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THE AITUTAKI EXPERIENCE IN THE DEVELOPMENT OF MANAGEMENT
STRATEGIES FOR THE TROCHUS FISHERY (COOK ISLANDS)

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Summary

The commercial exploitation of *Trochus niloticus* from Aitutaki began in 1981 with limited controls. This resulted in approximately 200 tonnes (dry shell weight) taken from an area of 460 hectares of known trochus habitat, over a period of fifteen months. In the past years, the Ministry of Marine Resources and the Aitutaki Island Council have used a combination of regulations to counteract the problem of overfishing in order to ensure the long term viability of the trochus fishery. The fishery is now managed through the use of the following regulations: short harvesting seasons; minimum and maximum (8 - 11 cm) size limits; limiting the catch to 60 % (originally, approximately 30%) of the harvestable stock, i.e. 8 - 11 cm basal diameter size range; and the use of Individual Transferable Quotas (ITQ's). (Zoutendyk and Passfield 1989). Government intervention through fisheries management strategies resulted in the trochus resource being utilised on a sustainable basis with the economic benefits of the resource made available to the resident population of Aitutaki.

A total of 280 *T. niloticus* were first introduced to Aitutaki in 1957. During the early 1980's attempts were made to introduce trochus to other islands from Aitutaki. The sole purpose of this, was to establish a future commercial fishery. During the 24 year period between the introduction of trochus to Aitutaki and the establishment of a commercial fishery, harvesting of the species was prohibited, to allow the stock to reach commercial levels. However, special permission was granted for the transfer of trochus to other islands. Trochus is currently only commercially exploited on Aitutaki, when the standing stock reaches approximately 550 - 650 shells per hectare. Trochus (dry shell weight) yields from Aitutaki range from 200 tonnes to 18 tonnes with an average (excluding the first harvest) of 32 tonnes.

Trochus populations on Rarotonga, Manihiki, Penrhyn and Palmerston Island are now well established however have not reached commercially exploitable levels and in the case of Rarotonga trochus are currently harvested for local consumption. The focus of this paper therefore will be based on the development of management strategies for the Aitutaki Trochus fishery.

Management of the Aitutaki Trochus Fishery

Currently the Marine Resources Act 1989 and the Aitutaki Fisheries Protection By-Laws 1990 are the only two statutes which apply to the trochus fishery. From the establishment of the trochus fishery on Aitutaki a management plan was developed by drawing on examples from trochus fisheries elsewhere and experience from past harvests on Aitutaki (FFA Report No.93/25). The aim for the development of an effective management plan was to maintain a catch as large as possible which would be profitable to the community and not biologically jeopardise the renewability of the resource. Table 1. Illustrates the development of management strategies for the Aitutaki trochus fishery in chronological order.

The management strategies put into practice for the Aitutaki trochus fishery are briefly summarised below.

Harvest season

The harvesting seasons following the 1981 harvest were very limited in duration ranging from one day to 3 months. Initial harvest seasons were declared arbitrarily. However due to actual yields grossly exceeding that of the set quota, harvest duration was then determined by the estimated time to attain the allocated quota. This system alone proved ineffective in controlling the allocated catch quotas. In 1987 the harvest duration's were allocated as separate 24 hour periods. The harvest seasons, were then closed when yields were pretty much close to the allocated total catch quota. The introduction of 24hr pulse fishing periods appears to have successfully minimised quota overruns.

Catch limits

It has been difficult to determine how the first two catch quotas were achieved, however after the second harvest season quotas were calculated as approximately 30% of the assessed biomass of 8 - 11cm shells. During the 1990/91 and 1992 harvest, the total allowable catch quotas were set at 60% of the assessed standing stock of legal size shells.

Trochus harvest inspectors are required to monitor all landing sites as the harvest progressed. This has proved logistically impossible (Sims. 1988).

Trochus reserve

A breeding reserve was introduced in 1983 which covers a 3km stretch of the windward reef of Aitutaki. The location of the reserve was designed to promote retention of plankton larvae in the lagoon (Sims. 1988). Pre- and post-harvest surveys in the reserve suggested that poaching has occurred in the reserve (Sims. 1988).

Size limits

Legal size limits were introduced after the establishment of the fishery and have changed over the years from the experience gained in each harvest. A minimum size limit of 8cm was imposed during the first harvest (Clark. D. pers.comm.). Experience from other trochus fisheries has indicated that trochus reach reproductive maturity at around 6-7cm basal diameter. A minimum size limit of 8cm allows most young trochus the opportunity to spawn before becoming vulnerable to fishing pressure.

During the first harvest season trochus buyers were reluctant to purchase large wormy shells, the outcome of this was the introduction of a maximum size limit of 12.5cm (basal diameter) during the 1983 harvest season. In 1984 the maximum size limit was reduced to 11cm (Bour. 1988). This appears to have successfully improved the value of the total catch. The maximum size limit was designed to limit the taking of low value (wormy) shells and preserve the more fecund animals within the population.

Licensing

Licensing of divers was first introduced in 1983 and is currently a requirement under law.

Trochus kept alive

There is a requirement that all harvested trochus must be kept alive until approved by a harvest inspector. This allows for the illegally harvested shells to be returned to the water.

Individual Transferable Quotas

During the 1990/91 harvest an Individual Transferable Quota (ITQ) system was introduced to control the problems with quota overruns. To determine the ITQ, the allocated total catch quota is divided evenly between all resident individuals of Aitutaki during the allocated harvest season, regardless of the desire to participate, age or actual ability to harvest trochus (Zoutendyk. 1990).

The ITQ as a management tool appears to be most favoured by the community, as all individuals receive an equal share of the economic benefits. The introduction of ITQ's was a success in reducing quota overruns, it also minimised the risk of stock piling prior to harvest seasons. ITQ's also have the added potential to increase the value of the total catch (Fishers are more inclined to fill their quota with high valued shells). ITQ's will most certainly be used in future harvest.

Table 1: A chronological history on the development of management strategies for the Aitutaki trochus fishery. (Tonnes expressed as dry shell weight)

Management strategies practiced during each harvest	The actual occurrence during each harvest season	Comments
1981/82 harvest season		
A short harvest season of 3 months was declared.	The actual harvest season, 15 months.	The harvest season was decided arbitrarily.

Harvest-able quota was set as 30 tonnes.	Approximately 200 tonnes of trochus shell was collected.	Records do not show how this quota was determined, probably by speculation ?.
Size limits.	?	A minimum size limit of 8cm (basal diameter) was imposed.

1983 harvest season

Three months was declared as the harvest season.	The actual duration of the harvest, three months.	The harvest season was determined by estimating the time to attain the set quota.
Harvest-able quota set as 20 tonnes.	A total of 35.7 tonnes harvested.	This quota was probably determined by speculation ?.
Legal size limits.	Illegal size trochus harvested were confiscated by harvest inspectors prior to processing.	The minimum size of 8 cm was maintained a maximum size limit of 12.5 cm basal diameter was introduced to remove poor grade (wormy) shells from the total catch.
Established a trochus reserve.	Poaching occurred in the reserve.	Three kilometres of stretch of windward reef was designated as a trochus reserve. The size of the reef was decided arbitrarily. Harvesting in the reserve occurred due to poor enforcement efforts.
Licences issued.	42 licences issued.	Licences cost, NZ \$1.00.
Trochus must be kept alive prior to inspection.	Illegal size shells were confiscated prior to processing.	Confiscated shells were returned to the lagoon.

1984 harvest season

Three months declared as the harvest season.	The actual harvest season, 12 days.	The harvest season was reduced due to the total catch grossly exceeding the set quota.
Harvest-able quota set as 20 tonnes.	A total of 45.7 tonnes harvested.	The quota was calculated as 30% of the harvest-able stock (8 - 11 cm size range).
Legal size limits.	Inspectors removed undersized and oversize shells prior to processing.	The minimum size limit was maintained however the upper size limit was reduced to 11cm (Bour. 1988), probably due to parasitic infestation on large shells. This has successfully improved the total catch value.
Maintained trochus reserve.	Poaching occurred in the reserve.	Harvesting in the reserve occurred due to poor enforcement.
Licences issued.	300 licences issued.	Licences cost, NZ \$1.00.

Trochus must be kept alive prior to inspection.	Illegal size shells were confiscated prior to processing.	Confiscated shells were returned to the lagoon.
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1985 harvest season

Three days was declared as the harvest season.	The actual harvest season, three days.	The harvest season was determined by estimating the time to attain the set quota.
Harvest-able quota was set at 20 tonnes.	A total of 27 tonnes was harvested.	Quota was set at 30% of the harvest-able stock..
Legal size limits	Illegal size trochus harvested were confiscated by harvest inspectors.	The legal size for trochus was maintained as animals with a basal diameter of 8 - 11 cm size range.
Maintained trochus reserve.	Harvesting occurred in the reserve.	Harvesting in the reserve occurred due to poor enforcement. This was suggested by surveys conducted in the reserve before and after the harvest season.
Licences issued.	250 licences issued.	Licences cost, NZ \$1.00.
Trochus must be kept alive prior to inspection.	Illegal size shells were confiscated prior to processing.	Confiscated shells were returned to the lagoon.

1987 harvest season

Two days declared as the harvest season.	The actual harvest season, two days.	The season was divided into two separate 24 hour periods till the quota was reached. This was introduced to prevent harvest overruns.
Harvest-able quota set at 40 tonnes.	A total of 45.1 tonnes harvested. Stock piling took place prior to the opening of the fishing season (Terekia. O. pers.comm.).	Quota set at 30% of the harvest-able stock . Stock piling prior to any harvest allow the fishers to achieve a large catch during the harvest duration.
Legal size limits.	Illegal size trochus harvested were confiscated by harvest inspectors prior to processing.	The legal size for trochus was maintained as animals with a basal diameter of 8 - 11 cm.
Maintained trochus reserve.	There were rumours that poaching just before the harvesting occurred in the reserve (Terekia. O. pers.comm.).	More effort was placed on enforcement.
Licences issued.	190 licences issued (day 1) 233 licences issued (day 2)	License issued for the first 24 hour harvest period was valid for the second 24 hour period. The cost of licenses remained at NZ \$1.00.

Trochus must be kept alive prior to inspection.	Approximately 350kg of processed shell was confiscated since they were processed without the knowledge of harvest inspectors.	The confiscated shells were later returned to the fishers, as ordered by the Island Council, without any form of prosecution (Terekia. O. <i>pers. comm.</i>).
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1988 harvest season

One day declared as the harvest season.	The actual harvest season, one day.	
Harvest-able quota was set at 20 tonnes.	A total of 18 tonnes harvested.	Quota set at less than 30% of the harvest-able stock (8 - 11 cm) (Zoutendyk and Passfield 1989).
Legal size limits.	Illegal size trochus harvested were confiscated by harvest inspectors.	The legal size for trochus was maintained as animals with a basal diameter of 8 - 11 cm size range. Confiscated animals were distributed throughout the lagoon.
Maintained trochus reserve.	Poaching just before the harvesting occurred in the reserve.	More effort was placed on the enforcement of the reserve during the harvest.

1990/91 harvest season

Five days declared as the harvest season.	The actual harvest season, five days.	
Harvest-able quota set at 25 tonnes.	A total of 26.2 tonnes harvested.	The quota was set at 60% of the harvest-able stock, (8 - 11 cm) size range. The introduction of ITQ's seems to have solved the problem of excess quota overruns.
Legal size limits.	Inspectors removed undersized and oversize shells from the catch prior to processing.	The minimum size limit was maintained at 8-11 cm basal diameter.
Maintained trochus reserve.	Harvesting occurred in reserve.	More efforts were exerted in enforcing the reserve. The total ITQ allocated to fishers who were caught poaching the reserve were confiscated by the inspectors, however they were later returned as ordered by the Island Council, without any form of prosecution.
Licences issued.	2,250 licenses issued.	The cost of licenses remained at NZ \$1.00.

Trochus must be kept alive prior to inspection.	Illegal size shells were confiscated prior to processing.	
Introduced Individual Transferable Quotas (ITQ).	15 kg allocated to all individuals, regardless of age, actual ability or desire to participate in the harvest.	It was difficult for fishers to reach there allocated quota, therefore a large proportion of wormy shells were collected.

1992 harvest season

Pulse fishing of 24hr periods.	The actual harvest season, 17 days.	A series of 24hr pulse fishing periods were declared until the catch approached the allocated quota.
The quota was set at 25 tonnes.	The actual harvested, 27 tonnes.	Because of the nature of the harvest few fishers participated, it therefore became difficult to achieve the allocated quota.
Legal size limits.	Inspectors removed undersized and oversize shells prior to processing.	The minimum size limit was maintained at 8cm, however during the progress of the harvest the maximum size limit was increased from 11cm to 12cm to allow for the allocated quota to be attained.
Maintained trochus reserve.	Harvesting occurred in reserve.	Poor reserve enforcement resulted in poaching. This was probably due to the efforts and results of the enforcement officers being overlooked during past harvest seasons.
Trochus must be kept alive prior to inspection.	Illegal size shells were confiscated prior to processing.	Confiscated shells were returned to the lagoon.

During 1992 there was a great need for finance to complete an Aitutaki community project. It was decided that the revenue received from the trochus harvest for that year be directed towards the completion of the community project. A series of 24hr pulse fishing periods was declared till the allocated quota of 25 tonnes was achieved. However as the harvest progressed it became difficult to obtain the allocated quota with legal size shell. The upper size limit was then increase to 12cm basal diameter.

Stock assessment results after the 1992 harvest have indicated that the standing stock of trochus to date, have not reached commercially exploitable levels (Figure 1).

Possible reasons and causes for the slow recovery in the population are as follows:-

- the assessment of the trochus population or interpretation of the assessment result could have been incorrectly performed,
- the use of 60% as a guideline in which quotas are currently set may be an unreasonable figure, as a means of determining the allowable catch,
- from a more cynical point of view, pressure from short-sighted bureaucrats who required a quick source of cash in order to complete a community project, could have played a role in the determining of a high quota.

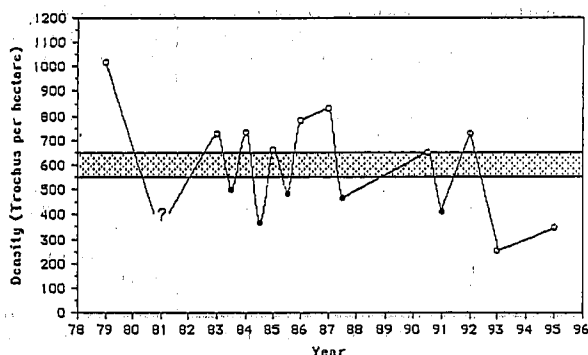


Figure 1. The history of density estimates (individuals / hectare) for the Aitutaki trochus resources. The closed circles represents post harvest density estimates. The shaded bar indicates the approximate density guideline in which trochus harvest are declared.

It is illustrated in Figure 1. that harvest occurred annually between 1983 to 1985 and should have occurred in 1986. This would have allowed for five successive annual harvest. Harvest-able quotas for the period were determined as approximately 30% of the standing fishable biomass.

Conclusion

During the development of the trochus fishery, established management tools were improved and others introduced. This has evolved into a management plan for the fishery which has proven to be a very effective mechanism in achieving most of its goals. In the near future there is a need to further investigate a more applicable figure (between 30 to 60%) in which harvest quotas are calculated. There is also a need to ensure that the reserve is strictly enforced, and poaches prosecuted in order to reduce future poaching. Further trends in the future are to produce a simple handbook on how to assess the trochus population and interpret field data on Aitutaki and possibly the development of a computer program in which catch quotas and individual transferable quotas are determined. This would most certainly reduce the risk of errors in stock assessment and analysis. Hopefully this will ensure that it becomes difficult for bureaucrats to tinker with the system.

It is anticipated that these goals will be achieved prior to the exploitation of trochus resources from other islands within the Cook Islands.

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the fact that the $\mathcal{H}^1$ -norm of the function $\mathbf{u}$ is bounded by the $\mathcal{H}^1$ -norm of the function $\mathbf{f}$ (see [10, Theorem 1.1]). In the case of the $\mathcal{H}^1$ -norm, the function $\mathbf{u}$ is the unique solution of the problem (1.1)–(1.3) in the sense of distributions. In the case of the $\mathcal{H}^1$ -norm, the function $\mathbf{u}$ is the unique solution of the problem (1.1)–(1.3) in the sense of distributions.

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