

Estimation of soft bottom intertidal bivalve stocks on the south-west coast of New Caledonia

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Abstract

Different random samplings were used to assess the biomass of intertidal bivalves on two main biotopes of the south west coast of New Caledonia. Over the 46.5 km line of sandy beach, the total bivalve biomass is 4.3 ± 1.8 t and the mean biomass of *Atactodea striata* is about 3.2 ± 1.2 t. Over the 9.85 km² sandy-muddy shore of the study area, bivalve stocks ($1,050 \pm 392$ t) are dominated by *Gafrarium tumidum* and *Anadara scapha*; their mean biomasses are respectively 270 ± 132 t and 418 ± 308 t. This resource is expected to meet the demand of the domestic market through an artisanal fishery.

Keywords : Bivalve, Pacific, New Caledonia, lagoon, soft bottom, stock, biomass.

Estimation des stocks de bivalves de substrat meuble sur le littoral sud-ouest de Nouvelle-Calédonie.

Résumé

Des échantillonnages aléatoires différents ont été mis en œuvre pour estimer les biomasses des stocks de bivalves intertidaux sur deux biotopes majeurs de la côte sud-ouest de Nouvelle-Calédonie. La biomasse totale des bivalves sur les 46,5 km de plages de sables de la zone étudiée est de $4,3 \pm 1,8$ t et la biomasse moyenne d'*Atactodea striata* est de $3,2 \pm 1,2$ t. Sur les 9,85 km² de substrats sablo-vaseux, les stocks de bivalves ($1\ 050 \pm 392$ t) sont dominés par *Gafrarium tumidum* et *Anadara scapha* : leurs biomasses moyennes respectives sont de 270 ± 132 t et 418 ± 308 t. Les stocks de bivalves des côtes de Nouvelle-Calédonie ne permettent d'envisager qu'une exploitation à caractère artisanal susceptible cependant de couvrir les besoins du marché local.

Mots-clés : Bivalve, Pacifique, Nouvelle-Calédonie, lagon, substrat meuble, stock, biomasse.

INTRODUCTION

Intertidal bivalve molluscs are a traditional food resource for most coastal populations, in the tropics as in temperate areas, the Western Pacific being no exception to this rule (Davy and Graham, 1983; Broom, 1985). In New Caledonia, these molluscs were an important part of the Melanesian diet in the past (Locard, 1896; Gifford and Shutler, 1956) and are still collected at low tide, as much for recreation as

for their food value. There is a strong demand for edible bivalves in New Caledonia and in 1989, 18.1 t of Veneridae and Mesodesmatidae were imported from New Zealand (Anonymous, 1990). Although local bivalve stocks are believed to be abundant, in the absence of relevant fisheries statistics, it is useful to quantify their biomasses with a view to assessing their fishery potential.

Among the many bivalves found along the shores of New Caledonia, we concentrated chiefly on the

three species most frequently found: *Atactodea striata* (Gmelin, 1791), *Gafrarium tumidum* Röding, 1798 and *Anadara scapha* (L., 1758). *A. striata* (*Mesodesmatidae*) is confined to sandy beaches of the Indo-Pacific zone (Pichon, 1962; de Baissac *et al.*, 1962; Fisher, 1966; Beu, 1972; Hughes and Gamble, 1974; Thomassin, 1978). *G. tumidum* (*Veneridae*) and *A. scapha* (*Arcidae*) are also Indo-Pacific species but characteristic of sandy-muddy sediments (Thomassin, 1978; Purchon and Purchon, 1981). Although all three species are gathered for food in many countries of the Indian Ocean (Nayar and Rao, 1985) and South-East Asia (Nielsen, 1976; Purchon and Purchon, 1981; Davy and Graham, 1983; Toral-Barza and Gomez, 1985), none has yet been specifically investigated to our knowledge.

MATERIAL AND METHODS

The main island of New Caledonia extends over 400 km and has a very long coastline. We confined our investigations to the whole of the south-western portion of the island, from the southernmost tip to

the Cap river, *i.e.* approximately 300 km of coastline. Our investigations were carried out during 1990. We started by doing a preliminary survey, exploring the intertidal fringe at low tide. This first phase enabled us to exclude large areas without bivalves. The whole portion of coast located south of Noumea (about 100 km) proved to be virtually devoid of intertidal soft bottoms and was thus excluded.

The inertial zone of our study area (*fig. 1*) was separated into two sets: sandy beaches and sandy-muddy shores (with or without seagrass beds). They were mapped using aerial colour photographs (scale 1/40,000), taken by the French National Geographic Institute in October 1982. A different random sampling was performed for each. This sampling method was chosen because prior knowledge of the size and the structure of the population is not required for preparation of the sampling unit selection protocol (Scherrer, 1983).

The sandy beaches are always narrow (≈ 10 m) and they were visible on the photographs as thin lines whose surface area was impossible to estimate. They were thus regarded as a one-dimensional statistical

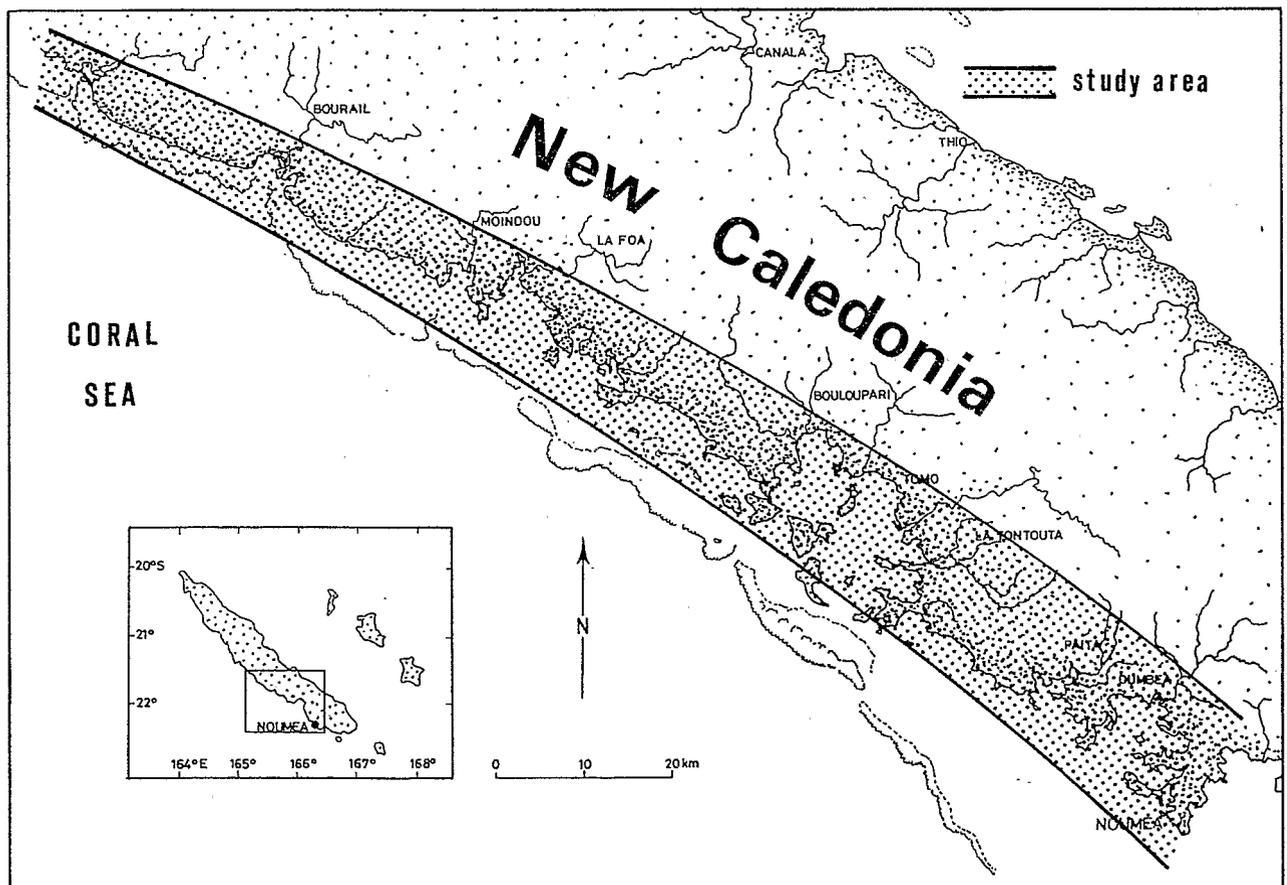


Figure 1. — Presentation of the study area.

population with a total length of 46.4 km and subdivided into 80 m sections. 50 sections were chosen at random, within each of which a sampling unit was positioned at random. The sampling unit consists of a strip of sand 0.5 m wide, perpendicular to the shoreline and covering the entire width of the beach. The sand was dug out to a depth of about 10 cm, passed through a 5 mm square mesh screen and all the bivalves retained on the screen were collected.

The sandy-muddy shore areas were traced directly on the aerial photos and covered a 9.85 km². They were gridded into 684 squares representing 120 × 120 m. 100 squares were chosen at random, within each of which a sampling unit was marked out with a 0.5 m² frame positioned at random. The sediment was dug out to a depth of about 10 cm and washed through a 5 mm square mesh screen on which the bivalves were collected.

On each sampling unit, the specimens were measured to the nearest 0.5 mm with a vernier calliper, parallel to the hinge of the bivalve. Total fresh weights (flesh and shell) were measured after allowing them to dry off on filter paper. Our results refer to density and biomass, expressed respectively in numbers of individuals and g of fresh weight per 0.5 m² of sandy beach or 0.5 m² of sandy-muddy sediment. The estimators of these variables were calculated on the vulnerable fraction of the stock, consisting of the specimens collected during sampling. For each statistical population, we determined the mean (\bar{y}_i) and the standard deviation (si) of the variables and then calculated the parameters relating to the study area as a whole (Cochran, 1963).

In order to specify our biomass estimations, we defined maximum exploitable fractions in the present state of the stocks for the three main species with reference to two limits (Clavier and Richard, 1986): the catch minimum length (Lm) and the minimum density of interest for the fishermen's activity (Nm). We assumed that Lm lies between the length at sexual maturity, *i.e.* 20 mm for *A. striata* and *G. tumidum*, 22 mm for *A. scapha* (Baron, 1992) and the maximum length reached by each species in our samples. Nm is the threshold of bivalves density for the gathering to be regarded as viable. We varied Nm from nil values to the maximum densities observed during our sampling, *i.e.* 0-30 for *A. striata*, 0-15 for *G. tumidum* and 0-12 for *A. scapha*. In short, for biomass calculations we took every sampling unit where the number of individuals longer than or equal to Lm was greater than or equal to the threshold value Nm. Thus, for every Nm-Lm pair, we estimated a potentially (maximum) exploitable biomass and results are shown as isobiomass curves.

RESULTS

Only two bivalve species were found on sandy beach: *Atactodea striata* and *Donax faba*. The total

bivalves biomass is 4.3 ± 1.8 t and the biomass of *A. striata* is about 70% of this value (table 1). The total edible bivalve biomass is $1,050 \pm 392$ t. *G. tumidum* and *A. scapha* together account for almost 70% of the total (table 1). Out of the 28 species found on sandy-muddy shore (table 2), 17 are commonly used as food (Davy and Graham, 1983).

The isobiomass curves of *A. striata*, as a function of the catch minimum length Lm and the threshold number Nm, are shown on figure 2. For a fixed threshold Nm, a 2 mm increase in Lm causes the maximum exploitable biomass to decrease by about 30%. The *A. striata* population consists largely of young individuals (fig. 3), the size classes between 20 and 26 mm being numerically about equal. A similar decrease in biomass is observed every time, for a fixed Lm, Nm increases by 5 individuals over the interval 0-20, which suggests that large-sized specimens are uniformly distributed over our study area.

For a fixed Nm value, an increase of Lm from 20 to 28 mm in *G. tumidum* does not cause a marked decrease in the maximum exploitable biomass (fig. 4). Similarly, where Nm is less than 4, an increase of Lm from 28 to 32 mm causes only a slight decrease in biomass, the maximum exploitable weight dropping from 250 to 200 t approximately. The length frequency histogram (fig. 5) shows a marked predominance of large-sized specimens which gives rise to a large accumulated biomass in the population. For a fixed Lm, an Nm increase of about 2 individuals over the interval 0-6 causes a constant decrease in biomass of about 25%. Thereafter, the decrease is much more marked as Nm increases. *G. tumidum* is therefore preferentially distributed in aggregates of up to 6 individuals per 0.5 m². For Nm=6 individuals per 0.5 m², the exploitable biomass of *G. tumidum* would be around 150 t.

As regards *A. scapha*, for a fixed Nm value, an increase of Lm from 22 to 42 mm does not cause a significant decrease in maximum exploitable biomass (fig. 6). Above 42 mm and for low Nm values, the biomass decreases steadily by about 50 t for every 2 mm Lm increase. The length frequency histogram (fig. 7) here again shows a predominance of large-sized individuals which also constitute a large accumulated biomass that is probably not very productive. For Lm less than 50 mm, an Nm increase over the interval 3-7 produces only a slight decrease (about 15%) in the maximum exploitable biomass. *A. scapha* is therefore preferentially distributed in aggregates of less than 3 or more than 7 individuals per 0.5 m². For an Nm value of 6 individuals per 0.5 m² and a catch minimum length Lm of 32 mm, the potentially exploitable biomass of *A. scapha* would be around 250 t.

Table 1. — Mean and confidence limits for sample (\bar{y}) and population (\hat{Y}) estimates (significance level: $\alpha=0.05$). The sandy beach species values (\bar{y}) are expressed for 0.5 m sampling units; the two sandy-muddy shores species values (\bar{y}) are expressed for 0.5 m² sampling units.

Bottom type	Main species	Number		Biomass (g)	
		\bar{y}	$\hat{Y} (\times 10^6)$	\bar{y}	$\hat{Y} (\times 10^7)$
Sandy beach	<i>Atactodea striata</i>	30.5 ± 12.6	2.8 ± 1.15	34.7 ± 12.6	0.32 ± 0.12
Sandy-muddy shores	<i>Gafrarium tumidum</i>	1.1 ± 0.5	21.3 ± 9.70	13.7 ± 6.7	27.05 ± 13.22
	<i>Anadara scapha</i>	0.6 ± 0.4	12.6 ± 8.01	21.2 ± 15.6	41.77 ± 30.82

Table 2. — Taxonomic list of bivalves collected on sandy-muddy shores. (*) indicates edible species.

<i>Anadara scapha</i> (L., 1758) (*)	<i>Marcia japonica</i> (Gmelin, 1791) (*)
<i>Anadara sp. cf. troscheli</i> (*)	<i>Modiolus aratus</i> (Dunker, 1857) (*)
<i>Anodontia sp.</i>	<i>Modiolus philippinarum</i> Hanley, 1943 (*)
<i>Callista sp.</i>	<i>Pinctada maculata</i> (Gould, 1950) (*)
<i>Chama sp.</i>	<i>Pinna sp.</i>
<i>Codakia tigerina</i> (L., 1758) (*)	<i>Pitar citrinus</i> (Lamarck, 1818) (*)
<i>Ctena sp.</i>	<i>Pitar striatus</i> (Gray, 1838) (*)
<i>Fimbria fimbriata</i> (L., 1758) (*)	<i>Psammotreta sp.</i>
<i>Fragum sp.</i>	<i>Tapes literatus</i> Röding, 1798 (*)
<i>Gafrarium pectinatum</i> (L., 1758) (*)	<i>Tapes variegatus</i> (Sowerby, 1852) (*)
<i>Gafrarium tumidum</i> Röding, 1798 (*)	<i>Tellina palatam</i> (Iredale, 1929)
<i>Lioconcha sp.</i>	<i>Tellina sp.</i>
<i>Macoma sp.</i>	<i>Tellina staurella</i> Lamarck, 1818
<i>Mactra sp. cf. luronica</i>	<i>Trachycardium rugosum</i> (Sowervy, 1840) (*)

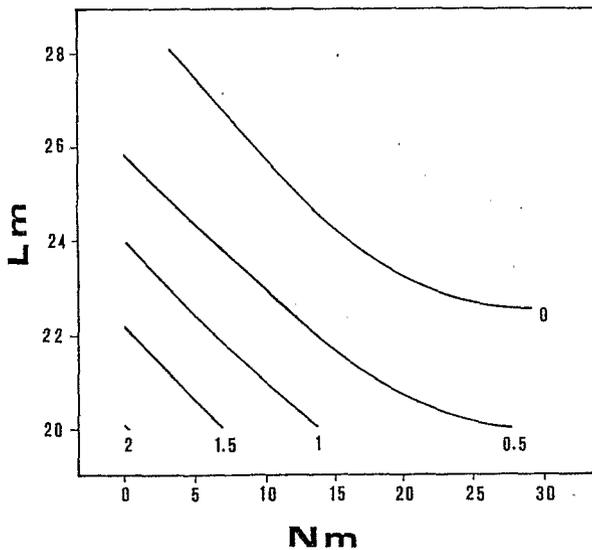


Figure 2. — Isobiomass curves (in tonnes) for *Atactodea striata* calculated with different shell size (L_m in mm) and minimum density of interest to the fishermen activity (N_m) on a 0.5 m unit. For biomass calculations we took every sampling unit where the number of individuals longer than or equal to L_m was greater than or equal to the threshold value N_m .

DISCUSSION AND CONCLUSION

The aerial photos used for mapping the statistical populations are at a scale of 1 : 40,000 and were

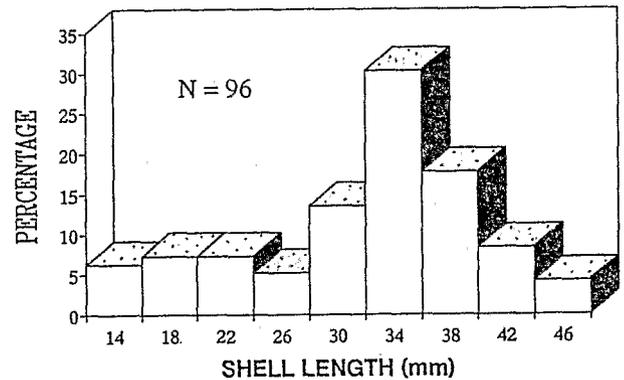


Figure 3. — Size frequency distribution of *Atactodea striata*. Only individuals greater than 10 mm are taken into account.

taken at half-tide. The contour of the bottoms is thus hard to appraise exactly and there are probably inaccuracies in our mapping of the intertidal zones; in particular, we probably underestimated the size of our statistical population as a result of the approximate positioning of the lower limit of the intertidal zone on the sandy-muddy areas. In addition, on the strength of the preliminary survey, we chose to discard extensive tracts of sandy-muddy shore, considered to be devoid of bivalves. Certain bivalve beds of limited extent may thus have been disregarded. This approach is somewhat similar to stratified sampling; it reduces variance of the estimators but possibly results in their being underestimated.

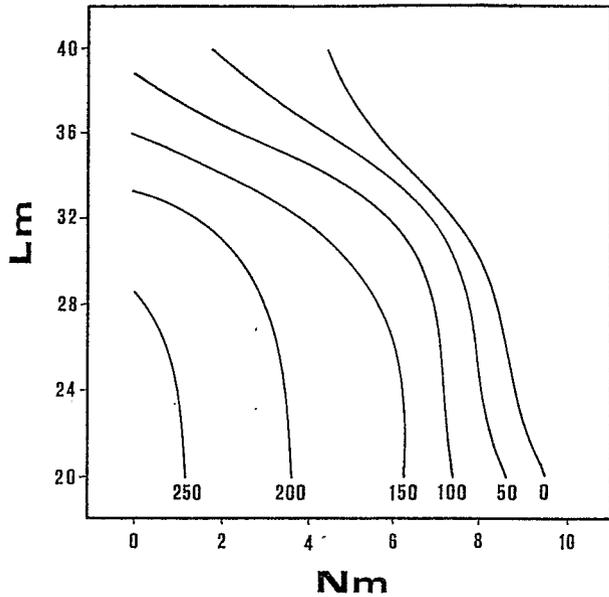


Figure 4. — Instantaneous mean potential catch (in tonnes) for *Gafrarium tumidum* calculated with different values of shell size (mm) and minimum density of interest to the fishermen activity (Nm) on a 0.5 m² area. For biomass calculations we took every sampling unit where the number of individuals longer than or equal to Lm was greater than or equal to the threshold value Nm.

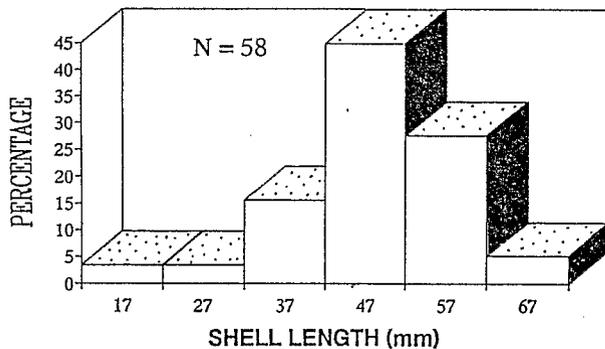


Figure 5. — Size frequency distribution of *Gafrarium tumidum*. Only individuals greater than 12 mm are taken into account.

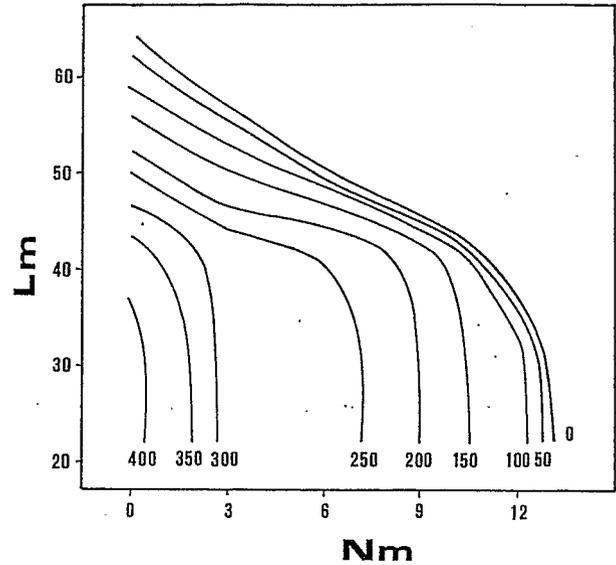


Figure 6. — Instantaneous mean potential catch (in tonnes) calculated for *Anadara scapha* with different values of shell size (mm) and minimum density of interest to the fishermen activity (Nm) on a 0.5 m² area. For biomass calculations we took every sampling unit where the number of individuals longer or equal to Lm was greater than or equal to the threshold value Nm.

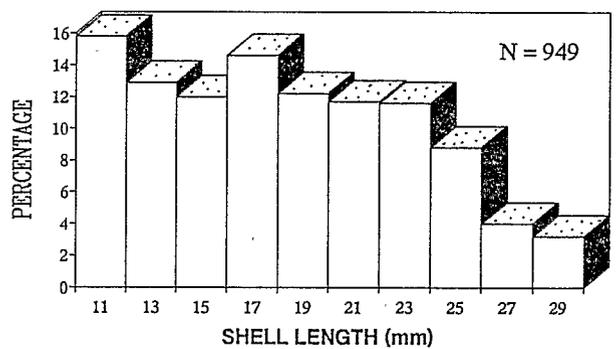


Figure 7. — Size frequency distribution of *Anadara scapha*. Only individuals greater than 12 mm are taken into account.

Biomass assessments for bivalve stocks on soft intertidal bottoms are scarce in the literature. In general, this type of study is aimed at ascertaining whether the biomass of a given stock is large enough to warrant starting or management of its exploitation. In the case of reared species, it is also used to assess the total quantity being farmed, in order to avoid exceeding the carrying capacity of the biotope (Sauriau *et al.*, 1989). For species that are already being fished, natural stock assessment is of lesser interest than fishery statistics, which make it possible to monitor the status of the resource.

For bivalve stocks on sandy beaches in the South-West Pacific, the only investigations we know of are those conducted by Cassie (1955) and Readfarm (1974) on the *Amphidesma ventricosum* fishery in New Zealand. These authors estimated the total abundance of this *Mesodesmatidae* bivalve without considering the harvestable tonnage. On the south-west coast of New Caledonia, the maximum exploitable biomass of *A. striata* is lower than 2 t. This low figure is due the relatively short total length of sandy beaches along the coast. *A. striata* is also present on the sandy beaches of the coral islets in the south-western lagoon, and a more comprehensive investigation, which includes these sites, would probably show the stock

to be larger. In the present state of our knowledge, *A. striata* would seem to be of interest only for recreational fishing.

Bivalves of the genus *Anadara* are present in large quantities in the Indo-Pacific region and more specifically on intertidal mud-flats of South-East Asia. Broom (1982) estimated the quantity of *Anadara granosa* marketed in 1979 in Malaysia to have been in the vicinity of 63,000 t. The same year, *A. granosa* production in Indonesia was 32,000 t (Unar *et al.*, 1983). These very high figures suggest the presence of substantial stocks, although they include aquaculture production. They also reflect the huge surface area of the intertidal zones existing around these countries. On the south-west coast of the main island of New Caledonia, our stock assessment concerned only 10 km² of shore area. The densities we found are of the same orders of magnitude as those observed on other shores. On 30 km² of mud flats in Colombia, for instance, Squires *et al.* (1973) estimated the *Anadara tuberculosa* stock at 1,500 t for an annual production of about 250 t. Similarly, in India, Narasimham

et al. (1984) estimated the biomass of the bivalve stock in Kakinada bay at about 21,000 t, including 7,000 t of *A. granosa*, for a surface area of 146 km². In view of the rather limited local market, the maximum exploitable biomass of *G. tumidum* and *A. scapha* (<250 and <400 t, respectively), is far from negligible for New Caledonia.

In the course of our investigations, *G. tumidum* and, to a lesser extent, *A. scapha* were found in large quantities on fairly small sites. The fact that the same environments exist all along the coasts of New Caledonia's main island, suggests that stocks of these bivalves occur elsewhere too. For both these species, we recorded a high percentage of large old individuals with slow growth rates. This accumulated, relatively unproductive, biomass should be the priority target of any commercial fishery that is started. The sustainable yield of such a fishery will certainly be much lower than our biomass estimates. Consequently, the bivalve stocks on the coasts of New Caledonia will only be able to sustain an artisanal type of fishery, which can nevertheless be expected to meet the demand of the domestic market.

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