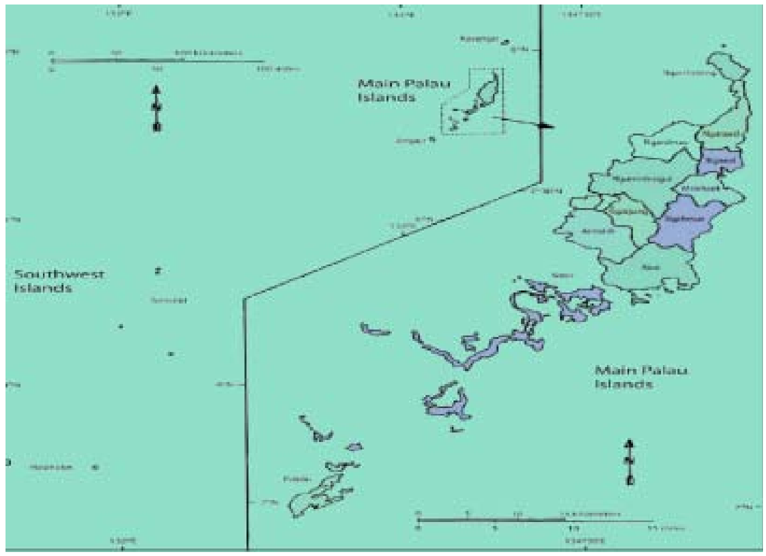
PALAU CASE STUDY - *TRIDACNIDAE*

AUTHOR:
Theo Isamu
Director, Bureau of Marine Resources & Marine Resources Scientific Authority of Palau

In the west central portion of the Pacific Ocean are several clusters of islands known to the world as Micronesia. Micronesia has three main island groups, (the Marianas, Marshall Islands, and the Caroline Islands) all of which comprise the former Trust Territory of the Pacific Islands. The Palau (Pelew) group lies farthest west among the Carolines which, in addition to Palau, encompasses the Federated States of Micronesia, (Yap, Chuck, Pohnpei and Kosrae).
Palau archipelago stretches over 2-8° north latitude and 131-135° east longitude. Major cities adjoining it are Manila (500n. miles northwest), Tokyo (1,900 n. miles north), Honolulu (4,450 n. miles northeast), and Sydney (3,300 n. miles south. Palau lies some 7° 30' north of the equator.

Of the 300-odd islands comprising Palau, eight are permanently inhabited. The total land area is less than 200 square miles. Babeldaob is the big island (second largest to Guam in Micronesia) which makes up the 75% of the acreage. Melekok is the provisional capital, however Koror is still the center of all government, economic and social activity where some of the 2/3 population still resides with even greater fraction of work force.

The larger islands were formed by Eocene volcanic activity and the interiors are mostly jungle. Kayangel, the northern most islands, is a coral atoll. The picturesque Rock Islands to the south are of lime-stone formation, two islets on the southeast Peleliu and Angaur are low platform and reef, with five islet groups on the southwest the Hatohobei, Sonsorol, Merrir, Helen Reef and Fanna are uplifted reef flats.



Map of the Republic of Palau Demarcating 16 States Boundaries

I. Background information on the taxa

The Indo-Pacific family Tridacnidae comprises two genera, *Tridacnae* Brugui’ere with five species: *Tridancnae gigas* (Linne*), T. gigas* (Linne), *T. drasa* (Roding); *T. derasa* (Lamarck,), *T. maxima* (Roding), and *T. crocea* (Lamarck); and the genus *Hippopus* represented by the species *Hippopus hippopus* and *Hippopus porcellanus*. Giant clams of the family Tridacnidae have been seriously considered as maricultural candidates. The first successful laboratory rearing occurred 3 decades ago (LaBarbera, 1975; Jameson, 1976) and mass culture techniques were not demonstrated until 1982 (Heslinga *et al*., 1984b).

1. BIOLOGICAL DATA

1.1. Scientific and common names

The classification of giant clams is as follows:

Phylum:	Mollusca
Class:	Bivalvia
Order:	Veneroida
Superfamily:	Cardiacea
Family:	Tridacnidae

According to Rosewater (1965) the family is geologically young, having existed from Eocene to recent times, and apparently evolving from a cardiid-like ancestor in the Eocene. The genera *Hippopus* and *Tridacna* both arose in the early Miocene. Brief taxonomic descriptions of the seven species are presented here based on accounts by Rosewater (1965, 1982), IUCN (1983) and personal observations.

Hippopus hippopus (Linnaeus, 1758), the Horse's Hoof, Bear Paw or Strawberry Clam, reaches approximately 400 mm in length. The valves are thick, heavy and triangular in shape, often covered with reddish spots and obscured by encrustations. The mantle is a deep yellow-green, irregularly mottled at the periphery and in the center.

Hippopus porcellanus Rosewater, 1982, the China Clam, is a very recently described species. Its shell is thinner and smoother than that of *H. hippopus*, usually devoid of pigmentation, and more semi-circular in profile. The mantle is similar to that of *H. hippopus* (Rosewater, 1982), except that prominent papillae line the margins of the incurrent siphon.

Tridacna squamosa Lamarck, 1819, the Fluted Clam, reaches about 400 mm and is characterized by an elongate shell with conspicuous fluted scales on its radial ridges (Fig. 12.2B). The valves are white and occasionally tinged with orange, and the mantle yellowish green.

Tridacna gigas (Linnaeus, 1758), the Giant Clam, is the largest extant bivalve and may attain weights of over 200 kg, of which 55-65 kg is living tissue. The shell may grow to 1370 mm in length. It is white and fan-shaped with deep radiating ribs.

Tridacna derasa (Roding, 1819), the Southern Clam, is the second largest tridacnid, reaching about 500 mm in shell length. It is characterized by a low primary and radial sculpture, variable shape, massive umbonal area and smooth white shell.

Tridacna maxima (Roding, 1798), the Small Giant Clam, is a partially burrowing species that reaches about 200mm in shell length. The mantle color is highly variable, ranging from bright blue to brown.

Tridacna crocea (Lamarck, 1819), the Crocus or Boring Clam, is the smallest of the tridacnids, reaching only 150 mm in shell length. The valves are greyish white, often fringed with orange or yellow both inside and out. They are triangularly ovate in shape. Mantle coloration is predominantly blue but shows great variability.

1.2. Distribution

The present day distribution of tridacnid clams is limited to tropical Indo-West Pacific seas, although fossil forms have been found in Middle Tertiary deposits of Northern Europe (Tridacna media Pusch; T. Wolfarti Chenu) and in Lower Miocene strata in Florida (Hippopus (?)

Gunteri Mansfield) (Rosewater, 1965). Present differences in the expanse of geographical distribution among different species of Tridacnidae are not easily explained by larval behaviour. For example, the most widespread species, *T. maxima*, and the narrowly distributed *T. crocea* show similar larval life spans (Yamaguchi, 1977). It appears that unknown ecological requirements are responsible for present distributional patterns

1.3. Biological characteristics:

1.3.1. *Biological and life history characteristics of the species*

REPRODUCTION;
Tridacnid clams are protandric functional hermaphrodites which reproduce by broadcast spawning (Wada, 1954). Early growth rates are rapid (50-100 mm per year for maricultured *T. derasa* and *T. gigas*) compared to other bivalves, but the onset of sexual maturity is relatively late. Palauan *T. derasa* reach male phase maturity at 3 years post-fertilization and full maturity at 5 years (Heslinga *et al*., 1984b, and unpublished data). Wada (1942) reported that *T. squamosa* and *H. hippopus* in Palau reach full maturity at 160-200 mm and 130-150 mm, respectively, which is about 3-5 years post-fertilization. *Tridacna maxima* in Tonga reaches male phase maturity at about 55 mm (2.5 years), and 50% are fully mature at 105 mm (5 years) (McKoy, 1979). Jameson (1976) found that *T. maxima* at Guam attains full maturity at 110-130 mm.

Pheromonal factors associated with sperm and eggs act as spawning inducers in tridacnids. Stress, handling, elevated temperature and the neurotransmitter serotonin have also been implicated as stimulants, but their effectiveness depends on the ripeness of the clams (Munro and Heslinga, 1983; Braley, 1985). The spawning process has been described in detail by Wada (1954), and his account corroborated by LaBarbera (1975), Jameson (976), Gwyther and Munro (1981), Beckvar (1981) and Fitt and Trench (1981). Ejaculation of sperm lasts for several minutes to more than an hour, and is followed by a quiescent period usually lasting less than an hour. Egg release may or may not follow. Fecundity is extremely high but not well documented. Jameson (1976) estimated that a *T. maxima* specimen spawned 10 million eggs. *Tridacna gigas* and *T. derasa* might easily produce greater than an order of magnitude more, since their gonads are much larger. There is no evidence that the tridacnids are capable of producing viable offspring through self-fertilization.

A significant diel and lunar spawning periodicity has been documented for *T. gigas* at Palau, where maximum reproductive activity occurs in the late afternoon during the second and fourth quarters of the lunar month (Heslinga *et al*., 1984b). Spawning seasonality is not evident in stenothermal equatorial areas like Palau but may exist at higher latitudes (Braley, 1984).

A typical bivalve trochophore gives rise to a D-shaped veliger on day 2 post-fertilization. On day 3 feeding begins on phytoplankton and particulates in the 1-10 micron range. Most workers list the larval swimming period as 10 days or longer in small laboratory culture vessels (LaBarbera, 1975; Jameson, 1976; Gwyther and Munro, 1981; Fitt and Trench, 1981; Murakoshi, 1978; Beckvar, 1981; Fitt *et al*., 1984), but in large outdoor tanks with food provided by the Wells-Glancy method, the tridacnid planktonic period is 5 days or less, and full metamorphosis of the larval population occurs by day 7 at about 30ºc (Heslinga *et al*., 1984b, and unpublished data).

During the swimming phase and immediately thereafter, veligers ingest (but do not digest) *Symbiodinium microadriaticum* cells, which move out of the gut by an unknown mechanism before taking up residence in the mantle region (Fitt and Trench, 1981). These cells eventually multiply into millions. After settlement and substrate exploration veligers metamorphose by shedding the velum. Byssal attachment follows, though this process is reversible, and the foot remains an effective locomotory organ for at least several months. The growth of tridacnids post-settlement is rapid; maricultured *T. derasa* reach mean lengths of 5.3 mm, 10mm, 12.1 mm and 20.0mm at 3,4, 5 and 6 months, respectively. Mean sizes of 15.3 mm, 12.6 mm and 19.3 mm were reached in 5 months by cultured *T. gigas*, *T. squamosa* and *H. hippopus* (Munro and Heslinga, 1983). Maricultured *T. derasa* specimens grew at an average rate of about 50 mm per year during their first 5 years in Palau. Rapidly growing individuals increased in size at nearly double the average rate during the first 2 years (Heslinga and Perron, 1983b).

Growth rates of wild tridacnids in nature have been reviewed by Munro and Heslinga (1983). Because absolute growth rates are positively correlated with maximum size, the most promising maricultural targets are the larger 2 species, *T. gigas* and *T. derasa*. In a frequently cited study, Bonham (1965) at Bikini used radioautography to determine that 520 mm and 550 mm *T. gigas* were 9 and 6 years old, respectively. Beckvar's (1981) data suggest that wild *T. gigas* in Palau may reach 500 mm in 6 years. These are extremely rapid growth rates. It should be emphasized, though, that these data describe wild individuals that have survived intense selection during the larval and juvenile phases. In maricultural operations, where survival rates are much higher than in nature and selection intensity greatly relaxed, average growth rates may well be lower than those recorded in nature.

Patterns of mortality in the Tridacnidae are not yet well understood, but it is logical to assume that because fecundity is unusually high, average larval mortality rates must also be extreme in nature. Based on *T. gigas* population size structures, many workers have concluded that recruitment rates must be low or erratic (Hester and Jones, 1974; Yamaguchi, 1977; Braley, pers. Comm.).

Wild juvenile clams probably suffer heavy predation pressure in nature. Experiments conducted at Palau showed that maricultured tridacnids in the 10-40 mm range experience nearly instantaneous mortality when released unprotected in their natural habitat (Heslinga et al., 1984b). Predators identified so far include hermit crabs (Dardanus), various molluscivorous fishes (Monotaxis, Balistoides, Rhinecanthus), carnivorous snails (Chicoreus, Cymatium), octopus (Heslinga *et al*., 1984a, b; and Perron *et al*., 1985). Cultured *T. derasa* specimens begin to attain immunity from crushing predators at about 100mm; at 150mm there are few predators except larger octopus and perhaps certain rays that can kill them. It is commonly believed that mature *T. gigas* and *T. derasa* have no serious enemies other than man.

The lifespan of giant clams has long been a subject of great curiosity to both scientists and laymen. At this point, however, longevity estimates are still largely speculative. McMichael (1975) in Australia concluded that 240 mm *T. maxima* were 40 years old, and McKoy (1979) estimated that 250-300 mm *T. maxima* in Tonga were well over 50 years old. Hamner and Jones' (1976) data indicate that 140 mm *T. crocea* in Australia might be about 60 years old. Summerhays (1976), citing data from the Queensland Fisheries Service, estimated that Australian *T. gigas* reached 500 mm in 10 years, and that very large (1400 mm) specimens might be 200 years old.

For maricultural purposes it is already clear that the most interesting part of the giant clam life cycle is the first 5-6 years, or roughly up to the onset of full (male/female) sexual maturity. Prior to this age meat and shell weight increase at a relatively rapid rate in *T. derasa*. When maturity is reached, growth rates decline as energy is increasingly channelled into reproduction.

1.3.2. *Habitat types*

Giant clams are normally restricted in their distribution to the shallow, well-illuminated waters of coral reefs. *Tridacna gigas* is found on sand and coral rubble on the leeward side of barrier reefs, from about 1-5 m depth. *Hippopus hippopus* occurs on sandy or rubble subtrates to 10 m depth on outer reef flats; it can also be common in lagoon areas and on sea grass beds. The globular shell shape may be an adaptation which permits rolling through the surf zone (Yonge, 1980), resulting in redistribution to sandy, back reef areas. *Tridacna maxima* is found often in the high energy waters of seaward reef slopes, where its burrowing habit and strong byssal apparatus prevent dislodgement by waves. *Tridacna crocea* burrows by mechanical and chemical means into coral heads on the reef top and is found with only the mantle visible. Hamner (1978) presented a detailed account of the population biology of *T. crocea*, including an analysis of many plant-like behavioural attributes which enhance intraspecific competitive ability. *Tridacna squamosa* often occurs on coral heads or rubble substrates at 2-20 m depth, both in exposed and sheltered habitats.

All tridacnids require clean, clear water of oceanic salinity. The optimal water temperature is not precisely known but appears to be in the range of 23-30°C

1.3.3. *Role of the species in its ecosystem*
The farming of giant clams is envisaged as means of promoting biological sustainability and maintaining biodiversity.

1.4. Population:

1.4.1. *Global population size*

1.4.2. *Current global population trends*
___increasing   _X_decreasing   ___stable   ___unknown

1.5. Conservation status

1.5.1. *Global conservation status* (according to IUCN Red List):

___Critically endangered	___Near Threatened
___Endangered	_X_Least concern
_X_Vulnerable	___Data deficient

IUCN red list assessments (1996):

T. crocea	Lower risk – least concern
T.derasa	Vulnerable
T. gigas	Vulnerable
T. maxima	Lower risk – conservation dependent
T. squamosa	Lower risk – conservation dependent
H. hippopus	Lower risk – conservation dependent
H. porcellanus	Lower risk – conservation dependent

1.5.2. *National conservation status for the case study country*

1.5.3. *Main threats within the case study country*

___No Threats
___Habitat Loss/Degradation (human induced)
___Invasive alien species (directly affecting the species)
_X_Harvesting [hunting/gathering] (subsistence/commercial]
___Accidental mortality (e.g. Bycatch)
___Persecution (e.g. Pest control)
___Pollution (affecting habitat and/or species)
___Other_______________
___Unknown

2. SPECIES MANAGEMENT WITHIN THE COUNTRY FOR WHICH CASE STUDY IS BEING PRESENTED.

2.1. Management measures

There is no management in place to regulate wild harvests outside conservation areas (see section 3). No exports are permitted of wild-taken clams (see section 2.3).

2.1.1. *Management history*

In the past giant clams were harvested from natural habitat and placed or pooled together in a nearby coastal area close to a community or village to only be harvested again during rough weather when family were unable to fish.

2.1.2. *Purpose of the management plan in place*

There is no management plan

2.1.3. *General elements of the management plan*

There is no management plan

2.1.4. *Restoration or alleviation measures*

The Palau Mariculture Demonstration Center (PMDC) Bureau of Marine Resources within the Ministry of Resources & Development started in 2005 a clam dissemination program to the community where to date 40 clam farms have been established consisting of more than 2 million clams disseminated. The variety of species of clams are *T. crocea*, *T. maxima, Hippopus hippopus* and *T. derasa* that make-up the most of these disseminated clams. The purpose of this program is to try and alleviate pressure of harvesting clams from the wild natural stock and also to set-aside at least 10% of clams from each farm so that they can spawn naturally in their own ranched enclosures and re-seed the nearby areas or use them as brood stock. The other objective of this program is to support food security and money making opportunity to support and improve standard of living in the community. All clams given to the farmers are free of charge.

Clam Culturing Techniques

In 1985 Palau increased its clam hatchery production of *Tridacnae derasa* to 250,000 p.a. (Heslinga and Watson 1985), however the selection of F1 for future brood-stock took place three years later, in 1989, when the clams have reached the male phase maturity. The criteria for selection of brood-stock was based on the *Symbiodinium* pigmentation color of blue green, dark green, ocean blue, and dark blue. We go back to collect wild spawners only if we want to diversify the genetic pool of our clams. The original brood-stock, derived from "a policy of using wild clams", were all placed back into the sea in "alphabetical order" close to the hatchery and other designated areas that are continued to be monitored. The founder clams are not afforded to be in the land-based tanks as they occupy much needed space for grow-out

Broodstock clams are (re)collected from the wild based on the moon phase for fecundity and are brought in to the hatchery for culture (after spawning they are returned to the wild in the same designated areas). They are brushed and scraped to rid of parasitic shells and calcareous algae. The clams are placed in the sun for an hour to stress them and then are placed in the hatchery tank where water was already prepared and warmed naturally by the sun. When the clams are spawning eggs they are placed in a styrofoam boxes with clean water where they continue to spawn eggs; sperm is collected later to manually fertilized the eggs as too much sperm will end up polluting the medium. Following the eggs being fertilized and once the free-swimming life phase has settled and metamorphosed and been counted, they are placed in the land based propagation tanks until they reach about 2.5cm. During the three months in the land-based propagation tanks they are continually thinned out as clams have the tendency to move and clump-up together where there is a possibility for their physical characteristics to be thwarted. After three months in the land-based propagation tanks, they can then be disseminated to farmers to rear in the sea in a protective cage of about 33.3 meter square. Currently Palau is using the F2 seedlings of *T. derasa, T. maxima, T.crocea*, and *Hippopus hippopus* for disseminating to farmers and export. Currently the *Tridacnae gigas* and *T. squamosa* are not being produced in our hatchery although we have the technology to produce them. No F1 specimens are exported or disseminated to farmers.

2.2. Monitoring system

2.2.1. *Methods used to monitor harvest*

All clams disseminated to farmers are counted and measured to get their mean sizes. The farmers are required to record mortalities in their farms including the local sales. The total mortalities and sales are deducted from the original inventory disseminated. The aquaculture personnel also conduct monitoring every six months for all the farms to asses whether the records are consistent.

2.2.1. *Confidence in the use of monitoring*

The monitoring of clam farms to assess the growth rate and to inventory the number of clams is a requirement to assist the farmers so that when they present invoices in reference to their clams sold then the total number sold is deducted from the inventory. Number of invoice and permit receipt with the number of certification and declaration forms are entered into our data base including species sizes and destination.

2.3 Legal framework and law enforcement

The inspectors are present at the airport every flight to inspect cargoes and checked in baggage. All marine resources or parts thereof to be exported or taken out of Palau are required to be declared. Falsification of declaration document warrant a fine of US$250.00 including each species failed to declare. Appendix II specimens such as tridacnid clams must be certified that they originate in Palau and that they are cultured pursuant to the CITES and that shipment is in accordance with the laws of Palau and will not be detrimental to the survival of the species in the wild, and if living will be transported in a manner which will minimize risk of injury, damage to health, or cruel treatment. The Marine Protection Act of 1994 and its Regulations prohibit exports of wild Tridacnid clams except cultured. The Act and its Marine Export Labelling Regulations mandate that all marine resources or part thereof are required to be declared by a person prior to being exported. Restricted marine resources and species stipulated in Appendix II of the CITES are required to be certified in-lieu or consistent with the CITES provisions.

3. UTILIZATION AND TRADE FOR RANGE STATE FOR WHICH CASE STUDY IS BEING PRESENTED

3.1. Type of use (origin) and destinations (purposes)

There are seven species of Tridacnid clams found in Palau and they have many uses. The meat is mainly used locally as food, an addition-al protein, and the most targeted or sought part is the abductor muscle that is sold locally in hotels and restaurants for $7.00 a pound for soup and or sashimi. The shells are used for arts & crafts. Wild clam specimens and captive-produced specimens can be used locally, however, captive-produced specimens only can be exported outside of Palau for aquarium trade and other commercialized activities. The exported captive-produced specimens are destined for Guam, Saipan, Honolulu, US Mainland, Germany, and France.

3.2. Harvest:

3.2.1. *Harvesting regime*

Harvesting for wild clams is not prohibited and there is no harvesting season; with respect to non extractive harvesting, clams are pooled in a specific frequent spot for eco-tourism and the designated conservation areas. Palau has 23 conservation areas and it's our mandate to replenish these conservation areas with cultured clams for species sustainability and diversity.

3.2.2. *Harvest management/ control (quotas, seasons, permits, etc.)*

The harvesting of wild and cultured clams is prohibited in the conservation areas. There are no quotas or seasons for harvest however non citizens are required to hold or own a collection permit if more than five marine specimens are collected in a day.

3.3. Legal and illegal trade levels

Illegal trade was never evident or practiced in Palau before and since the implementation of Marine Protection Act of 1994; due to our continued education awareness of the Act and its provisional requirements illegal trade has never been documented and is non-evident.

II. Non-detriment finding procedure (NDFs)

The CITES Article IV, paragraph 2a language is formally made part of the certification form in lieu of CITES, and Article IV, paragraph 3 is not applied because Palau Appendix II species such as Tridacnid clams can only be exported if they are cultured. Accordingly, non-detriment is achieved by restricting exports to captive-produced specimens; this culturing activity supports the conservation of the wild population through reducing harvesting pressure and by providing a source of animals for re-stocking the wild population.

1. IS THE METHODOLOGY USED BASED ON THE IUCN CHECKLIST FOR NDFs?

__yes _X__no

Palau does not use the IUCN checklist in making its non-detriment findings. Palau's methodology has never been based upon the IUCN checklist and such methodology, should it be complied with, may pose a problem with us because the clam exports are cultured based on our laws (24 PNCA 1204). As it is prohibited to export Tridacnidae clams harvested from the wild, Article IV may be problematic to be used as guidelines to monitor to ensure that such species throughout its range. CITES Article IV paragraph 2 & 2a, and paragraph 3 need, to me, to be modified and not used as factor to monitor species throughout their range. Our export process indicates by its in-lieu CITES Certification form that such species for exports/shipments are in accordance with the laws of the Republic of Palau, and will not be detrimental to the survival of the species in the wild, and, if living, will be transported in a manner which will minimize the risk of injury, damage to health, or cruel treatment. Traditionally Tridacnidae clams are consumed locally. Our current practice to sustain the population is explained above that 10% of the produced clams are farmed in the 23 conservation areas and these areas are prohibited entry.

2. CRITERIA, PARAMETERS AND/OR INDICATORS USED

The criteria or indicators is not applicable to us as the all Tridacnidae clam exports are cultured and to evaluate criteria and indicators as opposed to the sustainability of stocks in nature is somewhat perplexed and not clear.

3. MAIN SOURCES OF DATA, INCLUDING FIELD EVALUATION OR SAMPLING METHODOLOGIES AND ANALYSIS USED

4. EVALUATION OF DATA QUANTITY AND QUALITY FOR THE ASSESSMENT

5.-6. MAIN PROBLEMS, CHALLENGES OR DIFFICULTIES FOUND ON THE ELABORATION OF NDF AND RECOMMENDATIONS

Although the IUCN NDFs has never been applied however its applicability to our practice based on our laws is somewhat problematic and not very clear and this NDFs should be discussed further in the workshop to understand its conduciveness to our current practice.

REFERENCES

BECKVAR, N., 1981. Cultivation, spawning and growth in the giant clams *Tridacna gigas*, *T. derasa* and *T. squamosa* in Palau, Caroline Islands. Aquaculture, 24: 11-20

BRALEY, R.D., 1984. Reproduction in the giant clams, *Tridacna gigas*, and T. derasa in situ on the North- Central Great Barrier Reef, Australia, and Papua New Guinea. Coral Reefs, 3:221-227

BRALEY, R.D., 1985. Serotonin- included spawning in giant clams (Bivalvia: Tridacnidae). Aquaculture, 47: 321-325

CASTAGNA, M., and Kraeuter, J.N., 1981. Methods of growing the Hard Clam Mercenaria mercenaria. Virginia Institute of Marine Science Special Report in App. Mar Sci. Ocean Eng. No.,249, 110 pp.

DAWSON, R.F., 1985. Taiwanese clam boat fishing in Australian waters. Research Paper No. 33, School of Modern Asian Studies, Griffith University, Brisbane, Australia, 46 pp.

HESLINGA, G.A., and Fitt , W.K., 1987. The domestication of reef-dwelling clams. Bioscience, 37: 332-339.

HESLINGA, G.A., and Hillmann, A., 1981. Hatchery culture of the commercial top snail Trochus niloticus in Palau, Carolina Islands. Aquaculture,36: 35-43

HESLINGA, G.A., and Perron, F.E., 1983a. Conserving Palau's giant clams. Glimpse of Micronesia, 23: 46-49

HESLINGA, G.A., and Perron, F.E.1983b. The status of giant clam mariculture technology in the Indo-Pacific. South Pacific Comm. Fish. Newsl., 24: 1-5

HESLINGA, G.A., and Perron, F.E. In preparation. The status of giant clam stocks at Aulong Channel, Republic of Palau.

HESLINGA, G.A.,and Watson, T.C., 1985. Recent advances in giant clam mariculture. Proceedings of the Fifth International Coral Reef Symposium, 5:531-537

HESLINGA, G.A., Orak, O., and Ngiramengior, M., 1984a. Coral Reef sanctuaries for trochus shells. Mar. Fish. Rev., 46: 73-80.

HESLINGA, G.A., Perron, F.E., and Orak, O., 1984b. Mass culture of giant clams (f. Tridacnidae) in Palau. Aquaculture, 39:197-215.

HESLINGA, G. A., T.C., Watson, and T., Isamu. 1986. Cultivation of giant clams: Beyond the hatchery. Proceedings of the First Asian Fisheries Forum.

JAMESON, S.C., 1976. Early life history of the giant clams *Tridacna crocae*, *T.maxima* and *Hippopus hippopus*. Pac. Sci., 30: 219-233

LEWIN, R., 1984. Parks: How big is big enough? Science, 225: 611-612.

LABARBERA, M., 1975. Larval and post-larval development of the giant clams, *Tridacna maxima* and *Tridacna squamosa* (Bivalvia: Tridacnidae). Malacologia, 15: 69-79

MUNRO, J.L., and Heslinga, G.A., 1983. Prospects for the commercial cultivation of giant clams (Bivalvia: Tridacnidae). Proceedings of the Gulf and Caribbean Fisheries Institute, 35, 122-134

MUNRO, P.E., Beard, J.H., and Lacanienta, E., 1982. Investigations of the substance which causes sperm release in Tridacnid clams. Comp. Biochem.Physiol., 74:219-223

ROSEWATER, J., 1965. The family Tridacnidae in the Indo-Pacific. Indo-Pacific Mollusca, 1: 347-396

ROSEWATER, J., 1982. A new species of Hippopus(Bivalvia: Tridacnidae). The Nautilus, 96: 3-6

SUMMERHAYS, S., 1979. Giant clams. Oceans, May 1979: 25-28

TRENCH, R.K., 1979. The cell biology of plant-animal symbiosis. Ann. Rev. Plant Phys., 30: 485-532

YAMAGUCHI, M., 1977. Conservation and cultivation of giant clams in the tropical Pacific. Biol. Cons., 11: 13-20.

YONGE, C.M., 1975. Giant clams. Sci. Amer., 232:56-105

YONGE, C.M., 1980. Functional morphology and evolution in the Tridacnidae (Mollusca: Bivalvia: Cardiacea). Records of the Australian Museum, 33: 737-777