth moray	
Sideria picta	Peppered moray	
S. prosopeion	White-eyed moray	
CONGERIDAE		
Conger cinereus	Moustache conger	
SYNODONTIDAE		
Synodus variegatus	Reef lizardfish	Mokotaliga
PLOTOSIDAE		
Plotosus lineatus	Eel catfish	
BELONIDAE		
Platybelone platyura	Needlefish	Aku
Tylosurus crocodilius	Crocodile needlefish	Aku pa
BALISTIDAE		
Balistoides conspicillum	Clown triggerfish	
B. viridescens	Moustache triggerfish	
Melichthys niger	Black triggerfish	
M. vidua	Pinktail triggerfish	
Odonus niger	Redtooth triggerfish	
Pseudobalistes flavimarginatus	Yellowmargin triggerfish	
Rhinecanthus rectangulus	Wedge picassofish	
R. verrucosa	Blackbelly picassofish	
Sufflamen bursa	Scythe triggerfish	
MONACANTHIDAE		
Aluterus scriptus	Scribbled filefish	
Cantherhines dumerili	Barred filefish	
OSTRACIIDAE		
Ostracion meleagris	Spotted trunkfish	
TETRAODONTIDAE		
Arothron meleagris	Guineafowl puffer	
A. nigropunctatus	Black-spotted puffer	
A. stellatus	Star puffer	
Canthigaster valentini	Valentinni's sharpnose puffer	
ISTIOPHORIDAE		
Istiophorus platyptenis	Indo-Pacific sailfish	Haku piu
Xiphias gladius	Swordfish	Haku

DIODONTIDAE

Diodon hystrix	Porcupinefish	
D. litumsus	Shortspine porcupinefish	

LABRIDAE

Anampses caenileopunctatus	Blue spotted wrasse	
Bodianus laxozonus	Blackfin hogfish	
Cheilinus celebecus	Celebes wrasse	
C. fasciatus	Red-breasted wrasse	
C. undulatus	Humphead wrasse	
C. unifasciatus	Ringtail wrasse	
Choerodon anchorago	Yellowcheek tuskfish	
Cons aygula	Clown coris	
C. gaimardi	Yellowtail coris	
Epibulus insidiator	Slingjaw wrasse	
Gomphosus varius	Bird wrasse	
Halichoeres hortulanus	Checkerboard wrasse	
Hemigymnus fasciatus	Barred thicklip wrasse	
Labroides bicolor	Bicolor cleaner wrasse	
L. dimidiatus	Bluestreak cleaner wrasse	
Pseudocheilinus tetrataenia	Fourline wrasse	
Thalassoma hardwickii	Sixbar wrasse	
T. lunare	Crescent wrasse	
T. purpureum	Surge wrasse	Tufu
T. quinquevittatum	Five-striped surge wrasse	Meai
T. trilobatum	Christmas wrasse	

PINGUIPEDIDAE

Parapercis millipunctata	Black-dotted sand perch	

SCARIDAE

Bolbotnetopon muricatum	Humphead parrotfish	
Calotomus carolinus	Bucktooth parrot fish	
Cetoscarus bicolor	Bicolor parrotfish	
Hipposcarus longiceps	Pacific longnose parrotfish	
Scants altipinnis	Filament-finned parrotfish	
S. atropectoralis	Red parrotfish	
S. chameleon	Chameleon parrotfish	
S. festivus	Festive parrotfish	
S. flavipectoralis	Yellowfin parrotfish	
S. forsteni	Forsten's parrotfish	Paholo
S. frenatus	Vermiculate parrotfish	
S. ghobban	Blue-barred parrotfish	
S. microrhinos	Gibbus parrotfish	
S. oviceps	Dark-capped parrotfish	
S. prasiognathos	Greenthroat parrotfish	
S. rubtioviolaceus	Redlip parrotfish	
S. schlegeli	Yellowband parrotfish	
S. sordidus	Bullethead parrotfish	

EXOCOETIDAE

Cheilopogon atrisignis	Flyingfish	
C. spilonotopterus	Flyingfish	
C. unicolor	Flyingfish	
Cypselurus oligolepis	Largescale flyingfish	Hahave

POLYNEMIDAE

Polydactylus sexfdis	Sixfeeler threadfin	Ikasea

MUGILIDAE

Crenimugil crenilabis	Fringelip mullet	Fuafua
Valamugil engeli	Engel's mullet	Fuafua
V. seheli	Bluespot mullet	Kanahe

BLENNIDAE

Plagiotremus rhynorhynchus	Bluestriped blenny	

EPHIPPIDAE

Platax pinnatus	Pinnate spadefish	

SPHYRAENIDAE

Sphyraena barracuda	Great barracuda	Utu
S. forsteri	Blackspot barracuda	
S. novahollandiae	Arrow barracuda	
S. picuda	Barracuda	Koho utu

LUTJANIDAE

*Aphareus furca**	Blue smalltooth jobfish	Palu po
A.rutilans	Rusty jobfish	Palu gu
Aprion virescens	Green jobfish	Palu monega
Etelis carbunculus	Ruby snapper	Palu fagamea
Etelis coruscans	Longtail red snapper	Pakeko
*Lutjanus bohar**	Twinspot red snapper	Fagamea
L. ehrenbergi	Blackspot snapper	
L. fulviflamma	Blackspot snapper	
L. fulvus	Flametail snapper	
L. gibbus	Humpback snapper	
*L. kasmira**	Bluelined snapper	Foigo
L. monostigma	Onespot snapper	Hiku ila
Macolor niger	Black snapper	
Paracaesio kuskarii	Saddleback snapper	Kulapu
P. xanthurus	Yellowtail blue snapper	
Pristipomoides amoenus	Flower snapper	Palu heahea
P. auricilla	Goldflag jobfish	Palu hahave
P. filamentosus	Crimson jobfish	
P. multidens	Goldbanded jobfish	Palu hai
*P. zonatus**	Oblique banded snapper	

CAESIONIDAE

Caesio caerulaureus	Scissor-tailed fusilier	
Pterocaesio tile	Bluestreak fusilier	Ulihenga iva

HAEMULIDAE

Plectorhinchus chaetodontoides	Harlequin sweetlips	
P. goldmanni	Goldman's sweetlips	
P. picus	Spotted sweetlips	

LETHRINIDAE

Gnatlionodentex aiirolineatus	Yellowspot emperor	Kulapu
Gymnocranius griseus	Grey emperor	
Lethrinus elongatus	Longnose emperor	
Monotaxis grandoculus	Bigeye emperor	Fotho

MULLIDAE

Mulloides flavolineatus	Yellowstripe goatfish	Kaloama

M. vanicolensis	Yellowfin goatfish	
Parupeneus barbetinus	Dash & dot goatfish	Hafulu
P. bifasciatus	Two barred goatfish	
P. ciliatus	White-lined goatfish	
P. cyclostomus	Yellowsaddle goatfish	
P. multifasciatus	Multibarred goatfish	
P. pleurostigma	Sidespot goatfish	
SERRANIDAE		
Cephaloholis argus	Peacock grouper	
C. aurantia	Grouper	Pelepele
C. igarashiensis	Grouper	Palu kulukulu
C. miniata	Coral grouper	Malau pokoahu
C. sonnerati	Tomato grouper	Kaupatuo
C. urodeta	Flagtail grouper	Mataele
Epinephelus cometae	Blue grouper	Palu pusi
E. fasciatus	Black tipped grouper	Talaao
E. hexagonatus	Hexagon grouper	Gatala
E. metra	Honeycombe grouper	
*E. morrhua**	Grouper	
E. polyphekadion	Marbled grouper	
*E. re louti**	Grouper	Gutukafu
E. septemfasciatus	Convict grouper	
E. tauvina	Greasy grouper	Gatala
Plectropoma laevis	Giant coral trout	
P. leopardus	Leopard coral trout	
Pseudanthias randalli	Randall's fairy basslet	
Pseudanthias squammipinnis	Scalefin basslet	
*Saloptia powelli**	Goldenfish	Palu mame
*Variola louti**	Lyretail grouper	Malau
GRAMMISTIDAE		
Grammistes sexlineatus	Skunktish	
CIRRHITIDAE		
Citrhitus pinnulatus	Stocky hawkfish	Ulutuki
Patracirrhitus aivatus	Arc-eye hawkfish	
P. forsteri	Freckled hawkfish	
P. hemistictus	Whitespot hawkfish	Ulutuki
APOGONIDAE		
Apogon fraenatus	Bridled cardinalfish	
A. kallopterus	Iridescent cardinalfish	Ulamula
Cheilodipterus lineatus	Lined cardinalfish	
C. macrodon	Large toothed cardinalfish	
KUHLIIDAE		
Kuhlia mugil	Barred flagtail	
PRIACANTHIDAE		
Heteropriacanthus cnientatus	Glasseye	Kacne
MALACANTHIDAE		
Malacanthus latovittatus	Striped blanquillo	
ECHENEIDAE		
Echeneis naucrates	Sharksucker	

GEMPYLIDAE		
Promethichthys prometheus	Snake mackerel	Matimati
Ruvettus pretiosus	Oilfish	Palu sehi
BRAMIDAE		
Taractichthys steindachneri	Pomfret	Palu kokio
CORYPHAENIDAE		
Coryphaena hippurus	Dolphinfish	Tolofine
SCOMBRIDAE		
Acanthocybium solandri	Wahoo	Paala
*Gymnosarda unicolor**	Dogtooth tuna	Valu
Katsuwonus pelamis	Skipjack tuna	Takua
Thunnus alalunga	Albacore	Vaha leleva
T. albacares	Yellowfin tuna	Vahakula
T. obesus	Bigeye tuna	Hakua

Appendix II

SPECIMEN OF THE FISHERIES RESOURCES SURVEY QUESTIONNAIRE
EMPLOYED ON NIUE, JULY 1990

SOUTH PACIFIC COMMISSION

NIUE FISHERIES RESOURCE ASSESSMENT HOUSEHOLD SURVEY
(June 1990)

HOUSEHOLD IDENTITY

Name of head of household______________________________

Total no. in household______________________________

Names of individuals who fish:

Name	When last went fishing?	Where?	What gear used?	Weight of catch (kg)

What percentage of the household's total catch conies from each of the following sources?

Lagoon	Reef flat	Outside reef	Total

What proportion of the total catch is used for the following purposes?

	Home consumption	Sharing	Sale
Lagoon			
Reef			
Outside reef			

Which of the following forms of fishing are used by the household?

	Often	Sometimes	Never	Seasonally (note when)
Fish drives				
Gill netting				
Scoop netting (flying fish)				
Cast netting				
Handlining				
Rod and line				
Trolling				
Deep-bottom fishing				
Spear-gun fishing				
Spear fishing while walking				
Collecting lobsters				
Collecting beche-de-mer				
Collecting seaweed				
Gleaning (general collecting)				
Poisons				
Dynamite				
Other (specify)				

Main species of finfish caught (note season if applicable)

Local name	Reef walking	Fish drive	Hand line	Rod and line	Spear gun	Fish spear	Troll	Scoop net

Description of fishing gears owned by household

Boats: Total number________
Describe each boat:

Type	Length	Propulsion	Engine	Price paid	Year acquired	Shared with...?

Trolling lines: Total number_______
Describe each line:

Length	Estimated break strength	Type of lures used	Comments

Nets (e.g. gill nets, cast nets, scoop nets): Total number:______

Type of net	Material	Light source if used	Comments

Handlines: Total number________
Describe each line:

Material	Diameter (mm)	Estimated break strength	Comments

Other gears (e.g. spearguns, hand spears, etc.)
Describe each one:

Gear	Dimensions	Comments

Appendix III

GIANT CLAM SOCIO-CULTURAL SURVEY QUESTIONNAIRE

30 males and 30 females questioned in each of 3 age groups: teenage—30 years, 30—50 years and 50 years+ .

Question 1: How often do you eat giant clams?

	Never		Daily		Weekly		Monthly		Quarterly		Yearly	
	F	M	F	M	**F**	**M**	F	M	F	M	F	M
Percentage	10.0	0.0	0.0	0.0	13.3	8.8	20.0	29.4	13.3	5.9	43.3	55.9

Question 2: Do you collect clams yourself or pay/trade with fishermen?

	Self		Pay		Trade	
	F	M	**F**	M	F	M
Percentage	60.7	55.9	28.6	32.4	7.1	5.9

Question 3: How much do you sell/pay for various sizes of clams? Approximate size of most clams used for food? *(See text for response.)*

Question 4: In your view, are clams becoming scarce (any examples)?

	Yes		No		Don't know	
	F	**M**	F	M	F	M
Percentage	72.4	75.8	17.2	24.2	10.3	0.0

Question 5: Do you now have, or in the customary past, any special times of the year, special reef areas or general taboos on taking clams for food?

	Yes		No		Don't know	
	F	M	F	M	F	M
Percentage	23.3	20.6	73.3	70.6	3.3	8.8

Question 6: A. Do you see a need to restrict fishing of giant clams to preserve stocks?
B. Do you think the reduction in adult giant clam stocks on the reefs affects the numbers of clams on the reef in the future?

	Yes		No		Don't know	
	F	M	F	M	F	M
Percentage A	66.7	64.5	26.7	35.5	3.3	0.0
Percentage B	48.3	56.7	10.3	43.3	41.4	0.0

Question 7: Would laws restricting fishing of giant clams be gradually accepted, or taken with offence and not accepted?

	Accepted		Not accepted		Don't know	
	F	M	F	M	F	M
Percentage	75.0	78.1	21.4	21.9	3.6	0.0

Question 8: A. Would you like to see the government of Niue start experiments on culturing clams?
B. Would it be safe to leave small clams in underwater cages for experiments or would some people take the clams and destroy the experiments?

	Yes		No		Don't know	
	F	M	F	M	F	M
Percentage A	93.1	100.0	3.4	0.0	3.4	0.0
Percentage B	88.0	96.7	8.0	3.3	4.0	0.0

Question 9: How do you prepare giant clams for food ***(See text for response)***

SUMMARY OF FISHES AND MARINE ORGANISMS CAPTURED BY DIFFERENT FISHING METHODS ON NIUE, AS DETERMINED FROM QUESTIONNAIRE SURVEY

Figures in each column refer to numbers of respondents who cited the fishing method for capturing a particular species.

Niuean name	Common name	Reef gleaning	Fish drive	Hand-line	Rod & line	Spear-gun	Fish spear	Troll-ing	Scoop net	Cast net	Total
Aheu	Jacks		1	3	2	1				1	g
Aku	Needlefish				2						2
Aku pa	Longtom				3			1	1		5
Alili	Mollusc	27									27
Atule	Bigeye scad		1	3	8			2			14
Fagamea	Red bass			10	5						15
Faloa	Grouper			2							2
Feke	Octopus	10		3		1					14
Figota	Crab	1	1							1	3
Foigo	Snapper			2							2
Fouli	Mollusc	5									5
Fuafua	Mullets	2	3	5	19	2	1		1		33
Fuafuauli	Mol'usc	18		1	2						21
Fuakina	Sea urchin	1									1
Gatala	Grouper	1	1	5	12						19
Gege	Giant clam	6									6
Gutukafu	Grouper			1							1
Hafulu	Goatfish			5	3						S
Hahave	Flyingfish			4	2			1	14		21
Haku tagata	Billfish			2	2			3			7
Hapi	Surgeonfish	1	3	3	3	6	1				17
Humu	Unicornfish	1	1	9	46		1			1	59
Ikasea	Threadfin			1	11		1				13
Ilaila	Flagtail				7						7
Kaloama	Juvenile goatfish		2		12	1			1		16
Kamakama	Crab	4		1	1						6
Kamuta	RuJderfish				1						1
Kana	Soft coral	1									1
Kanahe	Mullet		1				1	1			3
Kaene	Bullseye			3	2		1	1			7
Kaupatuo	Grouper			1							1
Kavai				2							2
Kina	Sea urchin	3				5					g
Kohu	Barracuda			2				1			3
Kokio	Sweepers		1	3	6	1	1	1			13

Niuean name	Common name	Reef gleaning	Fish drive	Hand-line	Rod & line	Spear-gun	Fish spear	Troll-ing	Scoop net	Cast net	Total
Kolakola	Goatfish		1								1
Koiala	Surgeonfish			1	1	3	1				6
Kulapu	Snapper			2							2
Kulukulu	Grouper				1						1
Lakua	Skipper	1	2		1						4
Limu	Seaweed	3									3
Loi	Grouper			3	4						7
Loli	Beche-de-mer	6		1							7
Lupolupo	Juvenile jack				1						1
Mago	Sharks			8	1						9
Maia		1									1
Malau	Grouper	2		41	8						51
Mamene	Mollusc	1									1
Manini	Surgeonfish		2								2
Mataele	Grouper			14	5						19
Matapihu	Mollusc	9									9
Matapula	Soldierfish				1						1
Matimati	Snake mackerel			1	1						2
Meai	Wrasse	5	2	11	28						46
Meito	Surgeonfish	2	2	1	4	4				1	14
Memea	Goatfish				1						1
Mone aho	Parrotfish			1	1						2
Moheaho	Parrotfish	1	2	2	3	7	8				23
Motumotu	Fish	1		1	1						3
Mutaki	Fish				1						1
Mutumutu	Rudderfish		1	2	2						5
Nanue	Rudderfish				2						2
Nikiniki	Boxfish		1		1						2
Nue	Rudderfish	3	6	12	40	4	2			1	68
Paala	Wahoo			25	3			23			51
Paholo	Parrotfish		1			1					2
Paeko	Snapper	2									2
Paka	Swimmer crab			6							6
Palapala	Wahoo			1							1
Palu	Snapper		2	30	1	1		3			37
Papahua	Mollusc	7									7
Papaao	Fish		1								1
Parrotfish	Parrotfish		1								1
Pelepele	Grouper			7							7
Pikuila				1		1					2
Ponelolo	Surgeonfish		1								1
Pula				1							1

Niuean name	Common name	Reef gleaning	Fish drive	Hand-line	Rod & line	Spear-gun	Fish spear	Troll-ing	Scoop net	Cast net	Total
Samani	Rainbow runner			2				1			3
Selekihi	Soldierfish	1	2	29	24	2					58
Sepulupulu		1									1
Shark				1							1
Swordfish								1			1
Ta	Soldierflsh			8	10			1			19
Tafauli	Jacks		1	15	2						18
Takua	Skipjack tuna			4	1			14			19
Tukusea	Fish		1		1						2
Talaao	Grouper			10	2						12
Talau				4							4
Tapapu		1									1
Tapatapa	Crab			1				1			2
Tapola	Crab	1									1
Tavali	Jacks			1							1
Toke	Eels			2							2
Toloflne	Dolphinfish			6				4			10
Tufu	Wrasse	4	1	3	10	1	1				20
Tukutea	Surgeonfish				1						1
Uaila	Eel				1						1
Ugako	Mollusc	14									14
Ulihega	Round scad			4	14	1	1			1	24
Ulihega iva	Fusilier										
Ulua	Jack			6	2	1		1			10
Ulutuki	Hawkfish	5	1	9	29	1					45
Uo	Crayfish	5			1	2					8
Utu	Barracuda		1	18	4			8			31
Vahakula	Yellowfin tuna			24	2			21			57
Vahaleleva	Albacore			1							1
Valu	Dogtooth tuna			8	1	1		5			15
Total		91	40	373	315	43	19	93	7	4	995
No. of species		43	30	79	63	21	12	25	5	6	284

Appendix V

MONTHLY CPUE FOR DEMERSAL BOTTOMFISHING, TROLLING FOR LARGE PELAGICS AND SCOOP NETTING FOR FLYING FISHES AT NIUE, 1988-1990

Month	Bottom fish (kg/iine-hr)	Large pelagics (kg/line-hr)	Flying fish (kg/hr)
1988			
October	4.7	1.1	12.9
November		3.7	12.0
December			
1989			
January			
February			
March	3.4	1.8	8.7
April	3.6		5.0
May	6.0	4.6	10.1
June	4.7	2.1	
July	7.2	1.9	
August	5.6	5.9	
September	6.0	2.9	
October	5.7	3.1	14.9
November	8.5	4.8	15.5
December	2.1	1.9	9.1
1990			
January	6.9	0.8	
February			
March			4.6
April	5.5	1.5	
May	4.9		
June	5.8	1.7	
July	5.4	3.3	

Appendix VI

SUMMARY OF DATA ON GIANT CLAMS, CORAL COVER, CROWN OF THORNS STARFISH AND BECHE-DE-MER IN TOW TRANSECTS AT NIUE, JULY 1990

Tow Number	Depth (m)	Tow width (m)	Tow length (m)	%live coral cover	% total coral cover	Total no. of *T. maxima*	Total no. of *T. squamosa*	Total no. of crown of thorns	Beche-de-mer Total	Beche-de-mer Species
1	2-10	10	500	10	15	0	0	0	1	1A
2	7-13	8	500	5	10	3	1	0	3	1A 2B
3	7	10	350	10	15	21	0	0	3	1A 2B
4	8-16	8	350	10	15	8	0	0	7	7B
5	7-10	10	240	10	15	21	0	0	2	1A 1B
6	7-10	10	240	5	10	9	0	0	17	17B
7	7-10	10	200	15	20	31	22	0	3	1A 2B
8	10-16	8	200	15	20	10	3	1	9	1A 7B 1C
9	7	8	90	30	40	30	20	0	2	1A 1B
10	10	10	140	15	20	38	2	0	1	ID
11	10-13	8	140	10	15	22	0	0	8	3A 3B 2E
12	13-15	8	200	5	10	13	0	0	2	1A 1C
13	10-13	8	200	15	20	10	2	0	0	
14	3-10	10	180	5	10	0	0	0	1	1A
15	3-10	10	120	5	10	1	0	0	1	1A
16	3-10	10	200	5	10	4	0	0	0	
17	7-8	10	130	15	20	39	0	0	11	11B
18	10	8	200	15	20	14	0	0	14	4A 10B
19	3-15	8	300	15	20	38	2	0	17	3A 14B
20	4-10	10	380	>5	>10	9	0	2	8	1A 7B
21	4-10	10	140	>5	>10	10	0	1	7	1A 4B 2D
22	4-14	8	350	>5	>10	31	0	0	8	1A 6B ID
23	4-15	8	270	10	15	61	0	0	15	8A 4B 2D IE
24	6-16	8	120	35	50	20	0	0	3	2A IB
25	3-16	8	215	>5	>10	8	0	0	3	1A 2B
26	3-7	8	210	>5	>10	3	0	0	9	5A 4B
27	3-14	10	430	>5	10	19	0		0	
28	3-13	8	270	10	15	9	0	2	17	9A 8B
29	3-13	8	140	>5	10	2	0	1	9	8A 1B
30	3-15	6	350	>5	5	20	0	0	4	4A
31	3-10	10	145	5	10	4	0	0	8	8A
32	3-13	8	350	5	10	10	0	1	6	6A
33	3-13	8	190	5	10	24	0	1	14	11A 1B 2D
34	4-10	10	150	5	10	47	0	0	5	5A
35	7-14	10	350	>5	10	3	0	0	1	1A
36	3-15	8	225	10	15	2	0	0	0	
37	10-16	10	300	50	70	5	3	0	4	4A
38	13-18	10	450	65	80	13	5	0	14	10A 4B
39	6-15	10	350	65	80	17	3	0	17	11A 6B
40	10-15	10	120	55	70	3	7	0	3	2A 1B
41	6-15	10	120	40	60	4	7	0	3	3A
42	6-15	10	120	70	80	5	3	0	1	1A

Key to beche-de-mer species: A. *Holothuria atra,* B. *Thelenota ananas,* C. *Actinopyga mauritiana,* D. *Microthele nobilis,* E. *Bohadschia* sp.

Appendix VII

SIZE FREQUENCIES FOR *T. MAXIMA* FROM THREE SITES ON THE WEST COAST OF NIUE DURING JULY 1990

Length class (cm)	Location		
	Alofi	Avatele	Namakulu
1			
2			
3			
4			
5		1	
6	1		
7			
8	1	3	1
9	5	1	2
10	3	2	6
11	6	3	9
12	6	11	9
13	10	11	10
14	8	6	6
15	4	4	4
16	6	3	2
17		3	1
18		1	
19		1	

Appendix VIII

SUMMARY OF INTER-TIDAL REEF TRANSECTS FOR COUNTS OF THE NUMBERS OF BECHE-DE-MER AT NIUE, JULY 1990

Distance (m)	Transect										Total	Mean
	1	2	3	4	5	6	7	8	9	10		
10	10	4	25	0	1	0	2	0	0	0	42	4.2
20	3	13	9	0	0	0	0	3	1	0	29	2.9
30	4	2	2	0	1	0	0	0	0	0	9	0.9
40	0	2	2	0	0	0	0	0	0	0	4	0.4
50	1	2	4	1	0	1	0	0	2		10	1.0
60	1	1		4	0	4	0	0	0		6	0.8
70	6	0		0	0	0	1		0		8	1.1
80	16				0		2		0		19	3.8
90	5				0				0		10	2.5
100	5				1						8	2.7
110	1				2						7	2.3
120					1						6	3.0
130					0						0	0.0
140					1						1	1.0
150					4						4	4.0
160					3						3	3.0
Total	52	24	42	18	14	5	5	3	3	0	166	33.6

BIOLOGICAL DATA FOR LOBSTERS AND CRABS CAPTURED FROM THE REEFS OF AVATELE AND ALOFI DURING THE SURVEY PERIOD

Species	Carapace length (cm)	Sex and spawning condition
Panulirus penicillatus	8.7	male
	8.8	male
	6.8	female
	8.9	male
	7.2	female, berried
	8.4	female, berried
	7.9	female
	13.2	male
	10.9	male
	7.8	female, berried
	11.3	male
	9.0	female, spermatophore
	11.4	male
	7.3	female
	10.6	male
	7.5	female, berried
	6.6	female, spermatophore
	6.4	female, berried
	7.3	female
	8.2	male
	9.2	male
	7.3	female, spermatophore
	7.4	female, berried
	7.5	female, berried
	6.4	female
	7.4	female, spermatophore
	7.1	male
	8.4	male
	6.4	male
	8.6	male
	5.4	female
	6.7	male
	8.9	male
	11.5	male
	10.4	male
	9.1	male
	7.6	female, berried
Panulirus longipes	*1A*	male
	9.0	male
	9.2	male
	8.4	male
	6.9	mate
	7.7	male
	7.5	male
	7.8	male
	7.3	male
	9.9	male
	7.4	male
	7.1	male
	9.2	male
Panulirus versicolor	7.6	female

Species	Carapace length (cm)	Sex and spawning condition
Parribacus caledonicus	7.6	
	6.9	
	7.9	
	7.1	
	7.4	
	7.4	
	6.1	
	7.4	
Carpilius maculatus	9.0	
	9.6	
	10.9	
	10.4	
	9.2	
Etisus splendidus	9.8	
	10.5	
	10.4	
	10.3	