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Marine plant harvest in Portugal

Rui Santos* & Pedro Duarte
*Laboratório Nacional de Engenharia e Tecnologia Industrial, Departamento de Estudos de Impacte Industrial, Estrada do Paço do Luminar, Azinhaga dos Lameiros, 1699 Lisboa, Portugal; *present address: Halifax Fisheries Research Laboratory, P.O. Box 550, Halifax, NS, Canada, B3J 257 (author for correspondence)*

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Abstract

This work brings together the scattered information on marine plant harvests and the colloid extraction industry in Portugal, as an initial contribution to the improvement of resource management. The first phase of exploitation of marine plant resources started prior to the 14th century, with the gathering and sale of storm-tossed seaweeds for fertilizer. The harvest of seagrasses and algae at Ria de Aveiro was of great economic importance. The second phase of resource exploitation began with the wider scale harvest of agarophyte species for colloid extraction. Portugal is at present the third largest harvester of the agarophytes *Gelidium* and *Pterocladia* (2500 t annually), and it is the fifth largest agar producer (350 t annually). Other colloid-producing species, including *Chondrus crispus* and *Mastocarpus stellatus*, are also harvested for export. The total agarophyte landings, agar production and income from agar exports is far below the maximum levels attained in the early 1970s. The status of stocks in each different harvest zone on the continental coast and the Azores is examined. Although there is an effective management structure for the Portuguese marine plant resource, research is needed to provide a sound biological basis for management.

Introduction

Quantitative information on marine plant harvests has been identified as an important contribution to effective assessment and management of these commercial resources (Caddy & Fisher, 1984). Despite this importance, little has been published on the Portuguese industry. However, marine plants have been gathered for fertilizer along the north coast of Portugal since long before the 14th century, when contemporary documents referred to it as an ancient activity (Veiga de Oliveira *et al.*, 1975). These activities continue to the present and can be considered the first phase of resource exploitation. It was followed during this century by a wider scale industrial exploitation for colloid extraction. Palminha (1971) describes the seaweed industry on the Portuguese mainland and the Azores. He records the most important beds and harvest techniques, identifies the extractors and presents designs for harvest impact experiments.

The marine plant harvest in Portugal has never been assessed quantitatively. The present study brings together the available information, with the dual objective of both increasing understanding of resource use and laying the foundation for resource management based on resource science.

The gathering of marine plants for fertilizer and the seaweed based colloid industry is described and the status of the stocks, the extractors and the resource management is discussed.

Methods

Industrial data were located in several different sources and were sometimes contradictory or difficult to interpret. Most of the data on production of seaweeds and agar were obtained from two sources: 'Junta Central das Casas dos Pescadores' reports which were published yearly from 1965 to 1974, and 'Instituto Nacional de Estatística' reports, published since 1969. Other sources were consulted as well. Manuscripts of the deceased phycologist, F. Palminha, who studied the commercial marine plants of Portugal for more than 30 years, were examined, along with several internal reports of the institutions for which he worked. Internal reports from the institution that manages the seaweed resource, 'Direcção Geral das Pescas' (DGP), were another important source of information, as well as personal communications with DGP staff.

Results and discussion

Marine plants for fertilizer

The seaweeds washed ashore along the north coast, mainly *Laminaria hyperborea*, *L. ochroleuca*, *Saccorhiza polyschides*, *Fucus vesiculosus*, *Codium tomentosum*, *Palmaria palmata*, *Chondrus crispus* and *Gelidium sesquipedale*, collectively called 'sargaço', have been gathered and sold for fertilizer since at least 1308 when their exploitation was first regulated by King D. Dinis (Veiga de Oliveira *et al.*, 1975). A mixture of marine vascular plants, mainly *Potamogeton pectinatus*, *Ruppia cirrhosa* and *Zostera noltii*, and algae, including *Gracilaria verrucosa*, *Ulva* sp., *Enteromorpha* sp. and *Lola lubrica*, collectively called 'moliço', has been intensively harvested at Ria de Aveiro. It is collected with handrakes, from boats designed especially for this activity.

Data on both yields and economic importance of both harvests are scarce. The total amount of sargaço collected in 1891 between Rio Minho and Rio Cávado (Zone 1 of Fig. 1), was estimated to have a value, corrected for inflation, of 80 million escudos, about US $500,000 (Baldaque da Silva, 1891 *in* Veiga de Oliveira *et al.*, 1975). The moliço sold in one year from Ria de Aveiro had an estimated value, corrected for inflation, of 480 million escudos, about US $3,000,000 (Regalla da Fonseca, 1888 *in* Veiga de Oliveira *et al.*, 1975).

Silva (unpublished data) using records of boat number, estimated the yield of moliço for selected years between 1883 and 1967 was in average 274,600 t. The high yields and harvest value indicate its local importance. Some people harvested full time. The heavy harvest pressure led to early regulation of the activity; harvesters and boats were licensed, an open harvest season identified, and harvest tools and prices specified. The moliço annual crop has decreased since the early 1890's. According to Silva (unpublished data), the harvesters gradually abandoned the fishery for better paying, and less physically demanding positions. As well, there has been a shift to increased use of chemical fertilizers. The harvest of moliço and its use as manure is currently being encouraged by municipalities around Ria de Aveiro. In 1985, 1800 t of moliço were harvested. The total amount paid to harvesters was 2.6 million escudos, about US $17,000. The collection of sargaço, like moliço, lost its economic importance in the last century. Today sargaço is collected on a small scale by some farmers of the north coast, to fertilize poor, sandy soils.

Colloid industry

History and legal regulations

During World War II, the shortage of Asian agar in Europe encouraged the search for colloid producing species in Portugal. Experimental colloid extractions of Portuguese red seaweeds were done by Oliveira (1947). The agarophyte *Gelidium sesquipedale* was initially collected in the early 1940's at low tide along the continental coast, and then exported. The first Portuguese based agar extraction factory was built in 1947. The high abundance of the agarophyte *Pterocladia capillacea* on the Azores also indicated commercial potential (Palminha, 1971). By 1971 there were six Portuguese based agar factories, two of these on the Azores. At present only four are operating, including the two on the Azores.

The export of agarophytes was prohibited in the 1960's when a synthesis on the agar industry was commissioned by the Ministry of Economy, in order to establish a sound basis for the development and regulation of the industry. Regulations were first established in 1964, creating a harvest season and licensing policy. All species could be plucked from the substrate, from March to December, except for members of the Laminariaceae and Gigartinaceae, which could only be cut. Seaweeds washed ashore could be collected year round. It should be noted that with the recent integration of Portugal into the European Economic Community open market, the export of seaweeds is again possible.

Harvesting by divers was regulated in 1967. Harvest zones were defined to aid in the control of harvest effort. Since then both the number of boats and the number of harvesters have been regulated. There are six harvest zones along the continental coast (Fig. 1), and nine on the Azores, each representing one island. *G. sesquipedale* and *P. capillacea* are hand harvested mainly by boat-based hookah divers. Each boat can have up to five divers working at a time. The divers collect the seaweeds for six to seven hours per day. The harvest is placed in a basket of about 60 kg capacity which is winched into the boat. Each diver can harvest more than one metric ton per day.

Small amounts of *G. sesquipedale* and *P. capillacea* are gathered either by handraking from small boats or by collecting beached storm toss at low tides. All harvests are sun-dried and sold to licensed concentrators who are restricted to buying in a single harvest zone. The concentrators then resell the crop to the extractors. Fishermen harvesting beds close to the factories sell the wet crop directly to factory representatives. Harvest management is the responsibility of DGP

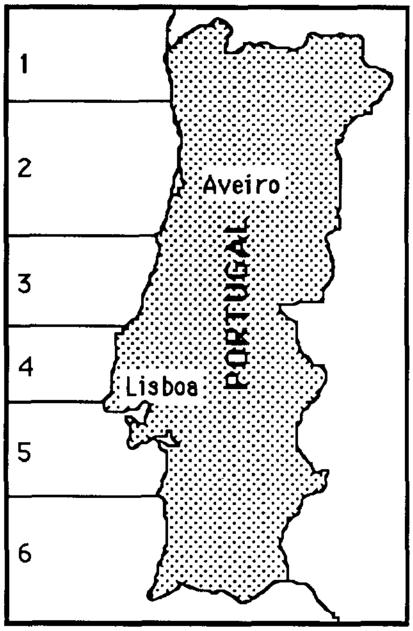

Fig. 1. Harvest zones of Portuguese continental coast.

('Direcção Geral das Pescas'). The start of the harvest season is decided by their personnel together with the harvesters. The decision is based on a subjective assessment of biomass by underwater observers. The harvest generally begins in July and ends in December. Storm toss gathering occurs year round.

Considerable amounts of carrageenophytes, such as the *C. crispus* and *Mastocarpus stellatus*, are also harvested along the continental coast (Fig. 2), mainly from Zones 1 and 2. The plants are plucked from the intertidal during summer, sun-dried, sold to concentrators and then exported. Small amounts of the agarophyte *Gracilaria verrucosa* are periodically collected in certain estuaries and sheltered bays. However, the extractors recently stopped processing this species.

Gelidium sesquipedale landings

Based on the *G. sesquipedale* total landings (Fig. 3), it appears the harvest was fully developed by the late 1960's. The highest values occurred after 1966, when harvesting by divers was intro-

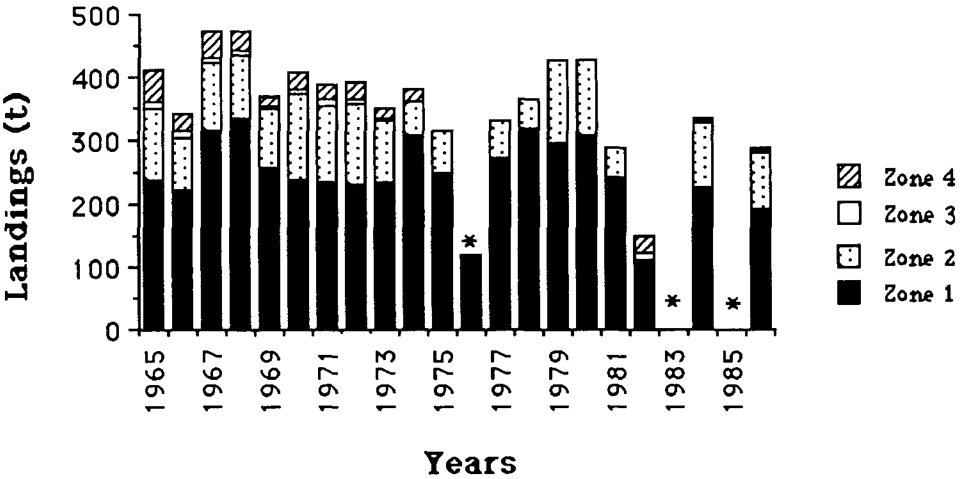

Fig. 2. Annual landings of carrageenophytes along the continental coast. No data is available for years marked with an asterisk.

duced. There was a constant decline in annual landings through the 1970's, followed by an increased in the 1980's. To interpret resource abundance variation based on a time series of annual yields, data on harvest effort, i.e. number of boats, number of divers or diving time, is necessary (Ricker, 1975). Effort data were not formerly recorded with harvest yield. Recently DGP personnel have begun demanding the completion of logbooks for each boat, which will yield daily information on the number of harvesters, diving time, harvest yields and sites harvested. Also, social and economic factors influence harvest effort levels, and therefore must be considered when interpreting variation in landings. Presently, the economic return to harvesters seems adequate to sustain their activity. An usual season has 30 to 50 diving days, which will yield a diver/harvester about US $13,000 per season.

Annual prices paid to harvesters per kg of dried seaweed have generally been higher since 1973, due to a change in the economy after the 1974 revolution. The price increase of 1974 was in part an attempt to stimulate effort and halt the trend of decreasing landings.

Figure 3 shows the annual landings of *G. sesquipedale* in each harvest zone. The low yields of Zones 1 and 2 do not necessarily represent low abundances, but instead reflect a low harvest effort. This region has little natural shelter and sea conditions are generally poor. Zones 3 and 6 show increasing yields in recent years (Fig. 3). This trend in Zone 6 is due to recent exploitation of virgin beds (*in verb.* from DGP personnel). The landing decline observed in Zone 4 may be due to recruitment overharvesting. Anecdotal evidence indicates that the substrate is soft in this zone. It disintegrates when plants are plucked (*in verb.*, DGP), causing high mortalities of prerecruits and holdfasts, and slower bed recovery. The Zone 5 yield curve, shows the common pattern of an exploited resource: a fast increase while the harvest is developing, followed by a strong decrease which is generally a result of overexploitation.

Pterocladia capillacea landings

The harvest yields of *P. capillacea* species on the Azores show a steady decrease to the low levels of the 1980's (Fig. 4). Except for S. Miguel Island, where they have remained relatively stable, the yields of each island are low through this decade (Fig. 4). Flores, Terceira and S. Miguel are the islands where the landings have been consistently higher and presumably where the standing stocks were originally higher.

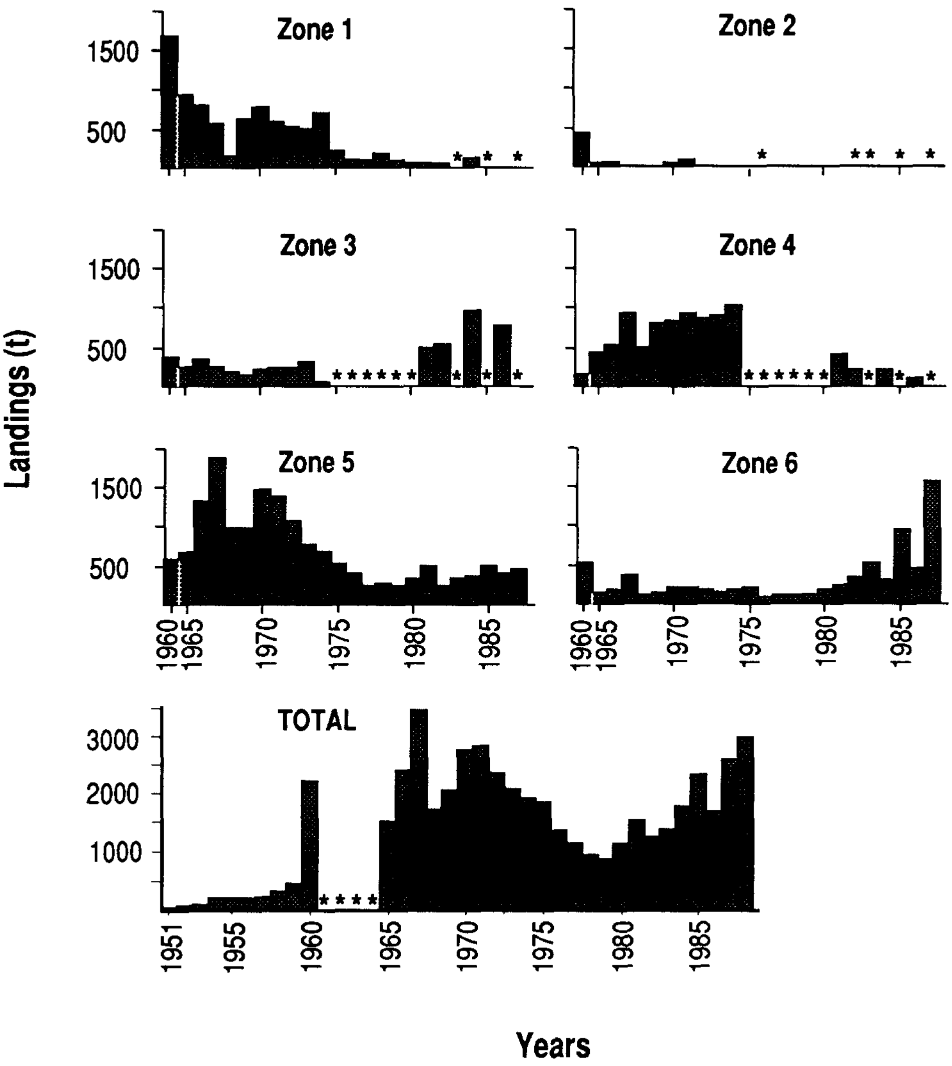

Fig. 3. Annual landings of *Gelidium sesquipedale* along the continental coast. No data is available for years marked with an asterisk. Data before 1960 were derived from agar production values.

The present low harvest yields seem to be due to a social rather than an overharvesting phenomena. There has been considerable emigration of young people, thus it is now difficult to get qualified diver/harvesters. The S. Miguel yields are more stable because this is the biggest island, and there is more shore based harvesting during low tide periods. Another factor which discourages potential harvesters is the low prices paid for *P. capillacea* on the islands, around 140 escudos per kg of dried seaweed, which is lower than that paid for *G. sesquipedale* on the mainland, around 200 escudos per kg.

Agar extractors

Portuguese agarophyte yields have never exceeded the production capacity of the national agar industry, which Palminha (1971) estimated to be 1,620 t of agar per year. This production potential was incorrectly interpreted as actual

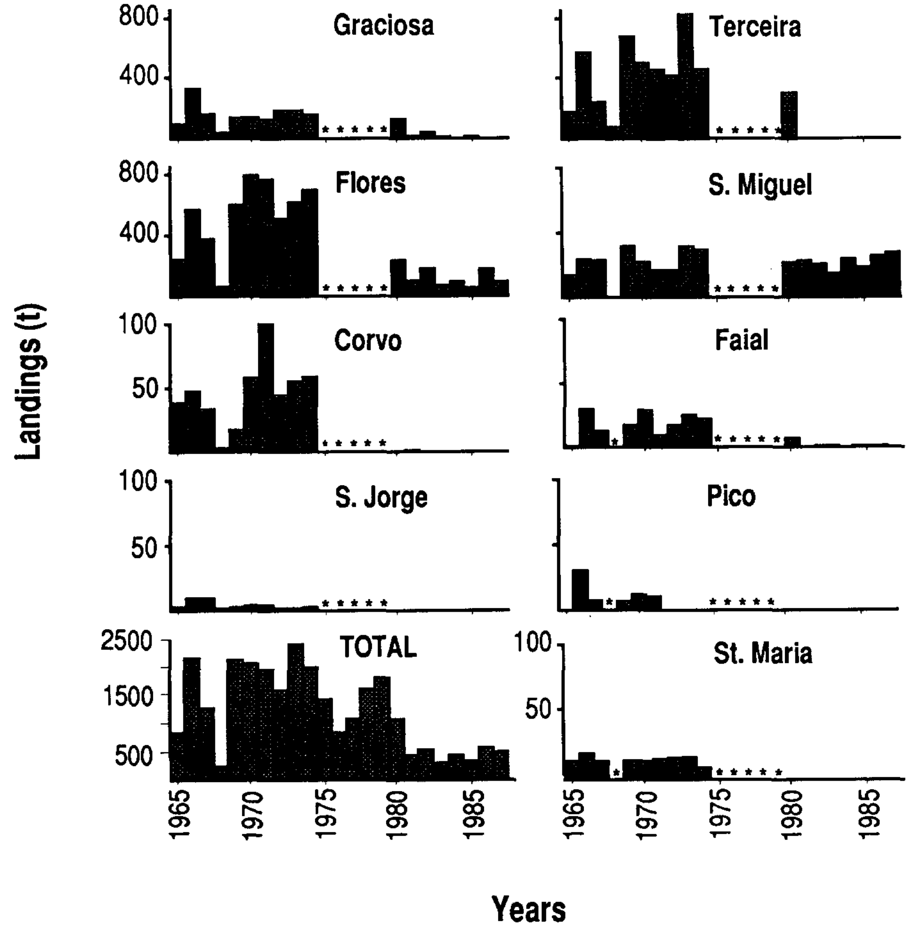

Fig. 4. Annual landings of *Pterocladia capillacea* on the Azores Islands. No data is available for years marked with an asterisk.

production by both Michanek (1975) and Santelices (1988). Each reported Portugal as the second largest producer of agar in the world. In fact, agar production peaked in 1973 at only 806 tonnes (Fig. 5). The decrease in agar production (Fig. 5) from the early 1970's to the early 1980's follows the decrease in total catch of agarophytes in Portugal (Figs. 3 and 4). Even though *G. sesquipedale* yields recovered in the 1980's, the strong fall in *P. capillacea* yields prevented a marked increase in total agar production. The importation of raw material was only important for a few years around 1980, to compensate for a low national harvest during that period.

Around 90% of the national agar production is exported to Japan (1985 to 1989 average: 79.0 t), USSR (35.5 t), West Germany (31.1 t), Italy (29.3 t) and Spain (22.7 t). The extractors annual economic return from exportation has decreased in the 1980's in concert with the decline in the crop. Data on the commercial yields of agar per dry weight of plants are not available separately for the two species. However, data on total agar production (Fig. 5) and on the use of plants by extractors allows a calculation of the agar yields. The yield varies between 7% and 22%, with an overall average of 15%. This is below the 17% to 25% commercial yields considered normal by Whyte and Englar (1981). According to Ana Lemos (*in verb.*), the *G. sesquipedale* agar yield obtained by one extractor has been around 20%, but is steadily declining in recent years.

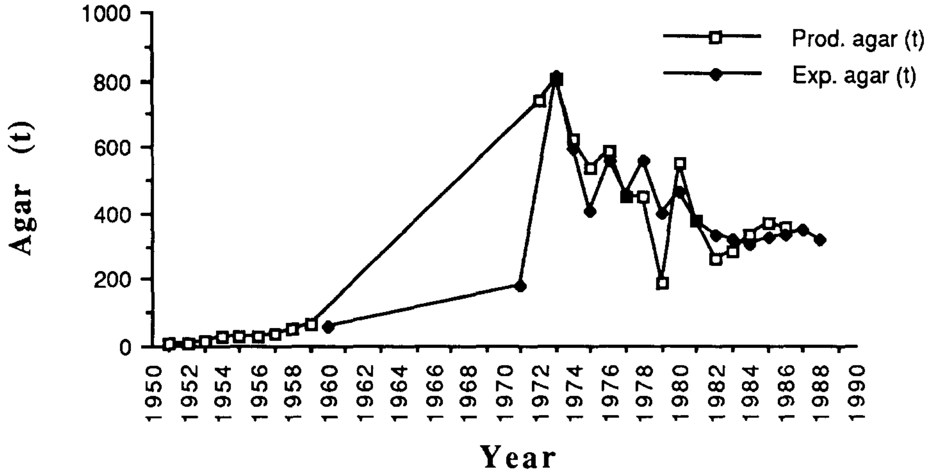

Fig. 5. Portuguese annual production and exportation of agar.

Conclusions

The requirements for a successful marine plant industry (Pringle *et al.*, 1989), are met in Portugal. There are sufficient natural resources, and the harvesting techniques, the labour force, the weather conditions and the harvesters remuneration seem adequate to sustain the activity. There is also a government agency with a mandate to manage the marine plant resource (DGP). With approximately 2500 t (dry weight) of *Gelidium* and *Pterocladia* harvested annually and production of 350 t of agar, Portugal has the third largest annual harvest of these species after Spain with 4000–5500 t and Japan with 3000–3300 t (Santelices, 1988). Portugal also ranks fifth in the production of agar from *Gelidium*/*Pterocladia* after Spain (890 t), Japan (568 t), South Korea (600 t) and Morocco (550 t) (Armisen & Galatas, 1987). Note that the Spanish harvest is largely storm-tossed material, and thus the weight is inflated due to impurities.

Concern about the future of the colloid industry has been expressed by the extractors, particularly with regard to the sustainability of the beds. Also, the integration of Portugal into the EEC common market will make it possible for large multinationals to outcompete the local extractors for national raw material. This study suggests that the concerns of the extractors are well justified. In fact, the total agarophyte landings (Figs. 3 and 4), the agar production (Fig. 5) and the economic income from agar exports have been decreasing and are far from the maximum levels attained in the early 1970's. Some recovery of total agarophyte landings has occurred in the last few years. However, this results mainly from the discovery of new, previously unexploited beds in Zone 6. The declining trend in the agar industry indicates the need for scientific studies on the resources. As several authors have pointed out (Silverthorne, 1977, Santelices, 1988 and Pringle and Sharp, 1990), besides knowing the resource distribution and abundance, biological data are also required for management.

Palminha *et al.* (1982, 1985) assessed the distribution and standing crop of *G. sesquipedale* along the south coast of Portugal, and Oliveira (1984) presented growth data. Fralick and Andrade (1981) studied some aspects of *P. capillacea* growth and reproduction and presented management recommendations for this resource, apparently without enough data to support their conclusions (Santelices, 1988).

Most aspects concerning demography, harvest impact on populations and synergistic effects of abiotic factors on growth and on the synthesis of cell-wall polysaccharides have not been studied. The marine plant resources in Portugal have been managed largely without scientific advice; rather, management has been based on the experience and common sense of non-scientific personnel.

At present, studies are being carried out by the authors on the population biology, productivity and harvest impact on the populations of *G. sesquipedale*. Production models are being developed so that different harvest strategies can be tested, providing useful indicators to be used to manage the resource.

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