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ASSESSMENT AND MANAGEMENT OF THE TROCHUS RESOURCE IN NEW CALEDONIA

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SUMMARY

Trochus niloticus is a large marine mollusc exploited for its nacreous shell. It is an important living resource for New Caledonia, from which it has been exported for over seventy years. The decline in trochus captures, after a record harvest in 1978 when 2 000 tonnes were exported, led the Territory to request ORSTOM to undertake a stock assessment by means of a systematic sample survey in the lagoon. From density measurements made at 312 stations, the total biomass and the exploitable biomass were estimated, for New Caledonia as a whole and for four main lagoon zones. The results obtained were included in a cohort analysis which has resulted in a better knowledge of the fluctuation of the fishing mortality coefficient, for each age class of the exploited trochus stock. On the basis of the data obtained from this survey and their structural analysis, a two-stage stock management strategy has been developed. The initial stage will start with a capture rate of 100 tonnes per year, gradually rising over five years to 400 tonnes per year. With the annual harvest kept to around 400 tonnes, the trochus fishery would then enter a "sustained production" stage that should, according to the model used and unless adverse climatic factors intervene, allow the exploitable biomass to be maintained at an optimum level. It would then be possible to ensure a regular supply of shells to local processing units, and thus to develop a small export industry of typically Pacific Island products.

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INTRODUCTION

New Caledonia, which is surrounded by one of the largest lagoons in the world, is a good reservoir of the Pacific species of trochus (Trochus niloticus). The shell of this marine gastropod yields one of the thickest, most resistant, most beautiful mother-of-pearl available on the world market.

Figure 1 shows fluctuations in trochus shell exports since 1907. The zig-zag curve reflects the vulnerability of the trochus stock, which is relatively easy to harvest, even by diving. Two major interruptions in commercial exploitation occurred, one during World War II and one during what is referred to as the "nickel boom" of the 60s. The end of the war and the mining slump in 1973 both gave rise to record trochus exports as a result of the long periods of stock regeneration.

1. SURVEY OF REEFS AND REEF FLATS SUITABLE FOR TROCHUS AND ASSESSMENT OF THE RESOURCE

1.1 Field sampling plan

Trochus colonies develop best on hard, creviced reefs and reef flats, generally consisting of dead coral heads and slabs encrusted with calcareous algae. This type of biotope is very common in the lagoon and the area to be inventoried was therefore very extensive.

During a first field trip, the sampling sites were marked out at random in the survey area, with the number of sites depending on the size of the reef to be sampled and our survey capability.

On each site, sampling was carried out as follows:

- along a transect: a strip about 2 metres wide was explored by two divers equipped with a flowmeter generally moving forward and then back over the same distance to allow for the current. The flowmeter enables the distance covered to be estimated. The trochus shells were counted on sight and a sample of sizes was measured.

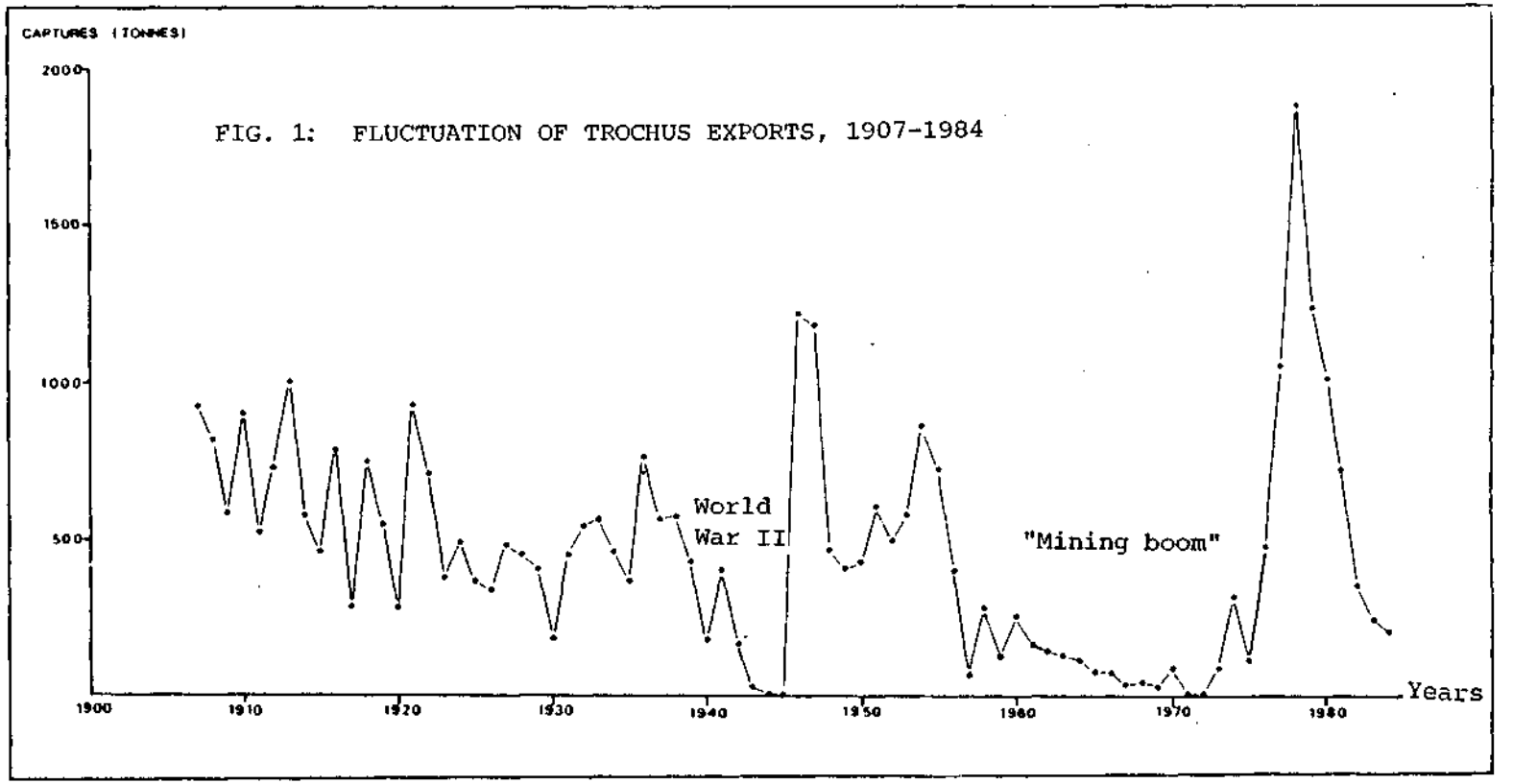


FIG. 1: FLUCTUATION OF TROCHUS EXPORTS, 1907-1984

- at a fixed station: a circular area with a radius of 3 metres, centred on a small buoy, was very thoroughly explored to assess the proportion of trochus shells hidden under coral blocks.

2. RESULTS OF THE SURVEY - DETERMINATION OF BASE DATA

2.1 Methods for calculating base data

2.1.1 Density

On each site, the area sampled was a rectangle having a width of 2 metres and a length equal to the distance covered along the transect. The number of trochus collected is converted into number of trochus per 1 000 m^2. This figure represents the density calculated for the station :D.

2.1.2 Measurement of areas

Assessment of the trochus population by numbers calls for an estimation of the area of reef they occupy.

The areas suitable for trochus were inventoried, their area was measured by planimetry on marine charts and aerial photos. On a trial basis, processing of LANDSAT images of three large reefs off the East coast was also carried out, to identify the biotope suitable for trochus and estimate its total area.

2.1.3 Trochus numbers and biomasses for the total population and for the exploitable stock

From known densities and areas the total number of trochus can be estimated. The mean weight of each sample was calculated using a size/weight ratio for the empty shell, previously determined during growth studies. In addition, from the size measurements it was possible to determine the percentage of trochus that are within the size range permitted by regulations since 1983 (9 to 12 cm). For each density, a mean weight value and a percentage thus allowed estimation of the total weight of empty shells, and the weight of exploitable empty shells. The flesh of a trochus accounts for about 15 per cent of its total weight and it is therefore easy to calculate the live weight. Since the useful value

of exportable empty shells, we shall define total biomass as the weight of empty shells of the total number of trochus, and exploitable biomass (or exploitable stock) as the weight of shells with a base diameter over 8 cm for the years 1978 to 1982, and between 9 and 12 cm for the years 1983 and 1984.

2.2 Presentation of results

2.2.1 Loyalty Islands and Isle of Pines

Trochus seem to have disappeared from these islands (one living trochus was found on Ouvea). It can be assumed that the trochus stocks there were depleted through over-fishing on the rather small reef flats and were gradually replaced in the same ecological niche by another species of the Trochidae family: Tectus pyramis which is not exploited and is plentiful in these islands.

2.2.2 Lagoon of Main Island

Our survey was divided into several large lagoon zones and the sum of the shell weights for each of these zones gives the overall state of the resource in 1984. Table 1 shows trochus numbers, weight and percantages for each zone.

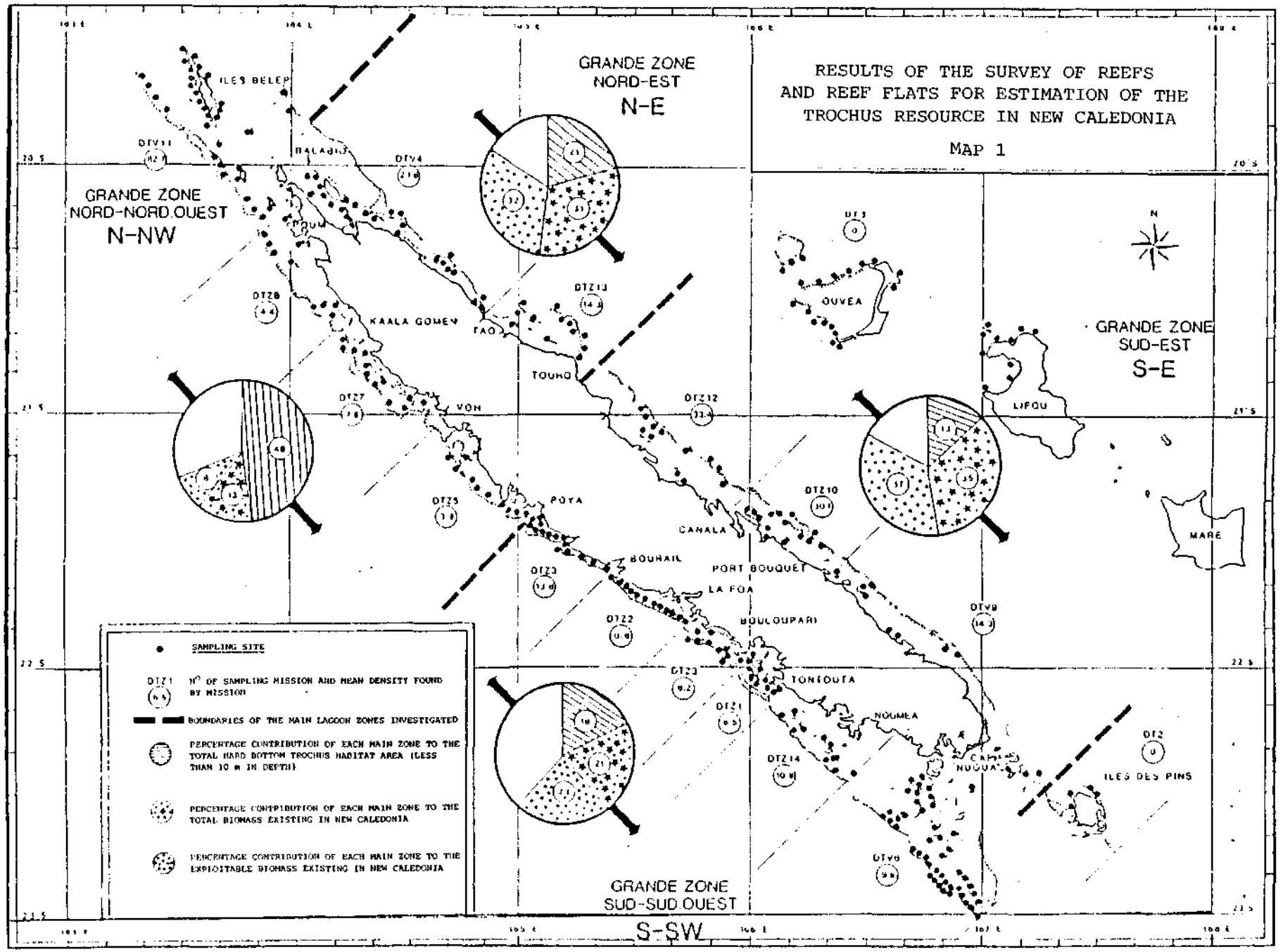
Map 1 shows the four main lagoon zones surveyed, with the distribution of the mean density calculated for each sampling trip and the respective contribution of these zones, in area and in total and exploitable biomasses, to the overall total.

2.3 Validity of results

A statistical study of the observed densities on certain transects enabled the standard error in relation to the mean to be estimated at 19%. The confidence interval (at $p = 0.95$) of the mean density would therefore be around $\pm$ 38%. The stochastic pattern of the survey plan suggests that the other sources of error (areas, extrapolations, mean weights) would be slight in comparision with the error on density. Biomasses would therefore be included in a confidence interval of about the same size, which is not a heavy handicap for the order of magnitude dealt with in this study.

Table 1. Summary of survey results, in values and percentages, by main lagoon zones.

Main lagoon zones	Surface area (x 1000 m^2)	%	Total Number of shells	%	Total live weight (kg)	%	Total weight of shells (kg)	%	Weight of exploitable shells ($9 < \emptyset < 12$) (kg)	%
S - SW	319 013	18	4 135 400	25	950 957	21	819 791	21	400 542	23
N - W	851 553	48	3 044 591	19	587 086	13	506 109	13	130 224	8
N - E	366 235	21	4 438 049	27	1 364 182	31	1 176 019	31	542 101	32
S - E	231 609	13	4 664 876	29	1 543 212	35	1 330 356	35	637 862	37
TOTAL	1 768 410	100	16 282 916	100	4 445 437	100	3 832 275	100	1 710 729	100


RESULTS OF THE SURVEY OF REEFS
AND REEF FLATS FOR ESTIMATION OF THE
TROCHUS RESOURCE IN NEW CALEDONIA
MAP 1
GRANDE ZONE
NORD-EST
N-E
GRANDE ZONE
NORD-NORD.OUEST
N-NW
GRANDE ZONE
SUD-EST
S-E
GRANDE ZONE
SUD-SUD.OUEST
S-SW
ILES BELEP
BALADE
KAALA GOMEN
FAO
TOUHO
VOH
POYA
CANALA
BOURAIL
PORT BOUQUET
LA FOA
BOULOUPARI
TONTOUTA
NOUMEA
CAP N.
OUVEA
LIFOU
MARE
ILES DES PINS
SAMPLING SITE
N° OF SAMPLING MISSION AND MEAN DENSITY FOUND BY MISSION
BOUNDARIES OF THE MAIN LAGOON ZONES INVESTIGATED
PERCENTAGE CONTRIBUTION OF EACH MAIN ZONE TO THE TOTAL HARD BOTTOM TROCHUS HABITAT AREA (LESS THAN 10 m IN DEPTH)
PERCENTAGE CONTRIBUTION OF EACH MAIN ZONE TO THE TOTAL BIOMASS EXISTING IN NEW CALEDONIA
PERCENTAGE CONTRIBUTION OF EACH MAIN ZONE TO THE EXPLOITABLE BIOMASS EXISTING IN NEW CALEDONIA

3. STATISTICAL ANALYSIS AND TROCHUS POPULATION DYNAMICS STUDY

3.1 Synthetic or global approach

The statistical data compiled for this study on trochus do not lend themselves very well to the use of a global model, of the Schaefer type for example. For one thing, the fishing effort must be known with a good degree of accuracy for it to be satisfactorily linked to catch. In our case, fishing effort could only be roughly estimated from the trochus fishing licences issued, and these are issued per craft and do not always indicate the number of crew members. Furthermore, this estimation includes neither casual fishing, which is quite considerable in the tribes and villages, nor undeclared commercial catches. Secondly, a global model assumes that the stock studied is subjected to a fishing pressure distributed at random over fishing grounds whose area does not vary too widely in time. In the case of trochus, considerable spatio-temporal fluctuation of the effort does occur (variable local interest in trochus fishing, variable difficulties of access to fishing grounds...). The trochus fishing activity must therefore be regarded as applied to mini-stocks that probably do not have identical characteristics, and in particular where the coefficient of catchability is not constant, which rules out use of the global model.

3.2 Analytic or structural approach

This type of modelisation is more demanding as regards parameters and requires a good knowledge of the growth and age structure of the catches, but it does not need the basic assumptions of the global model discussed above.

A previous study on trochus growth and natural mortality (Bour et al, 1982) as well as the size frequency distributions obtained from our survey, allowed calculation of the data required for the analytic model.

3.2.1 Analysis of cohorts of the trochus stock

The data used for this analysis were:

- Ci,j; Fi,j; Ni,j, which are respectively catch, fishing mortality coefficient and size of age class i, for the year j.
- The survey enabled estimation of Ni,84.
- F12,j were estimated from samples of trochus ready for export (in warehouse).
- The natural mortality coefficient M = 0.10.

Table 2 gives the results of the cohort analysis. On the basis of the above data, and by back calculation, the squares in the table were filled in diagonally from the Ni,j and Fi,j. The arrows in the table show the reconstructed and presumed development of each cohort since its position in 1978. The cohort concept reflects a factual situation for trochus, since the spawning season takes place from November to April (Bour et al, 1985) thereby creating a new generation each year that can be seen in the size frequency distributions of the young individuals.

3.2.2 Exploitable biomasses estimated from the numbers calculated by cohort analysis

The size/weight/age relationship gives us the mean weight of the shell of one trochus for each age class. Knowing the mean stock numbers for each age and for each year, it was possible to calculate the mean total exploitable biomass for each year. (The stock numbers obtained by cohort analysis correspond to the numbers at the beginning of the year; we calculated the mean numbers, in order to estimate the biomass).

Table 3 summarises known data on trochus stocks since 1978: fishing effort, actual catch, mean fishing mortality coefficient, mean exploitable biomass. It is recommended that in a fishery the rate of exploitation E should not exceed 50%. With E = F/F + M (M = natural mortality), we get F = 0.10 for this level of exploitation. The last line of the table gives the anticipated catch under these circumstances for each of the annual mean biomasses. This anticipated catch may be called optimum and sustainable since, for a given biomass, it ensures that exploitation does not endanger the stock.

Table 2: Cohort analysis (natural mortality M = 0.10)

PERMITTED SIZES		Over 80 mm					From 90 to 120 mm		
YEAR j / AGE i		1978	1979	1980	1981	1982	1983	1984	Fi (by age)
4	DIAMETER 76-85 (mm)	Ni,j= 4781 Fi,j= 0,23 Ci,j= 884	5 818 0,51 2 227	4 460 0,29 1 054	5 602 0,24 673	1 917 0,19 314	2 700 0 0	2 605 0 0	0,29
5	86-95	2 984 0,38 708	3 419 0,41 1 048	3 160 0,51 1 214	3 008 0,27 668	4 005 0,45 830	1 435 0,13 170	2 443 0,07 145	0,31
6	96-100	2 705 0,61 820	1 850 0,57 667	2 057 0,50 770	1 709 0,41 376	2 069 0,24 224	2 316 0,07 116	1 140 0,10 100	0,35
7	101-110	2 074 1,35 1 112	1 330 1,07 643	949 0,89 382	1 125 0,34 235	1 024 0,76 413	1 468 0,49 292	1 954 0,11 203	0,71
8	111-115	547 0,92 248	485 0,32 128	411 0,15 52	389 0,11 37	722 0,11 72	434 0,18 69	814 0,08 59	0,26
9	116-119	685 1,26 386	197 1,75 110	317 0,27 47	320 0,07 17	315 0,15 19	585 0,08 40	326 0,11 32	0,52
10	120-123	904 2,21 570	176 0,94 80	31 0,45 11	219 0,04 8	271 0,11 17	246 0,31 62	488 0,12 53	0,59
11	124-126	609 2,91 405	90 1,35 68	62 2,23 39	18 0,46 6	190 0,07 8	220 0,20 37	163 0,20 31	1,10
12	127-129	924 0,44 179	30 0,55 13	21 0,63 9	6 0,57 4	10 0,58 4	177 0,14 22	163 0,12 18	0,43

Table 3: Data to be taken into account for management of the trochus stock.

DATA \ YEARS	1978	1979	1980	1981	1982	1983	1984
f Fishing effort (No. of fishermen)	85	62	62	123	67	73	70
Y Actual catch (tonnes)	1915	1245	1012	724	350	241	205
$\bar{B}$ Mean exploitable biomass (tonnes)	3960	2176	1911	1982	2172	2109	2252
$\bar{F}$ Mean fishing mortality coefficient (estimated from warehouse samples)	0.44	0.55	0.63	0.57	0.58	0.14	0.12
Yop. (tonnes) Optimum sustainable catch for each $\bar{B}$ subjected to a 50% rate of exploitation (F = 0.10)	396	217	191	198	217	210	225

Figure 2 shows how the data to be taken into account fluctuated from 1978 to 1984. It shows in particular that, since the new regulations were introduced, $\bar{F}$ has been very close to the optimum exploitation value 0.10. The mean biomass, which had been halved by the intensive exploitation that occurred in 1978, stabilized from 1981 around 2 000 tonnes because of a considerable decline in actual catches. The sharp drop of $\bar{F}$ since 1983 has a favourable effect on the biomass which shows an increase in 1984.

This stabilization followed by the regeneration of the mean exploitable biomass that can be seen on the curve, are encouraging for an attempt to boost stocks to their 1978 level, i.e. an exploitable biomass of about 4 000 tonnes, through appropriate management. With a biomass of this magnitude, the optimum sustainable catch would be 400 tonnes (five times less than the actual catch in 1978). This figure should therefore be regarded as a target in the first instance, and then as a level to be maintained, by a quota system for example, to ensure sustained and regular production, which is a prime consideration for any export resource.

5. MANAGEMENT PROPOSALS FOR THE TROCHUS FISHERY

5.1 Initial stage

A catch quota (or restriction of the number of fishermen) together with regulations on permissible sizes, will be necessary for the success of this stage which could be implemented according to the following pattern (permissible sizes: between 9 and 12 cm).

Year	Quota fixed for year i (tonnes)	Exploitable biomass for year i + 1 (tonnes)
1986	100	
1987	150	2 557
1988	150	2 868
1989	200	3 234
1990	300	3 616
1991	400	3 967

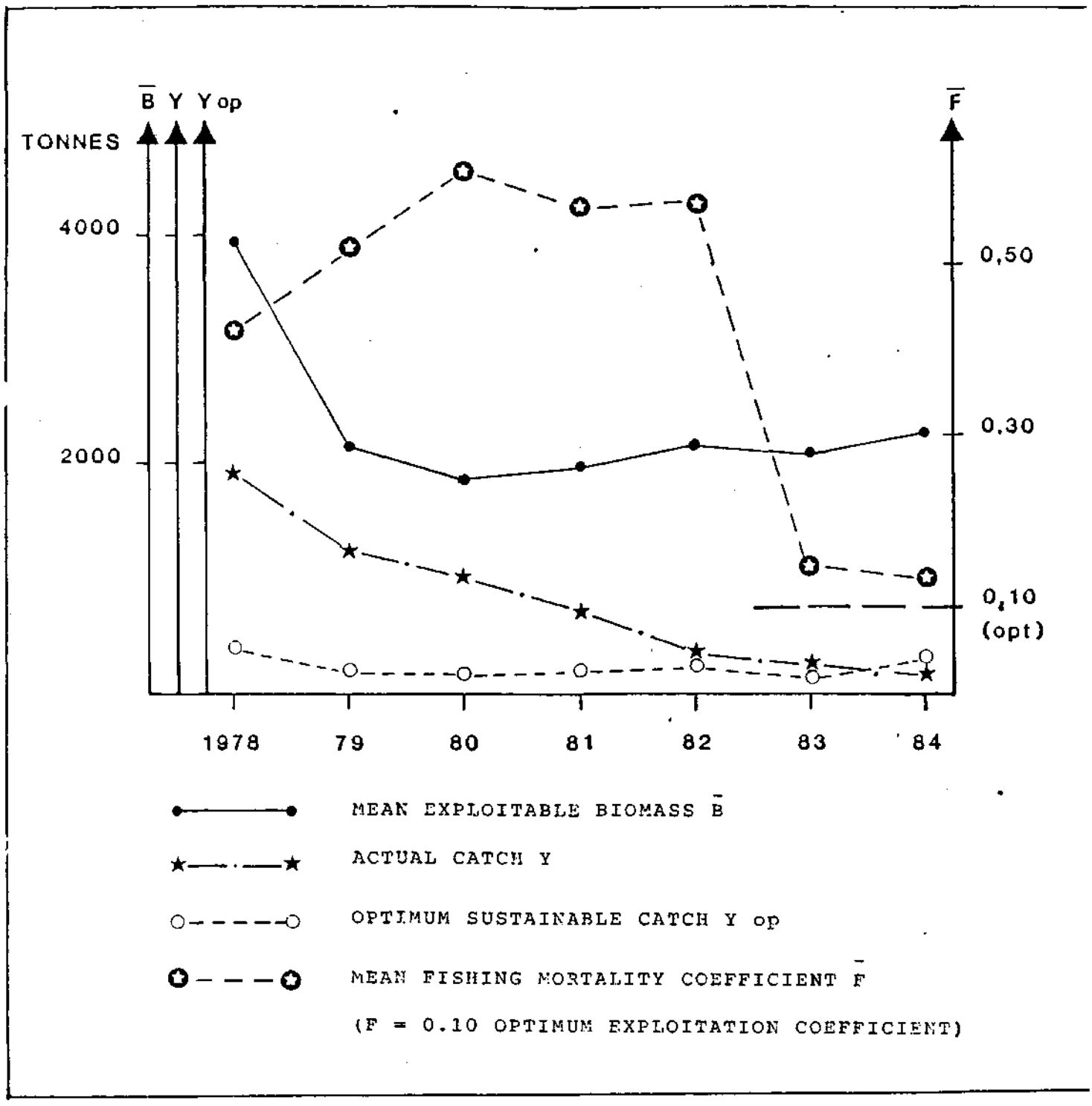


FIG. 2: FLUCTUATION OF THE MAIN DATA TO BE TAKEN INTO ACCOUNT FOR MANAGEMENT OF THE TROCHUS FISHERY.

5.2 Sustained production stage

An optimum quota of 400 tonnes of empty shells fits a theoretical model that assumes a constant environment and does not, for example, allow for a sudden drop in recruitment of juveniles following climatic changes or other factors. Regular monitoring of the level of the exploitable biomass is essential; it can be assessed in terms of stock abundance and measured by catch per unit of effort (C.P.U.E.).

For this monitoring to be effective it is necessary to know precisely the fishing effort applied, and therefore the number of fishermen who produced the catch recorded in a particular year. If the fishing effort and the total catch can be broken down by area, the abundance can be assessed for each area and the fishing strategy adjusted accordingly. These prospects all depend on the collection of reliable statistical data on catch and number of fishermen for each different area.

6. CONCLUSIONS

Despite the extensiveness of the New Caledonian lagoon, our survey of the reefs appears to have yielded a fairly clear picture of the state of the trochus resource in New Caledonia.

Analysis of the data showed that the decline in the biomass resulting from intensive exploitation was not irreversible, but that stocks would need at least five years for regeneration to allow sustained even production rather than the zig-zag pattern observed since the beginning of the century.

The establishment of trochus processing units (manufacturing buttons, mother-of-pearl handicrafts, etc.) in the various localities along the New Caledonian coast could be a good way of ensuring that catches are kept to the recommended level and evenly distributed geographically. Export of unprocessed shells would consequently be reduced by the quantities absorbed locally. Besides generating new jobs, processing of this valuable natural resource by a small local industry would offer opportunities for exportation of finished or semi-finished products typical of the Pacific Islands.

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