SPC/Fisheries 16/WP.18
10 August 1984

ORIGINAL : ENGLISH

SOUTH PACIFIC COMMISSION

SIXTEENTH REGIONAL TECHNICAL MEETING ON FISHERIES
(Noumea, New Caledonia, 13-17 August 1984)

THE STATUS OF TROCHUS NILOTICUS IN THE COOK ISLANDS : 1984

by

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ABSTRACT

Trochus niloticus was first introduced to the Cook Islands in 1957, and a breeding population quickly became established on Aitutaki. Trochus harvest seasons were conducted in 1981 and 1983-84, and produced almost 5 tonnes per kilometre, and 0.9 tonnes per kilometre of reef length, respectively. Introductions have been attempted to the Southern Group Islands, but have evidently been unsuccessful on the high "makatea" islands, which possess narrow fringing reefs. Trochus have not been introduced to the Northern Group, where most potential lies in the broad-reefed atoll islands.

Recommended development strategies include introductions to the North; and the establishment of a trochus hatchery on Aitutaki, to provide for supplementation of stock recruitment on all islands, and a higher sustainable level of exploitation. Modification of management strategies involving the narrowing of legal size limits to between 8 cm and 10 cm basal diameter, the establishment of a rotating reserve system, and imposition of individual quotas for each licence holder are recommended, although the impact of such strategies is difficult to predict. Close monitoring of stocks, and further knowledge of trochus population biology, particularly in the isolated islands of Polynesia, is required to allow evaluation of these management measures, and to effectively implement the supplementation programme.

INTRODUCTION

Trochus niloticus (Linnaeus), or the turban top-snail is the most widely exploited marine gastropod in the Pacific. From an original distribution extending from the Andaman Islands to Fiji, the species has now been introduced to nearly all island groups of the tropical Pacific. Almost wherever trochus has been introduced, it has quickly become established as an obvious member of the reef community, and as a prime economic concern.

The shell is valuable for its nacre, or mother-of-pearl translucence, and is used in the manufacture of buttons and jewelry. The current wholesale price (FOB) for cleaned Grade A shell is about US$800 per tonne. The raw meat, frozen, dried, smoked, or salted, is considered a delicacy by Asians, and has considerable market value. Neither the shell nor meat market is approaching oversupply, and demand in both is increasing.

With the present value and potential of the trochus industry to the Pacific island nations, there remain a number of concerns to management and research workers.

Because of its value, and by its nature, trochus is highly susceptible to overfishing. Being a large, obvious gastropod inhabiting shallow coral reef flats, and easily

harvested by free-diving, or walking on the reef, stocks are readily depleted by unregulated harvesting activities. Whilst moderate fishing intensity has minimal effect on the dynamics of a trochus population, (as the more valuable shells are found on smaller, less fecund animals) with overfishing, the older, wormed shells, though of less value, become vulnerable. Evidently, with the removal of these larger, highly fecund trochus, recruitment levels drop sharply, and the recuperative ability of the already depleted stock is severely hindered. Such effects are both delayed in their response, and difficult to assess.

Particularly in the small islands of Polynesia, there is a need for more effective application of management techniques. By their geographical nature, such islands are environmentally highly vulnerable, and the "trial and error", trochus management policies which have previously been evident, have mostly failed. Stable harvest quotas, effective reserves and careful population monitoring are required for each island, to ensure optimum economic returns. The recent work at the Micronesian Mariculture Development Centre, (M.M.D.C.), proving the practicability of hatchery production of trochus and thereby providing the means for intensive manipulation of stocks, through supplementation of recruitment, has dramatically broadened the scope of management, and the

economic potential of the industry. If the opportunities presented by these developments are to be fully realized, a concerted, co-ordinated programme of applied research is required to further illuminate the reproductive biology and population dynamics of trochus, and the response of stocks to manipulative and regulatory practices.

THE HISTORY OF TROCHUS IN THE COOKS

(a) Introduction to Aitutaki

Trochus was first introduced to the Cook Islands in early 1957, with one shipment of forty mature adults, (greater than 6cm basal diameter) from Fiji to Aitutaki, an "almost atoll", 130nm north of Rarotonga. (See Figure 1) (1 and 2). The population was allowed to establish itself, being protected by the disinterest of local people, rather than by legislation. Evidence that the population was reproducing was obtained in 1960, (3), and by 1965, trochus were described as being "plentiful". (4). The economic value of the resource was, however, largely ignored, and it was not until 1981, after the local island council complained that previously abundant stocks of Turbo sp, the local green snail, had decreased with the proliferation of trochus, that a harvest season on trochus was declared. (See Appendix I).

(b) 1981 Harvest Season

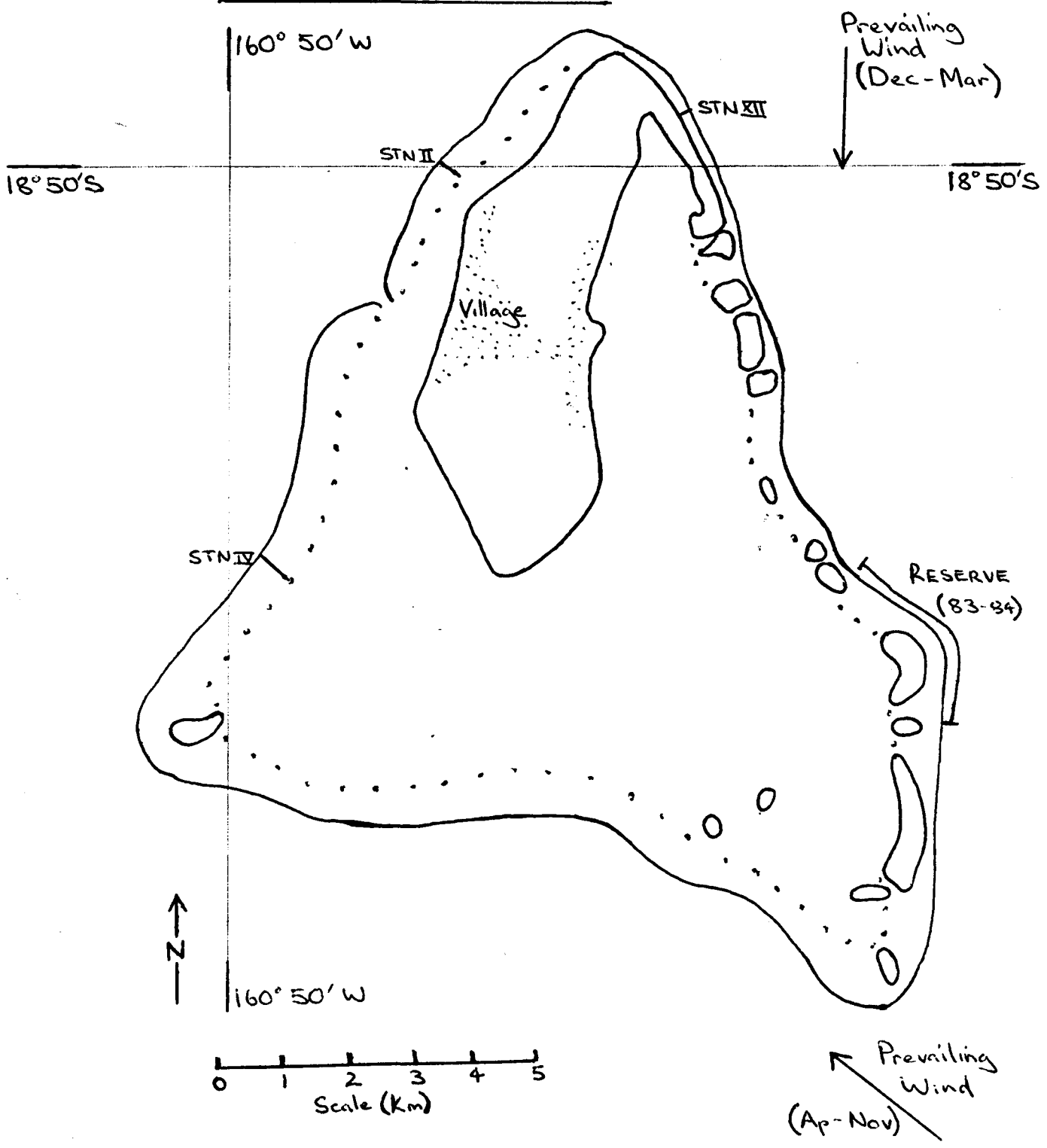
Regulations which accompanied the first harvest season on Aitutaki were based on those which have been employed throughout the industry.

They were:-

- the season was limited to three months duration, or 30 tonnes, whichever came first.

1 Stoddart, D.R., and P.E. Gibbs p 31
2 van Pel, H. p 47
3 Devambez, L. P 31
4 R. Powell. pers. comm.

FIGURE 1 - AITUTAKI



STNS II, IV and XII sampled for size class distributions (Fig 4)

- size restrictions of between 3½" (8cm) and 5" (12.5cm) diameter at the shell base were imposed.

- fishermen must hold a current licence, bought for the nominal fee of $1, prior to the season opening. In practice, the possession of a licence permitted the whole household to engage in harvesting activities.

When the quota was attained, the season was purportedly closed. However, following submissions from Aitutaki, and without notifying or seeking the advice of the Fisheries Department, permission was given to continue harvesting, and the season extended for over 15 months, with almost 200 tonnes of shell being taken. This level of exploitation (approximately 5 tonnes per km of reef length) is well above M^{c}Gowan's (5) estimate of 2.4 tons/mile (1.4 tonnes/km). The majority of shells harvested during this extended period were worm damaged, and returned only B-grade prices, or were rejected. The regulations concerning size restrictions and licences were evidently ahered to. (6).

(c) 1983-4 Harvest Season

In response to economic and other pressures, a harvest season was declared in November 1983. As well as the quota, (20 tonnes, no time limit), size limits and licensing regulations, a reserve was declared over a 3km section of the windward reef,

(5) M^{c}Gowan; John A. p 7
(6) J. Dashwood. pers. comm.

to preserve viable breeding stocks.

The pre-harvest population was estimated at 336,000 trochus (almost 115 tonnes). By February, 1984, when the season was declared closed, 35.7 tonnes had been taken. This represents a production level of 0.9 tonnes per km of reef length, or a fishing mortality of 31%. Such an impact could probably be sustained for yearly harvests, although some data indicate the depletion of small adults (8-10cm basal diameter) in areas most intensively fished. (See Appendix II).

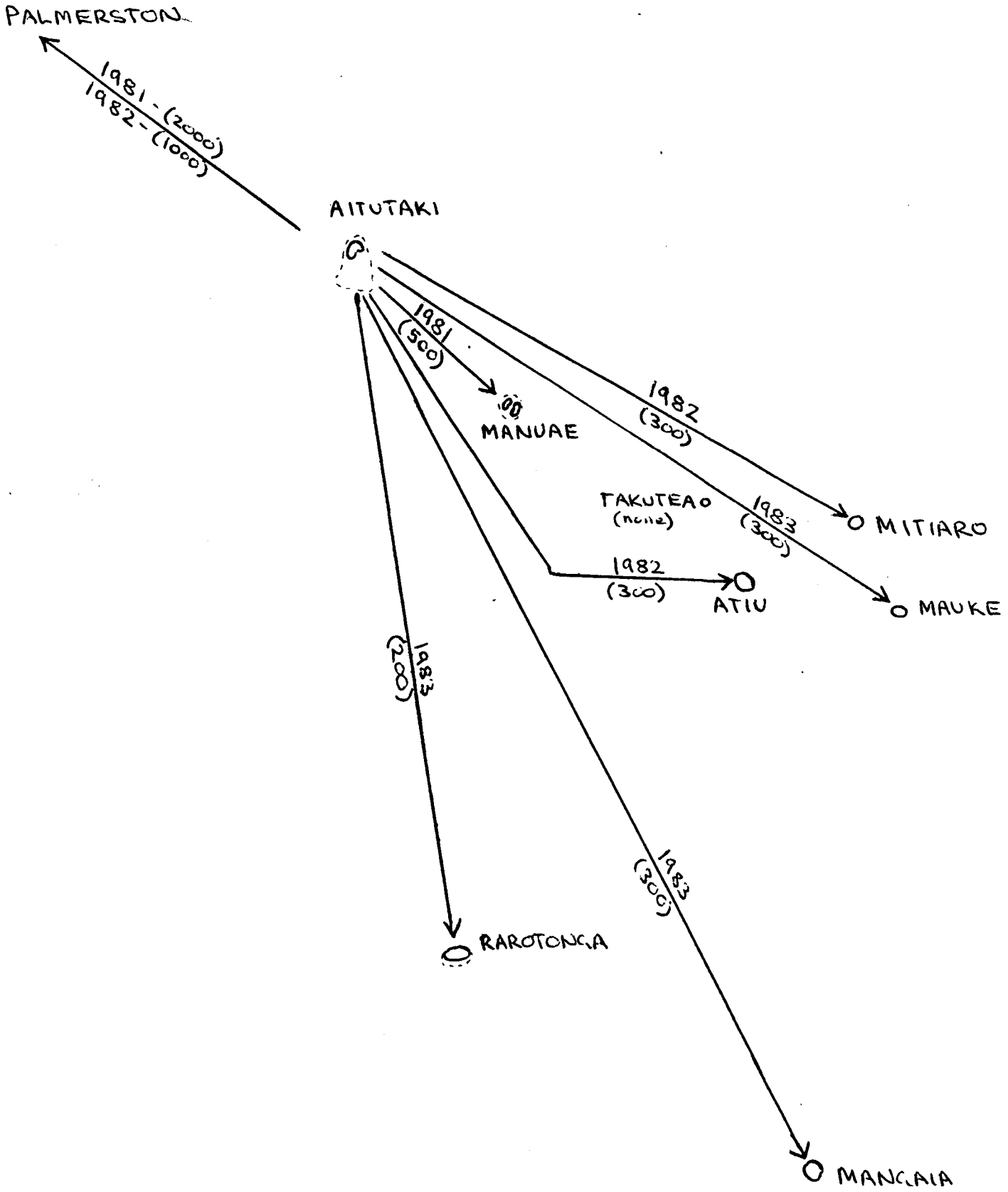
(d) Introduction to Other Southern Group Islands

Contrary to Bour, Gohin and Bouchet, (7) there have been no recorded instances of natural dispersal of trochus between the Southern Group islands, and in 1981, with the realization of the potential value of the industry, a programme was begun to introduce trochus to these islands. Figure 2 illustrates the history of this programme, giving the year and estimated number of trochus seeded to each island, from Aitutaki. Mature adult trochus (greater than 10cm basal diameter) were used in each case.

Of the nine Southern Group islands, only Aitutaki, Manuae, Palmerston, and, to some extent, Rarotonga, possess the area of reef flat and lagoon necessary to support commercially exploitable populations of trochus. The introductions to the

(7) Bour, W; F. Gohin and P. Bouchet p 8.

FIGURE 2 - TROCHUS INTRODUCTIONS TO THE SOUTHERN COOKS



other islands (Mangaia, Atiu, Mauke, and Mitiaro; all 'makatea' islands with narrow fringing reefs) were conducted with the intention of establishing trochus as a local dietary supplement. These islands may be capable of supporting small stocks, but commercial exploitation would inflict a heavy impact on the trochus population, for only minimal returns.

Figure 3 describes the observed or reported status of the introduced stocks in each island. While it is too soon to estimate sustainable stock and yield figures for when the populations are fully established, the limited viability of trochus on the 'makatea' islands, which had been predicted, is here clearly evidenced. The introduction to Palmerston was reportedly highly successful, and one may confidently assume the same for Manuae. Trochus have not been introduced to Takutea, a small, unihabited, low "makatea" island.

FIGURE 3 - SUCCESS OF TROCHUS INTRODUCTIONS TO SOUTHERN COOKS

ISLAND	INTRODUCED	PRESENT STATUS	SOURCE
PALMERSTON (Atoll)	1981 - 2000 1982 - 1000	Abundant	Local reports
MANUAE (Enclosed Atoll)	1981 - 500	?	Uninhabited
RAROTONGA (High, with barrier/fringe reef)	1983 - 200	Rare/extinct	Local reports Fish. survey (1984)
ATIU (High makatea, with fringe reef)	1982 - 300	Rare/extinct	Local reports
MAUKE (High makatea, with fringe reef)	1983 - 300	Rare/extinct	Local reports
MITIARO (High makatea, with fringe reef)	1982 - 300	Rare/extinct	Local reports Fish. survey (1984)
MANGAIA (High makatea, with fringe reef)	1983 - 300	Rare	Local reports Fish. survey (1984)
TAKUTEA (Low, with fringe reef)	None	?	Uninhabited

THE FUTURE OF THE COOK ISLANDS' TROCHUS INDUSTRY

If the trochus industry in the Cook Islands were to realize its fullest potential, the average annual production would probably not much exceed 200 tonnes. At current prices, however, this represents a foreign exchange earning of approximately US$160,000, and an increase in the per capita G.D.P. for the Cook Islands of almost US$10, per annum. There are several obvious steps which need to be taken before such a tangible development goal is attained.

Trochus has yet to be introduced to the atoll islands of the Northern Group, and yet it is these islands which should prove the most productive. While the benefits of a trochus hatchery programme to an already established industry have been outlined by Heslinga and Hillman (8,9, and 10), the ready availability of juvenile trochus for use as seed stock would also greatly extend the capability and effectiveness of an introduction programme. Any expansion of the trochus industry must be accompanied by the gathering of information on all aspects of trochus biology in the Cooks. The present pavcity of such knowledge is a considerable hindrance to the capability of management to make informed decisions.

(8) Heslinga, G.A. (1980) p 7
(9) Heslinga, G.A. (1981) p 45
(10) Heslinga, G.A. and A. Hillman (1981) pp 41-2

(a) Introduction programme

Whilst representing a considerable investment, with the charter and equipping of the necessary vessel or aeroplane to transport the seed stock, the introduction of trochus to the islands of the Northern Group would, in the long term, provide such a substantial return, that the initial expenditure is easily justified. (See Appendix III). In order for exploitable stocks to become established as soon as possible, the introduction programme should begin immediately. Despite the benefits of hatchery produced juveniles to such a programme, neither development should await the advent of the other. The density dependence of breeding success is obvious, (although no data are available), and seedings should be in the order of thousands, rather than hundreds, as have been conducted previously.

It is doubtful whether Rakahanga or Nassau could support exploitable stocks of trochus, and introductions to these two islands, and the reseeding of the high islands of the Southern group, should be accorded lesser priority.

(b) Trochus Hatchery

The proposed establishment of a trochus hatchery on Aitutaki, based on those in operation at the M.M.D.C., deserves special attention in the Cook Islands, as not only would a

hatchery enable supplementary recruitment programmes to be undertaken, (as outlined in 8,9, and 10), allowing an increased maximum sustainable yield, and greater economic returns, but the production of juvenile trochus from such a hatchery would allow the introduction programme to be conducted employing large numbers of these smaller trochus. This would enable perhaps over ten times more trochus to be seeded during each operation than if larger, heavier individuals were used, for an equitable cost. Bour, Gohin and Bouchet (1982) assume natural mortality is independant of age, and if this is so, there would be no disadvantages in using juveniles as seed stock. However, further work on age-specific mortalities in the wild is required to validate this assumption.

A hatchery capable of producing 50-100,000 juvenile trochus per year would be more than adequate. The heaviest expenses to be incurred, once the hatchery has been constructed, would be those involved in transporting the trochus to the island where they are to be planted. The juveniles could be flown to Penrhyn or Rakahanga, and then by ship to their destination, or a vessel with a wet hold, or bait tanks, could be used from Aitutaki.

Once the population are established, seedings could be conducted either yearly to each island, or, on a rotational basis. Preferably, the seeded stock would incur minimal

fishing mortality, so that the majority could attain the maximum fecundity size-classes (greater than 12cm) (11) and the benefits of the programme would be realized through increased natural recruitment. To this end, juveniles would be seeded in reserve areas, or, if under a rotating reserve system, in areas that will be reserved when the seeded cohort is most vulnerable to fishing (8-10cm size class).

(c) Review of Management Strategies

With the exception of the hatchery developments at M.M.D.C., no new management tools are available for utilization in maintaining trochus stocks. Size restrictions, seasons, involving licences and quotas, and reserves, remain the principal mechanisms for the regulation of harvesting. The failure of such measures is evidently more a problem of enforcement than of errors of judgement on the part of management personnel. (12). One possible answer is to impose the emphasis of the regulations at the buyer level, where there is perhaps greater responsibility, or at least, easier enforcement. Current management policies do need reviewing, and with the careful monitoring of trochus populations, the effectiveness of each method may be evaluated, and the strategy as a whole strengthened.

In accordance with Bour, Gochin, and Bouchet (13), size restrictions should be imposed that provide maximum economic

(11) Heslinga, G.A. 1981 p 44
(12) Heslinga, G.A. and A. Hillman (1981) pp41-2
(13) Bour, W. et al (1982) pp 40-3

yield per recruit. The optimum harvest size for New Caledonia was estimated at 9cm basal diameter. Size restrictions for the Cook Islands should be narrowed to between 8cm and 10cm basal diameter (from, previously, 8-12.5cm). These limits would encourage fishing of the youngest, most valuable, and least fecund adults. Such a step would also provide for regular, yearly harvesting, and with co-ordinated hatchery seedings, rational quotas, and reserve declarations, sufficient of each cohort should attain the larger sizes to maintain future recruitment levels.

Whilst the declaration of reserves 'in perpetuity' would ensure some of the population fulfill their maximum reproductive potential (with highest fecundity realized within a region of greatest trochus density), such a system may not be the most economically productive. Rotation of reserves, with each reserve, maintained for a period of four years, would allow trochus in the 6-8cm size class, in the reserve area, to outgrow the legal size limits, and an entire, or even hatchery supplemented cohort, would escape any fishing mortality. Although the specific requirements for a rotating reserve system are difficult to predict without further information on the density dependance of breeding success rates, and population responses to different fishing pressures, the system should be established, and developed as contingencies warrant, or as

further supportive data become available.

The quota system should be maintained, and used to protect vulnerable stocks, outside of the reserves, from a too intensive fishing effort. A certain, as yet indeterminable percentage of each cohort should be allowed through to the larger size-classes. An effective technique for rapid estimation of population numbers and structure should be developed, to allow quota limits to be set with confidence. If sufficient recruitment can be provided by hatchery supplementation, and reserves, then fishing mortality, in the vulnerable stocks, may be allowed to run as high as 100% of the 8-10cm size class.

The current practice of licensing trochus fishermen could be more fully utilized. To prevent quota over-runs or stock-piling during off-seasons, the quota for each season could be distributed among the licensed fishermen, with the buyer only allowed to purchase a set amount from each license holder. Such individual quotas would also maximise the economic return per capture, as shell quality would become of greater concern at the fishing level. This increased selectivity implies, however, a greater fishing effort, and the concept itself may meet with some industry disaffection.

An attempt should also be made to initiate the compilation of catch records by fishermen, possibly as an obligation of a license. Alternatively, fisheries officers could collect such statistics through interviews, and catch sampling.

To prevent the manipulation of the industry, which has been evident in the past, a regular, yearly harvest season, of fixed duration should be established. Each year, then, the only negotiable aspect would be the allowable quota.

The above management policies have all been suggested on the basis of the minimal knowledge of trochus biology in Polynesia, and inferences from work in Micronesia and Melanesia. Responsible, confident decisions can only be made after the necessary research into the reproduction and dynamics of trochus populations in the Eastern Pacific has been conducted. This research involves both emulation of previous studies in the Western Pacific, and increasing understanding of the response of trochus populations to various fishing intensities and management approaches.

APPENDIX I

Interspecific Interaction of Trochus with Turbinidae

Turbo sp (T. argyrostomus and or T. setosus) shares a similar ecological niche with trochus, (14), and though of no economic value, it is a food much preferred by local people. Little previous consideration has been given to the interaction between trochus and Turbo sp, and such local reports as those received from Aitutaki are the only basis for inferences of competitive exclusion of one by the other.

Tectus pyramis reportedly outcompetes trochus on some New Caledonian reefs (15) but there is no record of the species from the Cook Islands.

(14) Sims N.A. unp.
(15) Bour, W. et al p 4

APPENDIX II

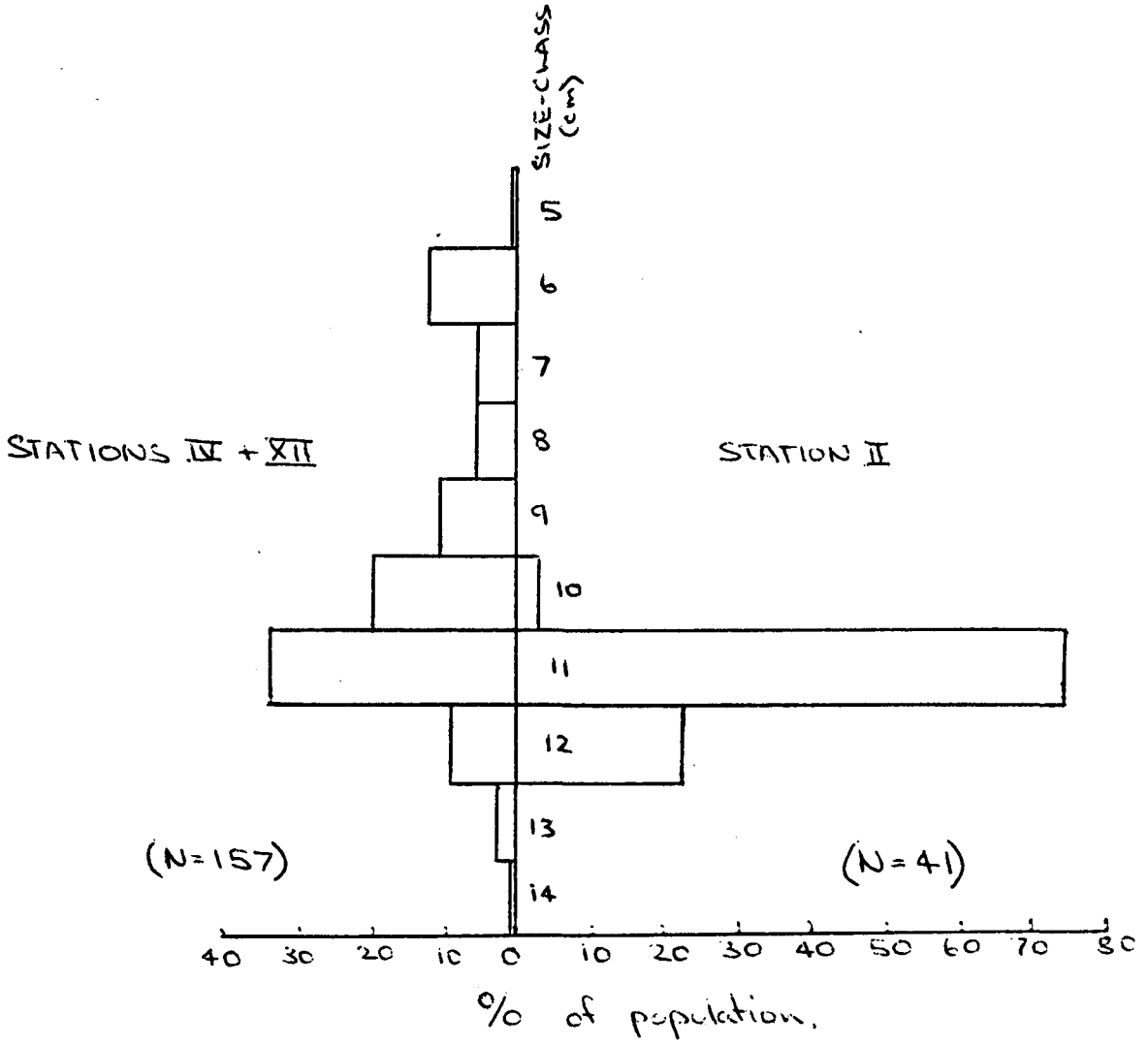
1983-84 Harvest Impact

The estimated harvest impact of 31% of the trochus population may be considered moderate, but a post-harvest survey of size-class distributions at three Stations indicates a heavy fishing mortality on the 8-10cm size-class, in areas which were intensively fished. (Figure 4). However, these data are limited by the absence of a pre-harvest size-class survey, or catch-effort data, and the moderately fished areas also show some decline in this age-class; possibly a result of reduced recruitment stemming from the depletion of the breeding stocks during the 1980 harvest.

Figure 5 illustrates the only catch statistics available from the 1983-84 harvest. (K. Sadaraka, pers. comm.). The decreasing ratio of Grade A to Grade B shell reflects the heavy fishing mortality on these smaller size classes. 12.4 tonnes of Grade A shell were taken in January, and, (if it is assumed that the 8-10cm size-classes represent Grade A shell), Figure 4 indicates considerable stocks of Grade A shell remaining. However, the allowable fishing mortality for these size classes is, as yet, indeterminable. The 'crash' of fisheries under heavy exploitation is well documented, and

FIGURE 4 - SIZE-CLASS DISTRIBUTIONS AT THREE STATIONS ON AITUTAKI. (POST-HARVEST, 1984)

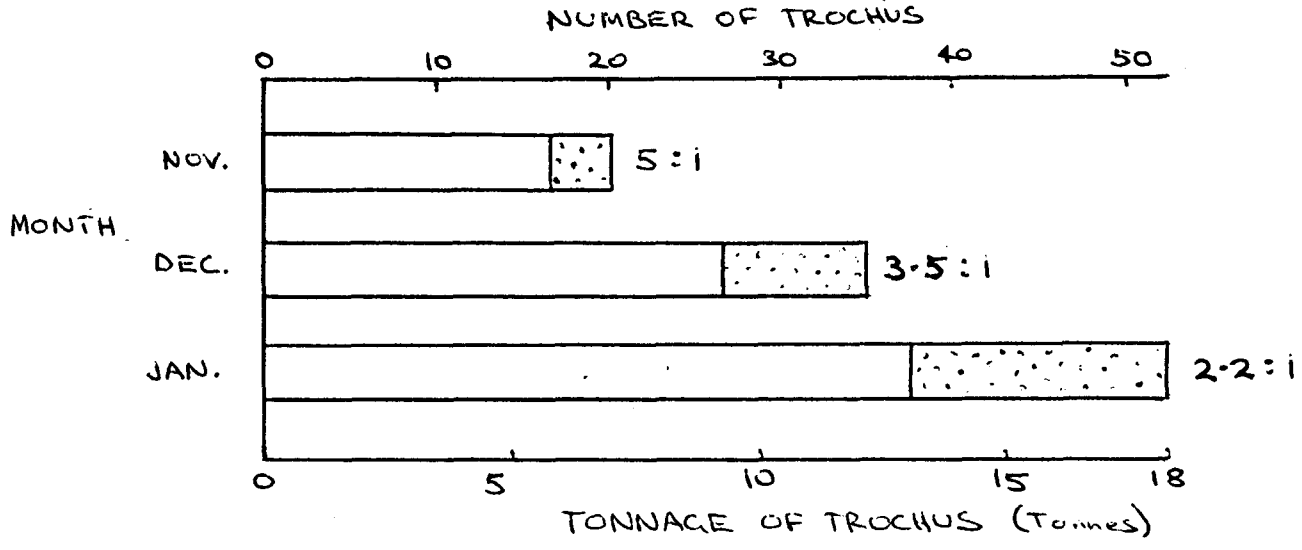
Reduced recruitment, resulting from the decimation of stocks during the 1981 harvest season, is evident in the depletion of the 7-10cm size-classes, in the moderately fished areas (STNS IV + XII) In the heavily fished region, (STN II), this depletion is almost total, reflecting the high fishing mortality suffered by these size-classes.



8 cm size class = Trochus with basal diameter 8 to 9 cm.

FIGURE 5 - TROCHUS HARVESTED NOVEMBER 1983 TO JANUARY 1984, BY GRADE.

The increase in total catch is due to increased effort, with the advent of the school holidays. The decreasing ratio of Grade A : Grade B reflects a decreasing catch per unit effort (C.P.U.E.).



Numbers beside bars indicate ratio of Grade A : Grade B shell.

Tonnage is for cleaned shell.

has always been preceded by indications of decreasing catch per unit effort. The decreasing ratio of Grade A to Grade B shell may be taken as such an indication.

APPENDIX III

Implementation of the Introduction Programme to the Northern Group

Action		Projected cost
1.	Air transfer 4,000 live 8cm (150g) (see Note 1) trochus from Aitutaki to Penrhyn. :	$ 5,200 (see Note 2)
2.	Hold 3,000 in holding tanks. Release 1,000 at Penrhyn. Tanks :	$ 500
3.	Transfer, via M.V. Ravakai (or other) of 3,000 trochus: 1,000 each to Manihiki, Pukapuka, and Suwarrow. Charter, 5 days at $350/day:	1,750
	Total cost initial transfer:	$ 7,450
	Susequent transfers (2, at least) at $6,950	$13,900
	Total cost of programme	$21,350

Projected Annual Revenue (After approx 10 years (See note 3))

Production from each island of say, 30 tonnes, at $1,200/tonne	$36,000
For four atoll islands	$144,000

All Figures are NZ$

Note 1: If hatchery trochus are available at less than 6cm (50g), approximately 15,000 trochus may be transferred for comparable cost.

Note 2: The possibility of obtaining assistance from NZRAF or MOT, utilizing their regular flights, should be investigated.

Note 3: If hatchery trochus are available this "gestation" period could be considerably lessened.

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