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STOCK ASSESSMENT OF PEARL-OYSTER RESOURCES IN THE COOK ISLANDS

by

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ABSTRACT

The aims and methods employed in recent pearl-oyster research in the Cook Islands are reviewed. The programme has involved assessment of the current status of stocks, measurement of the parameters of population dynamics, and examination of past and present fishing levels. The results are described, and their relevance to management and development of the resource is discussed.

1. INTRODUCTION

The pearl-shell fisheries of Manihiki and Penrhyn have been worked for over a century. It has only been since the late 1950's, however, that any serious efforts have been made to manage these most lucrative fisheries. Beginning with the work of Ron Powell and Stan Hynd, ad-hoc stock assessment surveys have been conducted, usually in association with calls for the opening of harvest seasons. The results of these surveys have, unfortunately, never been published, and have long since been lost. The only extant data is the annual pearl-shell production and export figures, and a preliminary report of the early Manihiki work (Hynd, 1960).

In the Gambier-Tuamotu archipelagos of French Polynesia, a pearl-oyster stock assessment programme has recently been undertaken (Intes and Coeroli, 1982; Intes, 1985; Intes et al, 1986). Relevant biological information for Pinctada margaritifera has also been collected in French Polynesia (eg Coeroli, et al. 1982; Intes, 1984), and from other work associated with pearl-oyster culture developments elsewhere (eg; Crossland, 1957; Hynd, 1960; Tranter, 1958, and Reed, 1962). This work, and its significance to management of pearl-oyster stocks is reviewed elsewhere (See pearl-oyster review paper this meeting).

2. AIMS

Recent pearl-oyster research activities in the Cook Islands have sought to provide the basic biological information necessary for rational management of stocks, and as a basis by which to plan for the development of pearl-culture industries. The specific aims of the programme are:

1. Stock Assessment: To assess current stocks and their distribution:
   - determine total standing stocks
   - identify patterns of density and size-class distribution, w.r.t. depth, substrate, lagoon topography, etc.
2. Biological Parameters:To determine basic biological parameters governing stock dynamics:
   - growth, both as input for stock management models, and for comparative evaluation of pearl-culture trials
   - recruitment rates, and patterns of spat-fall
   - natural mortality in the wild, and under culture

3. The Fishery: To monitor current fishing levels, and impacts on stocks:
   - commercial production values, level of activities, catches, and fishing mortalities in each fishery

METHODS

1. Surveys : SCUBA transects at randomly selected sites:
   - length and width of transects dependant on depth, abundance of pearl-oysters, number and experience of searchers,and allowable bottom-time limits. Transects ranged from 10-130m long, and 2-8m wide
   - density distribution patterns used to estimate total standing stocks (eg:density-depth relationship used with bathymetric maps, or other obvious density patterns
   - substrate quality estimated subjectively

2. (a) Growth:
   - tagged oysters, using dorsi-ventral measurement (D.V.M.) and heel-depth (H.D.) as growth parameters
   - comparison of growth rates under under natural conditions (differing depth trials), and under various culture conditions (flat platform, suspended under platform, suspended under long-line)
   - comparison of growth rates within, and between lagoons, with several trials through Manihiki lagoon, and trials in Penrhyn and Suwarrow lagoons (extant stocks), and Pukapuka and Rakahanga lagoons (introduced stocks).

   (b) (i) Mortality and (ii) Recruitment:
   - year-by-year recruitment rates monitored from commercial spat-collector records (Manihiki, Rakahanga and Suwarrow)
   - standing/fixed transects established in Manihiki for monitoring natural recruitment and mortality rates
   - mortalities from growth trials provide relative natural mortality rates between lagoons, and between treatments (Manihiki, Penrhyn, Suwarrow, Rakahanga, and Pukapuka)

3. Compilation of production and export data, from historical records, recent records from pearl-shell traders (as available) and monitoring of catch/effort data from 'creel-census' type survey (Penrhyn only)

RESULTS

1. Surveys : (a) Manihiki:
   - standing stock estimated at around 2.0 million pearl-oysters (using bathymetric map)
   - no oysters below 120 ft depth, very few (and those only juveniles) above 30 ft depth
   - total average density 6.7 / 100 m sq
   - densities highly variable, (markedly clumped pattern)
   - general trends of increasing density with (i) increasing depth, (ii) increasing substrate 'quality', and (iii) towards the centre of the lagoon
   - greatest densities in 90-119 ft depth strata (average of 11.6 / 100 m sq)
   - significant correlation of increasing shell diameter with increasing depth (at $p = 0.05$)

- mean shell diameter for population of 134 mm

(b) Penrhyn:
- standing stock estimated at 4.0 to 6.2 million pearl-oysters (using N-S gradient of density distribution)
- no oysters below 120 ft depth, low densities (less than 2/100 m sq) in 0-29 ft and 30-59 ft depth strata
- total average density of 3.1 / 100 m sq
- densities highly variable, (markedly clumped pattern)
- broad trend of increasing density with depth, but greatest density in 60-89 ft stratum (8.2 / 100 m sq)
- gradient of increasing density from southern to northern end of lagoon
- no significant relationship between size-class distribution and other parameters
- mean shell diameter of 150 mm (n=25) is greater than that of Manihiki (almost significant at $p = 0.05$)

(c) Suwarrow:
- standing stock estimated at 400,000 pearl-oysters
- densities very low, no oysters below 120 ft
- total average density of 0.4 / 100 m sq
- oysters encountered in survey only in southern sector of lagoon; incidental observations found others in western sector, and near passage (in North)
- heavy juvenile predation evident (small shell fragments common)
- mean shell diameter of 155 mm (n=14) is greater than that of Manihiki (significant at $p = 0.05$), but not significantly greater than that of Penrhyn

2. (a) Growth rates:
- faster on sand substrate than on rock
- faster on culture lines than on wooden platforms
- not significantly different between Manihiki and Rakahanga lagoons
- not calculable for Suwarrow (heavy predation gave low tagged oyster recoveries, with final n=13)

(b)(i) Mortalities:
- very heavy in Suwarrow (58% loss over 0.58 yrs), with calculated $Z = 1.53$, using observed losses, (ie. artificial M, assuming F=0. Not natural M, as detached oysters more susceptible to predation)
- moderate in Manihiki, (27% loss over 1.05 yrs), with $Z = 0.30$, using observed losses, (ie. artificial M, as above), and $Z = 0.15$ (using estimated K, L(inf), mean L, and L(min) from growth and population data)

(ii) Recruitment:
- uneven distribution of spat-falls within lagoons
- two major spat-fall seasons, in Aug-Sept, and Feb-Mar
- highly variable in time and space from year-to year
- fixed quadrats established at 6 stations in Manihiki

3. Production figures:
- reliable production and export figures up to 1981
- more recent figures available from only one trader
- catch/effort data collection in progress in Penrhyn

DISCUSSION

(a) Stock Assessment

The SCUBA-transect method employed for estimation of standing stocks was the most appropriate, given the limitations of man-power and logistics. The high variability encountered in pearl-oyster densities suggest that larger transects might have provided more accurate estimates. High variability in observed densisties between stations, however, also indicates that larger numbers of stations would also be needed to overcome these inaccuracies.

The results of the initial surveys of the fixed-transects for mortality and recruitment studies (involving tagging of oysters and resurveying of transects), can be used to provide a measure of searcher efficiency in the SCUBA-transect survey work. Although final analysis of this data is pending, initial indications are that SCUBA-transect searchers may underestimate actual pearl-oyster densities by as much as 50%, depending on substrate rugosity, oyster density, transect width, etc.

Large survey scales (both area, time and effort) would be required to remove the variability from standing stock estimates. This implies that SCUBA-transects are not an efficient method of monitoring stock abundances as an ongoing management strategy (ie. annual surveys to estimate total allowable catches, as in trochus). However, the estimations obtained here can be used, together with approximations of the population dynamics parameters, to obtain indications of the current status of the stocks, and to predict resposes to future fishing pressures.

The absence of pearl-oysters below 120ft depth is significant, in view of the oft-quoted local belief (and in Hynd, 1960) that unfished stocks at depth act as a natural breeding reserve. Size-class and density distribution patterns appear to be closely correlated to patterns of fishing pressure, and may provide useful measures of the responses of stocks to future management strategies.

(b) Biological Parameters

The results of the growth rate experiment of culture techniques validate the directions which pearl-oyster culture developments have led. Further trials of location and treatment are underway to more accurately define the optimal holding situations for pearl-culture. The satisfactory growth results from Rakahanga lagoon are encouraging, and indicate that pearl-culture may yet prove to be, at least feasible, if not economically viable, in lagoons where pearl-oysters are not naturally found.

The use of D.V.M. and H.D. as parameters of growth are appropriate both as indicators of shell growth (and age-at-size, to provide information on the age structure of populations), and as a valid criterion for evaluation of commercial pearl-quality (see Coeroli and Mizuno, 1985, and Mizuno, 1983).

The evidence from the survey data and history of exploitation of Suwarrow stocks, suggest that the population

there has been fished down to a level where it is only marginally self-sustaining. Predation is evidently of great significance on stocks in this situation (uninhabited atoll, with an abundance of molluscivorous fishes and octopii) and similar constraints might be operating at a lesser level on stocks in Penrhyn lagoon (inhabited atoll, but with a large, deep lagoon, and similarly abundant oyster predators). This would explain the apparent marked decrease in pearl-shell production from these lagoons over the last century, and the slow recovery period of the populations. These inferences are of significance to management and development of these stocks, and call for concerted spat-collector trials in both lagoons.

(c) The Fishery

Historical records of production can be used, as say in Manihiki, to obtain estimates of the virgin standing stock levels. Such estimations are of relevance to identification of maximum advisable levels of standing stocks of cultured oysters.

Without accurate measures of past effort, the historical records themselves are limited as indicators of relative stock abundance through time. Even if some measure of effort were available, its significance would be lessened by the inherent inaccuracies in the data. (For example, effort as diver hours or diver days; considerations of diver efficiency including technique used, experience and working depth; and beach-price for shell, and other influences on incentive level.)

CONCLUSION

The pearl-oyster research programme in the Cook Islands has both given direction to development policies, and provided a rational basis for the resolution of management issues concerning the resource. In light of these findings, and other recent studies (particularly French Polynesia), the questions of approach and implementation of management strategies and development programmes have been reviewed. These discussions are detailed elsewhere. (See pearl-oyster review paper this meeting.)

Examination of the aims, methods, and results obtained during this study might also be of relevance to workers intending to, or in the process of, assessing the status of other valuable, vulnerable, sedentary resources in Pacific Island contexts.

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