AQUACULTURE OF CORAL, LIVE ROCKS AND ASSOCIATED PRODUCTS

Aquaculture Policy

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Government of **Western Australia**
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DISCLAIMER

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EXECUTIVE SUMMARY

Aquarium enthusiasts use corals, live rock and associated products (e.g. live sand) for display and to maintain healthy water quality conditions in their marine aquariums. There is a large and growing market for these products. While the wild harvest fisheries for aquarium products in Western Australia are sustainably managed, output is capped, so increased product is needed to meet the market demand. With a trend towards the capping of wild harvest and additional pressures, such as the introduction of Marine Parks and other marine protected areas, the aquaculture of these products is set for industry development and expansion.

The large diversity of coral and associated species provides considerable flexibility in the range of culture systems and technologies. They can be grown in onshore, recirculated or flow through systems and in offshore open water systems. Offshore open water systems are generally considered a low impact aquaculture industry because the animals require little maintenance, no additional feeding (just sunlight), the footprint of farms is relatively small and a relatively low number of working days is required on any one site.

The Department of Fisheries has prepared this Aquaculture Policy to provide guidance to industry when considering the aquaculture of coral, live rock and associated products in Western Australia. The document provides background information about coral, live rock and associated products relevant to the development of an industry in WA and identifies the management arrangements.

The *Fish Resources Management Act 1994* ("FRMA") is the Act relating to the management of fish resources in Western Australia. Under Section 90 of the FRMA, parties engaging in aquaculture and related activities are required to have an aquaculture licence granted by the Chief Executive Officer of the Department of Fisheries. These requirements extend to the culture of coral and live rock. In accordance with Section 92 of the FRMA, the Chief Executive Officer can only grant a licence if he is satisfied certain criteria have been met.

The Department of Fisheries has clear processes for the assessment of applications and granting of licences in coastal waters. These are described in *Ministerial Policy Guideline No. 8: Assessment of Applications for Authorisations for Aquaculture and Pearling in coastal waters of Western Australia* ("MPG8"). The MPG8 process will apply to the assessment of applications for coral and live rock aquaculture in coastal waters. Applications for the aquaculture of live rock and coral in on-shore systems will be assessed under Section 90 of the FRMA in accordance with existing procedures.

SECTION 1 INTRODUCTION

Aquarium enthusiasts use coral, live rock and associated products (e.g. “live” sand) to enhance the aesthetics or function of marine aquariums. There is a large and growing market for these products.

Coral and live rock are used to:

- develop an architectural structure for aquariums and aquaculture tanks;
- contribute a large surface area substrate that facilitates biological filtration of a marine aquarium and stabilises its water chemistry;
- enhance the aesthetics of aquariums, providing a base to attach other corals, sponges, anemones and clams, giving shelter for the inhabitants; and
- provide an active biological filter within an aquarium environment.

The biological features of coral and their life history make them good candidate species for aquaculture. Corals reproduce either asexually and sexually. The techniques for asexual propagation are relatively straightforward. Similarly, the technology required for the culture of live rock can be as simple as placing a substrate in the marine environment and later harvesting the rock together with whatever has settled on it.

Coral can be cultured using a variety of production systems in a range of environments throughout Western Australia, from the tropical north to the temperate south. While the culture methodology is under development and may require considerable ‘fine tuning’, the culture of these groups of marine organisms is likely to employ relatively low technology.

Coral may be cultured in offshore aquaculture sites using bottom culture, or in suspended longline culture systems similar to those used to culture pearl oysters and mussels. Land-based operations using flow-through or controlled recirculating water production systems may also be used to culture animals outside their natural distribution and closer to markets or distribution points.

The wild harvest fisheries for these products in Western Australia are sustainably managed; however, output is capped, so increased output is needed to meet market demand. This provides an opportunity for aquaculture development.

From an economic perspective, the species found in WA are generally suitable for commercial production and have been grown profitably in Australia (Willis and O’Sullivan, 2004) and abroad (Falls *et al,* 2003).

This Aquaculture Policy is designed to provide guidance to industry when considering the aquaculture of coral, live rock and associated products in Western Australia.

SECTION 2 BACKGROUND

The coral 'group' is populous and diverse in terms of the range of species. The inherent flexibility of the reproductive strategies of the myriad species makes many of them suitable for aquaculture.

2.1 What is Coral?

Corals are marine animals from the Phylum Cnidaria. They exist as small sea-anemone-like polyps, typically in colonies of many identical individuals. There are a number of classifications of marine organisms within the Phylum Cnidaria, which include primitive animals generally known as jellyfish, sea anemones and corals. The largest of the Cnidarian Classes is the Class Anthozoa, which contains over 6000 species of coral and 'coral-like' species.

'Coral' is the common name for members of the Order Scleractinia, which all possess hard limestone or carbonate skeletons – the 'stony' corals. Other Anthozoan groups include Soft Corals (Order Alcyonacea), False Corals and Coral Anenomes (Order Coralliomorpha) and the Button Polyps (Order Zoanthidea). It is these groups, alongside the stony corals, that are commonly found in the aquarium trade. Figure 1 represents the taxonomic relationships within this group.

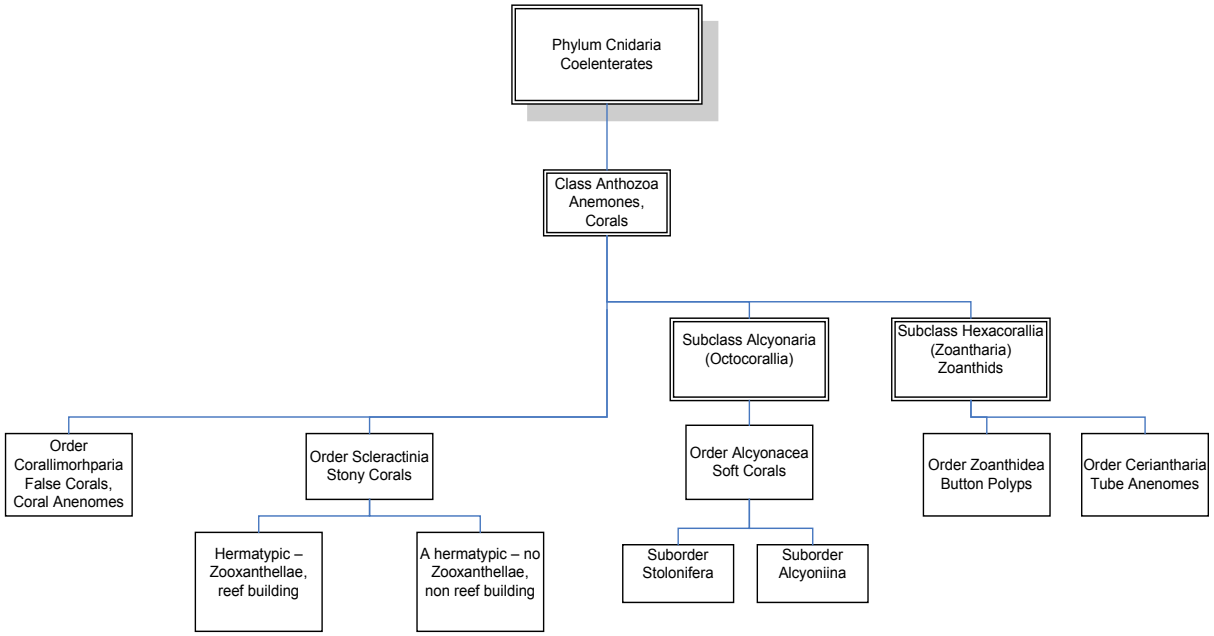

Figure 1 Taxonomic Relationships of Corals and Associated Orders

In this paper, "coral" refers primarily to hard and soft corals (as well as live rocks and associated products); however, the associated Orders, which are described below, form an important and economically lucrative part of the coral and aquaculture industry.

2.1.1 Stony Corals

Within the Order Scleractinia, there are two forms of stony coral:

- Reef-building coral (hermatypic) that incorporate symbiotic algae (zooxanthellae) and therefore require sunlight to survive; and
- Non reef-building coral that can survive in the dark (no symbiotic algae) and may be found in caves or the ocean depths (ahermatypic).

There is also a number of non-Scleractinian corals that build skeletons but not of a calcareous structure. Referred to as 'false corals' (Veron, 1986), these include familiar groups such as *Tubipora* and *Millepora* (Fire Coral).

Unique to the Scleractinians, the secretion of a calcareous exoskeleton provides the colony with a base over which the polyps settle. Within the hard corals classification, there may be further demarcation based on the polyp size and growth form of the colony. This distinction is also used in the trade and divides the hard corals into Small Polyp Stony (SPS) and Large Polyp Stony (LPS) classifications.

The generic groups and the characters of both Small Polyp Stony and Large Polyp Stony that are currently sold in the aquarium trade or aquacultured are detailed in Table 1.

Table 1 Hard Coral generic groups currently traded or aquacultured, broken into Small and Large Polyp Stony Classifications - (Information sourced from Veron 1986, Hargreaves 2004, Allen and Steene 1996, Fabricius and Alderslade 2002, Ruppert and Barnes 1994).

Scientific (genus) Name	Common Name	Growth Form*	Distinguishing Feature(s)	Abundance
Small Polyp Stony corals				
Acropora	Staghorn Coral	May be any or all forms but usually table or plate like or arborescent – composed of tree like branches.	Axial and radial corallites. Rapid growth.	Very common on shallow water reef slopes.73 species in Australia, 54 from WA.
Montipora	Plating Coral	Variable - Sub massive, encrusting, branching, foliaceous laminar	Very small corallites – most similar to *Porites.*	Very common to rare.
Pocillopora	Cluster coral	Branching Polymorphic dependent on habitat.	Wart like growths called verrucae covers the colony.	Common to very common.
Stylophora		Branching Compact bush.	Blunt ended branches.	Common.
Seriatopora		Branching Compact bush.	Corallites are arranged in neat rows along branches. Some species an attractive pink.	Common.
Porites				
Goniopora		Columnar or massive.	Greatly extended polyps day and night (aggressive and attack other corals).	Common in turbid protected waters.
Alveopora		Massive or branching.	Similar to Goniopora but polyp has 12 rather than 24 tentacles.	Uncommon but widely distributed.
Pavona	Cactus coral	Foliate.		May form massive monospecific stands.
Large Polyp Stony Corals				
Fungia, Heliofungia, Diaseris, Cycloseris, Polyphyllia	Mushroom Coral	Solitary free living disc or cigar shape.	Very large polyps can be up to 50cm including tentacles.	Common on reef slope.

Scolymia		Large solitary polyp.	Very large polyps can be up to 10cm.	Common on south WA coast.
Lobopohyllia				
Favia, Favites		Massive often – hemispherical.	Large conical corallites.	Common on back reef areas.
Goniastrea, Platygyra	Honeycomb or Brain corals	Massive often – hemispherical.	Precisely packed corallites sometimes with large 'valleys'. Vibrant colours. Very tough corals and often found in intertidal zone.	
Trachyphyllia		Large free living.	Fleshy polyps.	Rare on reefs. Common in protected shallow embayments.
Euphyllia	Bubble or hammer coral		All polyps are large, long tentacles with lighter coloured tips, some species have a T shaped tip	
Catalaphyllia		Small cylinder	All polyps are large and fleshy – resemble anemone due to large oral disc and ring of tentacles.	Occurs in turbid water.
Plerogyra	Grape Corals	Fist sized and shaped colonies.	All polyps are large and fleshy – resemble bunch of grey grapes.	Uncommon.

* Growth forms include massive, columnar, encrusting, branching, foliaceous (forming a whorl), laminar (forming a tier) and free-living (Veron 1986).

2.1.2 Soft Corals

Soft corals are prominent members of the shallow water coral reef community that belong to the Order Alcyonacea. They are known as soft corals because they lack a hard, carbonate skeleton but maintain body shape using free or fused spicules, or sclerites, embedded in the colony tissues.

The shape of the sclerites when identified microscopically can determine the species of soft coral; therefore, field identification of soft coral species is commonly limited to genus. Most soft corals look different depending on whether the tentacles are extended. The soft and flowery appearance of the tentacles is most sought after for aquarium displays.

Several genera commonly found in the market are popular with marine aquarium enthusiasts. Within this group, those currently traded or aquacultured within Western Australia are described in Table 2.

Table 2 Soft coral generic groups currently traded or aquacultured

Scientific Name (genus)	Common Name	Growth Form*	Distinguishing Feature(s)
Sarcophyton sp.	Toadstools or mushroom leather corals.	Massive form.	Large colonies with a rough and leathery texture and sit on a broad pedal base (Hargreaves 2004).
Lobophyton sp.	Lobed or ridged leather corals	Encrusting disc.	Large disc (up to 1.5m diameter) with radial ridges.
Sinularia sp.	Flat, slimy, digitate or Knobby Leather corals.	Various.	
Cladiella australis	Finger leather		
Clavularia viridis Technically Order Stolonifera	'Tree fern' or 'palm corals' Green tube coral.	Encrusting.	Produce large sheet like colonies where individual polyps are connected together with a stolon. Very attractive specimens with eight conspicuous feathery tentacles.

2.1.3 False Corals and Coral Anemones – the Coralliomorphs

The Order Coralliomorpha consists of three families, ten genera and between 45 and 85 species (Hargreaves 2004). They are difficult to identify to species level and the taxonomic ambiguity is due to the lack of internal and external characteristics to distinguish between taxa.

Despite difficulties in species identification, Coralliomorphs are common in the trade. Table 3 outlines some of the species (taxa) that are currently traded or aquacultured within Western Australia.

Table 3 Coralliomorph generic groups currently traded or aquacultured

Scientific Name (genus)	Growth Form*	Distinguishing Feature(s)
*Discosoma***	Oral disc a relatively smooth delicate.	Smooth flower like polyps that appear fleshy yet delicate. Asexual reproduction through pedal laceration to rapidly form colonies.
*Amplexidiscus**	Flat mushroom like disc that can grow to over 40cm diameter.	Oral disc covered in small rounded tentacles, edges of the disc is smooth.
Ricordia	Flat mushroom like disc.	Small tentacles on surface of oral disc. Asexual reproduction by pedal laceration.
*Metarhodactis** - *trade name*	To be advised.	To be advised.

NOTE: *Not collected locally in WA but sourced interstate or over seas. **Collected locally in WA.

2.1.4 Button Polyps – the Zoanthids

Very common in marine aquariums, this group (Order Zoanthidea) is an important encrusting group on live rock. They are primarily photosynthesisers using zooxanthellae but some small plankton may be ingested by some species. The Order Zoanthidae has either a skeleton or a basal disc and comprises three main groups (Hargreaves 2004):

- Individual polyps that occur singly and are found embedded in sand (*Sphenopus*);
- Polyps living in colonies and may be connected by *stolons* but without a supportive tissue (*coenenchyme*) between polyps – may have sand embedded within supportive column (*Zoanthus, Protopalythoa*); and
- Polyps are embedded in coenenchyme and contract completely within (*Palythoa*).

Most traded product is either *Zoanthus* or *Protopalythoa* but sometimes incorrectly sold as *Palythoa*. Despite difficulties with identification, Zoanthids are very common in the trade. Table 4 outlines some of the species (taxa) that are currently traded or aquacultured within Western Australia.

Table 4 Zoanthid generic groups currently traded or aquacultured

Scientific (genus) Name	Growth Form*	Distinguishing Feature(s)
Zoanthus	Can form tightly packed compact colonies.	Small (5-10 mm) oral discs with ring of long tentacles around margin. Asexual reproduction through budding off the stolons to rapidly form colonies. No sand embedded in body tissue.
Protopalythoa	Oral disc on a short stem. Individuals or colonies of little 'mushrooms'.	Larger (10-25 mm) oral discs with ring of short tentacles around margin. Upright columns with sand embedded in the body tissue.

2.2 What are Live Rock and Associated Products?

"Live rock" is a trade name for a substrate (generally a rock or dead coral) colonised by a range of benthic flora and fauna. Clearly the substrate itself is not alive but the veneer of organic matter living on or around it is.

For the purpose of this Coral Policy, it is important to note that in any referral to quantities of live rock, the weight includes the rock, substrate or other substance in addition to the weight of the organisms attached to, or inhabiting it.

The organic covering may include algae (green, brown and red), crustose coralline algae, sponges, bryozoans, hydroids, zoanthids, tunicates, coralliomorphs, bivalves and polychaetes. The porous nature of 'wild' live rock means that it also provides a refuge for other organisms such as crabs, shrimp, fish, nudibranchs and molluscs.

'Live sand' is either natural coral sand collected from the ocean or non-living coral sand, or aragonite (limestone) sand cultured to make it 'live' through inoculation of existing live sand. The marine bacteria that grow on it and the many micro- and macro-organisms that reside in it make sand 'live'. Live sand can serve as the main base for biological filtration in a saltwater aquarium, as the organisms help consume organic matter in the sand bed. Good quality live sand also adds aesthetic value to an aquarium system.

Live rock and live sand serve as the 'backbone' of marine display aquariums. Live rock is known by many names in the aquarium trade, such as reef rock (low density material, usually coral skeleton), inshore rock (more dense and may be limestone or local 'continental' rock) and base rock (low level of colonisation by flora and fauna).

2.3 Market

The global market for marine aquarium products is substantial and growing rapidly, with worldwide trade estimated to exceed US$7 billion (Falls *et al* 2003). Growth in the trade of live stony corals (Order Scleractinia) throughout the 1990s increased from around 200,000 units (where one unit equals one saleable piece of coral) in 1990 to 750,000 units in 1999 (CITES, 2002), with industry sources aiming to double that figure by 2010. The trade in live reef rock has increased 1,700 per cent since 1988 (**U.S. Coral Reef Task Force 1999**).

The USA is the largest consumer of coral, with an estimated 1-1.5 million hobbyists living in

the USA (US Fish and Wildlife Service 2003) importing 80 per cent of live coral and 90 per cent of live rock exported globally. Ornamental aquarium products are a major aquaculture industry in the USA worth approximately US$1 billion. Twenty per cent of retail sales are for marine species (Falls *et al* 2003). Growth in the market demand for coral is estimated at 12 to 30 per cent in the USA per annum. This is consistent with global annual growth, which is estimated at 10 to 15 per cent or 40-60,000 units per annum.

As with any wild fishery, the limits of sustainable take of coral and community expectations regarding the utilization of the resource may lead to a gap between supply and demand. The global market is growing and the supply of wild stock limited. Improved management arrangements are needed to ensure sustainability of the coral reef communities (Ellis 2002); for example, in many locations in the US and islands under US jurisdiction in the Atlantic and Pacific, the wild harvest of live rock is banned (Falls 2003).

For the reasons described above, the aquaculture of live rock, coral and associated products is seen as a business opportunity with growth potential. As well as the economic opportunities, aquaculture can generate environmentally responsible, certifiably sustainable and acceptable products that suit the market, can be manufactured to order and supplied to specifications, are accustomed to a 'culture system' and can support profitable businesses.

Several factors contribute to coral having potential in Western Australia. These include suitable sites, a wide range of species, existing expertise in the collection and marketing of wild-caught product and a clean environment. Consequently, there is interest in the commercial aquaculture of coral in Western Australia.

SECTION 3 AQUACULTURE OF LIVE ROCK, CORAL AND ASSOCIATED PRODUCTS

3.1 Industry Overview

Coral aquaculture developed from the propagation skills of marine aquarium enthusiasts and was well established and widely practiced in the USA by the late 1990s. At present, propagation techniques are well established for about 50 coral species (CITES 2002).

Hard corals are farmed on some scale in France, the Netherlands, Germany, China, Dominica, Fiji, Indonesia, Israel, Marshall Islands, Philippines, Singapore, United Republic of Tanzania, United States, Puerto Rico, Palau, Solomon Islands and Japan (CITES 2002). The industry in Australia is presently characterised by a few small experimental producers, mainly in Queensland (Willis and O'Sullivan 2004).

At present, live rock is 'cultured' in the US in Florida, Hawaii, Michigan and Idaho, using calcium carbonate rocks either collected from the land or artificially constructed. These are 'seeded' by placing them on leased areas of the seabed or in land-based tanks that already contain live rock.

The greatest constraint to future growth of the coral aquaculture industry is competition from cheap, wild product originating from Fiji. Much of this product is collected in an unsustainable manner.

Research on the development of large-scale hard and soft coral aquaculture techniques has been conducted through the Centre for Tropical and Subtropical Aquaculture based in Pohnpei in the Federated States of Micronesia (Ellis and Sharron 1998, Ellis and Ellis 2002). This research provided the foundation for the development of a coral aquaculture industry in Micronesia.

Most of the cultured coral is now grown from cultured donor colonies or from a few wild-sourced individuals. The techniques may vary but generally the coral is held in trays secured to the seabed, on racks or suspended culture systems, or in land-based tanks, with either natural or artificial light.

Coral aquaculture is potentially a low impact industry. The culture of live rock can be as simple as providing a substrate, permitting recruitment of benthic flora and fauna on the substrate and maintaining a high light environment (although crustose coralline algae may be more colourful and therefore valuable when grown in low light conditions). Similarly, coral grows with the benefit of good quality water and light.

Inoculating clean limestone or beach sand with sand extracted from the natural benthic environment produces 'live sand'. The live culture of bacteria, worms and other micro invertebrates in live sand maintains optimal water quality and a healthy substrate within the tank environment.
Corals and live rocks are generally photosynthetic; they have minimal dependence on, and therefore rarely require, supplementary feeding. Live rock does not require cleaning. The bio-fouling of most concern to coral culture is macroalgae that may shade the colonies.

3.2 Aquaculture Production Systems

A coral aquaculture system is described by its location and whether it is ocean- or land-based. The onshore and offshore aquaculture production systems currently used for coral and live rock growout are considered in the following sections.

As for any proposed aquaculture project, detailed analyses and assessments of financial feasibility should be undertaken before any substantial investment is made.

3.2.1 Onshore, Flow-Through Systems

Onshore, flow-through production systems for coral and live rock growout use marine water, with different stages of particulate filtration or chemical treatment. The culture units include tanks, trays, raceways and ponds.

Onshore systems used for growout are usually intensive to semi-intensive; at present in Australia, they are small to medium scale and support coral biology research trials. There are currently no coral hatcheries to provide seed stocks, so production is dependent on vegetative propagation techniques.

Fundamental requirements for successful coral and live rock aquaculture are the availability of large surface area and adequate light. Consequently, most coral and live rock tanks are wide, shallow and fitted with fluorescent or metal halide lights to enhance growth. Lined earthen, fibreglass or concrete raceways may be used. Outdoor culture is the most economically viable option in locations where the temperatures are suitable. In tropical areas within the natural distribution of the species, culture tanks may be shaded so temperature extremes do not stress the stock.

Corals and live rock are cultured within the water column in racks or trays designed and placed to maximize light availability, water flow and assist in the management and movement of batches. Large donor or broodstock coral colonies and live rocks may be placed in individual blocks on the bottom of the tank.

Live rock and coral held in tank or raceway systems can be stocked at the relatively high stocking density of 20-50 kg/m^2, depending on the density of the substrate. The optimum density varies according to growth form and water quality and stocking rates are adjusted to avoid negative density-dependent effects such as poor growth.

Water flows vary according to overall stock density, water volume availability and species needs. Flow rates usually exchange around 10 per cent of the total system volume per week.

3.2.2 Onshore, Recirculating Systems

Live rock and coral growout also takes place onshore, outside the natural distribution of the species, using intensive recirculating water systems.

Recirculating systems are usually housed in insulated buildings, in which the water is artificially or geothermally heated to the required temperature. Several of these systems are presently used in Australia to grow coral (Willis & O'Sullivan 2004) or by wholesalers or others in the marketing chain to hold stock.

The water discharged from or contained within the culture units is treated using a combination of physical and biological filtration, before being pumped back into the culture system. Recirculating systems are typically intensive and support high stocking densities. They all require some degree of water changes of synthetic or fresh seawater, due to accumulation of nitrates and the addition of freshwater to compensate for evaporation.

A significant advantage of recirculating systems is their relative independence from the local environment and limited water requirements; however, these systems are expensive to establish and the technology needed for their efficient operation at a commercial scale is still developing.

3.2.3 Offshore, Open Systems

Offshore production systems almost invariably use bottom culture on racks, baskets, panels or cages or suspended culture using longline systems similar to those used to culture mussels and pearl oysters. The use of suspended culture longline systems is well established in WA, with pearl and mussel farm techniques likely to be suited to suspended culture of coral, when suitable tray and basket systems are developed.

The use of bottom culture on racks, cages or fence lines is also used in pearl culture and is therefore a technology that is understood. The racks or cages may be of any shape or dimension, with the individual design and deployment varying according to the features of the site at which they are located.

Factors such as water depth, currents and exposure determine the suitability of a site for offshore production systems. The features of any specific site can determine the species most suited for that site and the most practicable type of production system. For example, Ellis and Ellis (2002) have demonstrated that, in a shallow lagoon environment, rack or table systems are adequate for the culture of a number of hard and soft coral species.

3.2.4 Coral Species Cultured

The diversity of corals is great and some morphological and reproductive strategies lend themselves more to aquaculture than others. At the outset, species that are easy to culture by fragmentation or other asexual propagation techniques are likely to dominate the species cultured. The stony coral species most compatible with vegetative reproduction are the small polyp stony corals but the greatest market demand/opportunity is for large polyp stony corals, which may not be suited to these techniques.

Large polyp stony species are highly sought after however their availability is limited. The development of improved husbandry techniques and further aquaculture experience may be a way to supply the market with these specimens.

As for all aquaculture industry sectors, production is ultimately driven by demand in the market place. In the early stages of developing a coral aquaculture industry, it is likely that production efforts will focus on abundant and easily cultured species. In the longer term however, proponents may chose to devote resources to research and development of culture practices for the more uncommon, higher value species.

SECTION 4 CORAL AND LIVE ROCK FISHERIES

4.1 The Wild-Capture Fishery in Western Australia

The Integrated Fisheries Management Program of the Department of Fisheries manages the Marine Aquarium Managed Fishery. The quantity of coral and live rock caught by this fishery in Western Australia is small and capped by quota management at 7.5 and 1.5 tonnes, respectively. Of the 13 marine aquarium licensees, five are currently permitted to collect coral and three to collect live rock. Compared to the commercial fisheries of Queensland and other countries in the Indo Pacific, the volume harvested by the Western Australian fishery is insignificant.

The commercial catch in Western Australian centres around the Dampier Archipelago, Exmouth Gulf and in other areas of the west coast, including the reefs offshore from the metropolitan area. Commercial fishing for live rock and coral can occur anywhere on the Western Australian coastline (excluding Marine Parks where this activity is not permitted). Factors that tend to restrict coral harvest activities to the above locations include proximity to airfreight services and markets; clean water suitable for the targeted species; and reef locations within an economical distance from a port.

4.2 Recreational Take of Corals and Live Rock

The recreational fishery of coral in Western Australia was banned in 2001 by the gazettal of a Section 43 prohibition on the take of coral and associated groups. This prohibition was in response to concerns of the over-fishing of small areas that were convenient to infrastructure such as boat ramps. The issues surrounding recreational take are outlined in Fisheries Management Paper 163 (October 2002).

4.3 Pressures on the Wild Capture Fishery

Recently, pressure on the wild capture fisheries for marine aquarium products has been increasing through the proposed zoning and formation of Marine Protected Areas (MPAs) and Marine Parks. The rezoning of the Great Barrier Reef Marine Park in Queensland in 2003-04 significantly altered the areas available to collectors and fishers through the designation of new reserves, or changing permitted activities on other reefs. Similar proposals in Western Australia to increase the area preserved within Marine Protected Areas or changes to the permitted activities in existing Marine Parks has or will have, effects on the wild fishery that include:

- reduction in the available area for fishing activities;
- some licence holders possibly leaving the fishery;
- new zoning plans that may reduce the availability of some species restricted to those zones; and
- by reducing supply, increasing the value of existing product.

Due to the anticipated pressures on the wild fishery, aquaculture may be seen as a commercial opportunity. The product previously removed from the wild by the commercial fishery could be propagated through aquaculture, enabling a greater quantity than the harvested amount to be sold at a later date. This product would be entering a market environment of increasing demand (global and domestic) and a shrinking supply base from the wild capture fishery. The skills of the participants within the commercial fishery in biology, technical knowledge and market connections may mean this sector would be well placed to evolve into a successful sector of the aquaculture industry.

SECTION 5 REGULATORY FRAMEWORK

This section provides an overview of the current regulatory framework.[1]

5.1 Fish Resources Management Act 1994

The *Fish Resources Management Act 1994* ("FRMA") is the Act relating to the management of fish resources in Western Australia. The objects of the FRMA [in part] are to conserve, develop and share the fish resources of the State for the benefit of present and future generations, and to manage and foster the development of aquaculture.

5.2 Aquaculture Licensing

Under the FRMA, unless the contrary intention appears, "aquaculture" means the keeping, breeding, hatching or culturing of fish. The definition of fish in the FRMA is any aquatic organism of any species (not necessarily alive), or parts of an aquatic organism, but specifically excludes amphibians and aquatic reptiles, birds and mammals.

Under Section 90 of the FRMA, parties engaging in aquaculture and related activities are required to have an aquaculture licence granted by the Chief Executive Officer of the Department of Fisheries. These requirements extend to the culture of coral and live rock.

In accordance with Section 92 of the FRMA, the Chief Executive Officer can only grant a licence if he is satisfied that:

(a) The person is fit and proper to hold such a licence;

(b) The granting of the licence will be in the better interest of the aquaculture industry;

(c) The activities to be conducted under the licence are unlikely to adversely affect other fish or the aquatic environment; and

(d) The activities to be conducted under the licence have been approved by other relevant authorities.

In relation to (d), "the activities to be conducted under the licence have been approved by other relevant authorities", a range of other approvals may be required. These may include:

- Environmental assessment by the Environmental Protection Agency (EPA) under the *Environmental Protection Act 1986*;
- Approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*;
- Planning approval by the Department of Lands; and
- Local government planning approvals.

5.3 Policy

The Department of Fisheries has clear processes for the assessment of applications and granting of licences in coastal waters. These are described in *Ministerial Policy Guideline No. 8: Assessment of Applications for Authorisations for Aquaculture and Pearling in coastal waters*

[1] An assessment of Regulatory and Policy Frameworks from other jurisdictions from within Australia and overseas was carried out in the development of the Draft Policy paper. No additional information was found that could add value to this document.

of Western Australia ("MPG8"). The MPG8 process was developed to ensure appropriate use of public waters and provide transparent and inclusive consultation with the community.

The MPG8 process will apply to the assessment of applications for coral and live rock aquaculture in coastal waters. As indicated in Table 5, licensees with existing marine based sites, proposing to diversify into coral will be required to apply for a "major variation" under the MPG 8.

Applications for the aquaculture of live rock and coral in on-shore systems will be assessed under Section 90 of the FRMA in accordance with existing procedures.

Table 5 Aquaculture Licences and Assessment Processes

Licence Type	Department of Fisheries process
Application for a new offshore aquaculture licence.	MPG 8 Consultation and assessment process.
Variation of an existing offshore aquaculture licence to include live rock and coral.	Major variation and processed through MPG8.
Application for a new onshore aquaculture licence.	Application pack per standard Department of Fisheries licensing process for land based sites.
Variation of an existing onshore aquaculture licence.	Variation per standard Department of Fisheries licensing process for land based sites.

Details of the MPG8 are available by contacting the Department of Fisheries or can be downloaded from the web page:

http://www.fish.wa.gov.au/comm/broc/mpg/mpg008/index.html

5.4 Collection of Fish for Aquaculture Purposes

The grant of an aquaculture licence provides authority to conduct aquaculture activities for commercial purposes. An aquaculture licence does not however, confer approval to collect relevant fish from the wild for farming purposes, including broodstock collection for propagation, or juvenile collection for growout.

Generally there are three avenues by which coral stock may be obtained for aquaculture:

1. Purchase from commercial fishers;
2. Purchase from other aquaculture licence holders; or
3. By making an application for a Ministerial Exemption under Section 7 of the FRMA.

SECTION 6 MANAGEMENT / POLICY

This section identifies the management issues and potential risks associated with the emerging coral and live rock aquaculture sector. In setting out this policy so it is aligned with the objectives of the FRMA, the management arrangements are provided according to the format set out below.

Issue and Risk	Identifies the relevant issue or risks associated with the appropriate management of the industry. Includes consideration of associated compliance, regulatory and environmental risks.
Industry Comment	Outlines the needs of the coral aquaculture industry for conducting efficient and profitable business operations.
Policy Management Arrangements	Outlines the policy and management arrangements the Department of Fisheries proposes to apply to the issue.

6.1 Grant of an Aquaculture Licence

Issue and Risk

Section 92 of the FRMA states that if a person applies to the Chief Executive Officer (CEO) for the grant of an aquaculture licence and the CEO is satisfied that the applicant meets all essential criterion, the CEO may grant to the person an aquaculture licence. Such licence may authorise the person, or persons acting on that person's behalf, to engage in an activity referred to in Section 90 of the FRMA. In relation to the criterion that the person is "fit and proper", the Department needs to be satisfied that persons provided with the opportunity to utilise crown waters for aquaculture, have the skills, experience and "good track record" to maximise productivity and reduce risk of failure or non-compliance.

Industry Comment

It is in the better interests of the licensees within the aquaculture industry that all licensees have the ability to conduct their proposed activities efficiently and legally. This maintains the reputation of the sector, provides a credible and arguable case for the growth of the industry in an increasingly competitive environment and ensures that future investment may not be influenced by performance history.

Policy Management Arrangements

The management arrangements are:

- Licence applications will generally be assessed in accordance with Ministerial Policy Guideline No. 19: *Matters of Importance in Respect of the 'Fit and Proper Person' criterion for authorisations under the Fish Resources Management Act 1994*. Accordingly, applicants will need to demonstrate they are "fit and proper" to undertake coral or live rock aquaculture and provide detailed information regarding their existing skills, or contracted skills, that will be incorporated in the operational and corporate management of the business.
- Marine based licence applications will be assessed in accordance with Ministerial Policy Guideline No. 8: *Assessment of Applications for Authorisations for Aquaculture and Pearling in coastal water of Western Australia*. This practice is likely to be continued in most cases for coral applications

6.2 Number and Size of Marine Based Sites Per Company at Grant

Issue and Risk

There may arise an issue in relation to the number and size of marine sites granted per licensee for coral and live rock aquaculture.

The risks associated with granting an individual or single company multiple, large sites include:

- non- or under-performance on any of the sites decreases the value to the state;
- the potential for applicants to speculatively acquire sites and take up valuable waters that may be productively utilised by other aquaculture licensees; and
- undercapitalised licence holders attempting to develop sites in excess of their capabilities, possibly leading to business failure and ultimately to a negative impact on investment in the aquaculture industry.

The Department will consider the ramifications of granting multiple marine-based sites to individual proponents to ensure that sites are appropriately utilized. There may be merit in considering the number of sites available to each licensee and restricting their size, to ensure they are manageable and do not cause negative environmental impacts.

Industry Comment

Parties entering into this sector may seek access to a number of sites, either to spread risk (due to impacts such as cyclones), to provide culture conditions suitable for a range of species and to reach production levels necessary to enter markets. It is also possible that some proponents may be opposed to the Department granting multiple sites to others during the early stages of industry development, as this may limit future access.

Policy Management Arrangements

In relation to the size of marine sites granted for coral and live rock aquaculture, there is no clear advantage to the Department or industry at this stage to prescribe a specific size restriction. It is more appropriate to allow applicants to specify and provide justification for their desired site and its area.

The management arrangements are:

- Historically, separate aquaculture licences have been required for each site. This practice is likely to remain.
- The assessment process for coral and live rock aquaculture licence applications will generally follow the policy applied to other aquaculture industry sector, unless otherwise stated in this policy document.
- The Department will consider the number of licences granted to undertake coral aquaculture on a case-by-case basis and take into account the availability of land or water, the exposure of the site and possible environmental effects of proposed culture infrastructure.
- The applicant must provide suitable justification for the area or size of the site. Issues such as navigation and disease control will determine whether the distance between sites is appropriate. Each application will be assessed on a case-by-case basis.
- Performance criteria may be imposed to ensure proper site utilisation. Criteria may include reporting on licence conditions and conduct, taking into account the development status of the industry, the development of the site and the proportion of site being utilised.
- Licensees are required to provide monthly production returns per existing regulations.

6.3 Coral Species Identification

Issue and Risk

The identification of coral species is difficult when compared to fish, crustaceans and molluscs. The taxonomy of hard and soft corals is one of the most complicated fields of marine science; however, some good references provide guidance for laboratory and field-based identification of coral species (Veron 1986, Fabricius & Alderslade 2002).

The morphological plasticity of species, affected by location within the natural range, depth and environmental niche, further contribute to ambiguity. Many coral species can only be clearly identified by microscopic examination of the spicules (soft coral), corallites and the arrangement of skeletal septa (hard coral). Given the significant difficulties involved in identification of coral species, the plethora of synonyms in the taxonomy and an even greater number of common or marketing names, a clear and uniform naming system is important.

Several names are often used for the one species in the market place and the use of subjective or descriptive non-scientific names is common. For example, a trade name of "brown mushroom coral" is used to describe a species that can also be blue or purple, depending on where it is sourced and the depth at which it has grown. Correct identification may require referral of preserved specimens to a recognised expert for a particular genus. This process is clearly not appropriate for field use by Fisheries and Marine Officers undertaking on-site compliance audits.

Inconsistent and unclear nomenclature creates challenges for the management and compliance activities imposed on a coral aquaculture industry. The tools and techniques used to gain certainty in the highly technical field of coral taxonomy and identification are not consistent with the practicalities of growing and marketing corals by industry and are not appropriate for use by Department of Fisheries compliance field staff.

For example, the use of taxonomy at the species level on aquaculture licences may create a confusing or conflicting situation if farmers and compliance officers are not able to distinguish one species from another.

Industry Comment

The aquaculture industry requires a consistent naming system that suits the wholesale and retail markets. The name of a product may be very closely linked to the value as a collectable species, or ones similar to it, and may impact on marketability.

The use of existing common names is not likely to change as they are adopted on a global scale; therefore, industry must adopt the product names acceptable in the market but that also provide sufficient detail to satisfy the statutory reporting requirements of the Department of Fisheries.

Policy Management Arrangements

The Department recognises that a less complicated identification system is needed; therefore, for some cases, it has resolved to simplify the taxonomy by referring to genus instead of species. There may be occasions however, where the Department will require the proponent to provide additional information relating to the species name or equivalent means of identification. This situation may apply to genera that include many species; for example, *Acropora spp* includes over 500 species all collectively known in the trade as "staghorn coral".

The management arrangements are:

- Coral will generally be identified to genus level and where practicable to species level.
- Applicants will be required to provide in the licence application sufficient information relating to the identification of the genus (or species if known) of coral they wish to aquaculture. Such information may include providing genus- or species-specific information and photographs.

6.4 Distinguishing between Aquacultured and Wild-Captured Coral and Live Rock

Issue and Risk

With the development of a coral aquaculture industry, the Department needs to ensure appropriate arrangements are in place to guarantee the aquaculture licence is not used to launder illegally harvested wild coral and live rock. This will require mechanisms to distinguish between live rock and coral product sourced from the wild or derived from aquaculture production.

Reliable means to distinguish between wild caught and aquacultured product might also provide the industry with an opportunity to certify its product and market it as "environmentally sound".

Industry Comment

Industry will need to be diligent to demonstrate its coral and live rock products have been produced by aquaculture. This requirement constitutes an administrative cost to industry and the Department of Fisheries; therefore, the system adopted to achieve this objective should not severely impact on the economical viability of the industry. Similarly, the benefit to the Department of Fisheries in having a system in place that can demonstrate sustainability must not have a prohibitive administrative cost.[2]

Increasingly concerned with the origin of product, the global coral market is sensitive to purchasing from sources not demonstrably sustainable. Within the wider marine aquarium market, the ability to certify sustainably produced aquaculture product could enhance the value of the product, provided it is properly marketed and non aquaculture products are not sold as such. The ability for industry to demonstrate its product has been lawfully obtained and sold is also a Commonwealth Government requirement (Department of the Environment, Water, Heritage and the Arts) for the grant of export permits.

Policy Management Arrangements

The management arrangements are:

- The Department of Fisheries will generally include a requirement for individual tagging of coral as a licence condition. Licensees will have the ability to develop their own method of tagging that satisfies prescribed criteria. Examples of suitable tagging methods include, (but are not limited to) the following:
  - Numerical tags. A numeric tag can be inserted that correlates to other consignments or farm management paperwork or another unique tag that identifies the stock as cultured. This will clearly distinguish between wild and cultured product and uses a traceable and transparent procedure. Tags would assist in identifying between cultured coral, source colony and the history behind the culture of an individual specimen on a farm.

[2] In this context, "sustainability" implies the ability to track coral from wild take through fragmentation and subsequent culture to provide new coral colonies.

– *In vivo* staining. *In vivo* staining is the process of dyeing living tissues using so-called "vital" stains. Stains introduced to living cells are eventually toxic to the organism. To achieve desired effects, stains are used in very dilute solutions, ranging from 1:5,000 to 1:500,000. An example of a vital stain previously used to mark coral colonies is Alizarin, or 1,2-dihydroxyanthraquinone.

– Genetic markers. With the development of more advanced molecular science techniques, genetic tags may provide an important compliance and management tool. The Department of Fisheries could ensure lines of fragmented clones are derived from the donor stock by correlating the genetic information from donors with a sample of the fragments in culture. This tool could ensure the records correctly relate to the tags of each generation.

– Data dots. Comprising tiny discs laser-etched with multiple lines of code, data dots are less than 1 mm diameter. The code provided by the data dot would be unique for each asset or, in this instance, coral piece. The code is stored in a worldwide verification database. The Department of Fisheries, as the "primary identifier", would be issued with a device suitable for verification of products. The data dots can be detected with an ultra violet light and their laser-etched code read with a simple magnifying device. They are also corrosion, temperature and shock proof and can be scanned through 25 mm of concrete.

The encrusting nature of corals mean many tags could become obscured, posing difficulties in developing a tagging method that is appropriate in the market, accessible when required for a compliance audit and cost effective for the grower. Given the fact these products are destined for display purposes, outwardly visible tags may not be appropriate; however, they can be removed after purchase at the retail point of sale.

In order to meet this requirement, the tagging method shall:

- incorporate into the matrix of the coral or attach to the substrate, an approved tag that identifies the producing company;
- incorporate a tag into the plug to which the coral fragment is secured; and
- provide for each tag to bear a unique and recordable form of identification that corresponds to logbook returns identifying date of propagation or fragmentation, genus or species, source colony tag number and batch number.

To distinguish between wild and aquacultured coral the Departmental policy will generally be that:

- The Department will require aquaculture licence applicants to clearly define the proposed method of tagging or marking systems.
- The proposed method or type of substrate to be used must be specified.
- The Department proposes that licences will be conditioned to require all tags to remain on the product in culture and transport to market.
- To distinguish between wild and aquacultured live rock the Departmental policy will generally be that:
- No natural reef coral or rock material can be used for live rock culture in open system aquaculture licence areas – rock harvested from the marine environment will not be authorised. (There may be a need for natural reef coral or rock material in closed recirculating systems in order to "seed" manufactured substrate.)
- Only manufactured substrate can be used for the culture of live rock.

- Approved substrates may be a manufactured composite mixture of limestone sand, gravel, shells or concrete.
- Manufactured live rock and live sand will not require an approved tag or marking system, however, standard recording procedures will still occur in this case.

6.5 Environmental Management

Issue and Risk

Appropriate environmental management measures need to be constructed around the development of a coral and live rock aquaculture industry.

Unless managed properly, negative environmental impacts of coral aquaculture could include:

- physical removal, breakage, shading and other disturbance of the benthic habitat;
- physical impact of farming gear such as anchors;
- interactions between aquaculture gear and megafauna (dolphins, whales, seals, turtles and dugongs); and
- loss of equipment as a result of storms or other events and the harm that this gear may cause if left outside the aquaculture licence area.

Industry Comment

The aquaculture sector wants to have access to sites for growout with supporting boating infrastructure and access that enables the aquaculture of these species. Where offshore growout is undertaken, this may involve the installation of suspended culture longlines, trays, racks and placement of equipment directly on the seabed.

Policy Management Arrangements

Environmental conditions will be included on aquaculture licences to address issues raised during the MPG8 consultation process. The technical advice and input of relevant agencies, such as the Department of Environment and Conservation informs the decision making process. For some cases, separate environmental assessments and approvals will be required, particularly when considering requirements to undertake earthworks and discharge of water from an aquaculture facility.

The Department of Fisheries has a suite of standard aquaculture licence conditions that require licence holders to submit specified environmental monitoring data; these take into account any surrounding sensitive habitat. General, conditions will prohibit the installation of aquaculture infrastructure in areas of seagrass and coral.

Where applicants are seeking to aquaculture in areas containing seagrass and coral, the Department anticipates the applicant will need to demonstrate how activities and infrastructure will be effectively managed to avoid impact on these habitats.

The management arrangements are:

- Aquaculture licences for coral and live rock will generally be conditioned to mitigate environmental risks from anchors and aquaculture apparatus.
- All aquaculture licensees will be required to submit, implement and maintain a Management and Environmental Monitoring Plan (“MEMP”).

- Aquaculture licences for coral and live rock will generally be conditioned to ensure MEMP reporting requirements are met.
- The licensee must comply with directions given by the Department of Fisheries to mitigate any environmental impact that has occurred because of aquaculture activities.

In addition to the standard monitoring conditions, further licence conditions that deal with the impact on the environment will be considered on a case-by-case basis. The conditions will be developed to ensure the management arrangements imposed are consistent with the severity of the likely risks when the aquaculture business is in operation. Applicants should ensure they provide sufficient information to enable the Department of Fisheries to make a proper assessment in this regard.

The Department of Fisheries will, in consultation with industry, other government departments and relevant stakeholders, undertake an environmental risk assessment around the activities of this industry and develop a code of conduct and minimum standard environmental monitoring program to guide sustainable activities within this industry. This will be undertaken as and when resources permit.

In determining applications, the Chief Executive Officer will take into consideration advice received from the Environmental Protection Authority and the Department of Environment and Conservation, consistent with other government agency approvals. The applications will be subject to assessment by the DEC against provision of the *Environmental Protection Act 1987* through the referral process.

6.6 Translocation

Issue and Risk

The ornamental fish and aquarium trade is in the business of providing species that are non-endemic, or may not be collected locally to hobby enthusiasts. Due to the strong domestic and global demand for these products, the culture of non-endemic species within Western Australia may provide significant business opportunities to aquaculturists.

The three main risks associated with the translocation of aquatic organisms are the potential of the translocated species to:

i. Impact on the genetic diversity;

ii. Introduce non-endemic organisms; and

iii. Impact on the natural environment and the biodiversity of native species.

These risks are discussed further below:

Genetic diversity

Where individuals are introduced to the wild from a different gene pool to the natural population, there is a risk that this introduction could alter the natural genetic structure of the local population. Therefore, to reduce the risk of impacting the genetic integrity of local populations, non-endemic species must be contained within a land-based, closed, recirculated facility. Only species endemic to the growout area, can be used to stock ocean-based farms.

Introduction of non-endemic organisms (e.g. pests and diseases)

The translocation of coral and live rock has the ability to unintentionally introduce or spread other organisms to the area of the aquaculture facility and may impact local ecosystems. The

coral or live rock may have non-endemic organisms attached to their surfaces or the equipment (structures or water) may be contaminated with non-endemic organisms. To reduce the risk of introducing or spreading non-endemic organisms, non-endemic species must be contained within a land-based, closed, recirculated facility.

Most corals show some signs of disease following chronic environmental stress or acute interference (such as taking cuttings for propagation). Given that understanding of the pathology of coral disease is very limited and broader questions of the epidemiology of specific pathogens unknown, a considered approach to relocation of species in open systems should be encouraged while still allowing for the reasonable development of the industry. This considered approach may result in only locally endemic species being relocated; however, the Chief Executive Officer will make a determination on a case-by-case basis.

Impact on the natural environment and the biodiversity of native species

The translocation of aquatic organisms to a water body can affect the ecosystem either directly, through predation or competition, or indirectly, through alterations of the environment. While there are no recorded instances of 'feral' coral and live rock populations becoming established in the world, the introduction of unwanted non-endemic algae species associated with live rock and aquarium systems are of considerable concern. Some species of bryozoans are significant fouling species and are difficult to control because of resistance to antifouling treatments. Similarly, some species of serpulids (plume worms), barnacles and a range of other species is also of concern.

For example, in Western Australia, the green algae *Caulerpa taxifolia* is an illegal import. It has caused major problems in the Mediterranean, New South Wales and South Australia from releases by aquarium enthusiasts, which have caused significant habitat modification. The alteration of an ecosystem can have significant effects since the entire aquatic community can be affected, rather than specific prey or competitor species.

Policy Management Arrangements

The Department will require applicants to provide detailed information about the source and movement of any non-endemic coral or live rock to their aquaculture facility. This information must demonstrate that the proposed translocation of coral and live rock stock poses a low risk of impacting genetic diversity of local populations, introducing and spreading non-endemic organisms and impacting the natural environment and diversity of native species.

While there is a recognisable economic benefit to the aquaculture of live rock and coral, there is also a need to ensure aquaculture will not adversely impact upon the natural environment and biodiversity.

Introductions of non-endemic coral or live rock may only be permitted in land-based, closed, recirculating systems. Therefore, growout of coral or live rock can only occur for organisms that are endemic to the area of the ocean-based farm. Any parental stock used for breeding growout stock within a hatchery must also be endemic to the area of the ocean-based farm.

Escape of animals or their embryos and, or, gametes from open flow through aquaculture systems poses a risk to the genetic diversity of the corals at the culture site. Generally, threats from aquaculture within the natural range of the species should be considered low risk; however, trying to outline genetic zones for so many species of corals would be fraught with difficulty. The Department of Fisheries is therefore hesitant to support the culture of any species outside of its recognised biogeographical range in either offshore or flow-through systems however each application will be considered o its merits.

The Department must ensure the operation of aquaculture industries maintain good animal health to sustain strong businesses and to protect the natural environment. Animal health protocols currently in place for other aquaculture species are enforced under licence conditions. This includes the requirement that the aquaculture licensee:

1. Notifies the Principal Fish Pathologist if high or unexplained mortalities occur;
2. Submits a sample for examination (histological sectioning and analysis) of juveniles produced in a hatchery;
3. Stock is not moved from hatchery to growout farm without a valid Fish Health Certificate.

These and other similar licence conditions will be applied to the development of the industry in order to protect the environment and the interests of other coral and live rock licence holders.

Under the licence conditions for operation of licensed aquaculture hatcheries in WA, prior to the removal of endemic only stock from the hatchery and placement on a growout site, disease testing of the batch by the Department of Fisheries' Fish Health Laboratories is required. While coral diseases and their causes are currently poorly understood, processes for screening tissues of other invertebrates (such as oysters and abalone) for bacteria, fungi and protozoan pathogens would be applied under licence conditions.

The management arrangements are:

- Historically, non-endemic species have not been permitted outside land-based, closed, recirculating, biosecure aquaculture facilities. This arrangement is expected to continue.
- Growout of coral or live rock can only occur for organisms that are endemic to the area of the ocean-based farm. Further, any parental stock used for breeding growout stock within a hatchery must also be endemic to the area of the ocean-based farm.
- Existing hatchery inspection and accreditation and, or, certification processes currently in place for aquaculture hatcheries in Western Australia are likely to be applied.
- The standards and conditions for mollusc hatcheries in Western Australia will be applied to the sexual reproduction of corals. Minor modification of these protocols may be considered.
- Submissions of samples, health certificates and screening procedures will form the basis for coral disease management, surveillance and response.
- Standard transportation requirements, such as notifying the Department 48 hours in advance, packaging and processing, and disposal of waste water will apply for the translocation of non-endemic species.

6.7 Culture Methods

Issue and Risk

Coral and live rock aquaculture may take place on land or in the sea, depending on the location, species cultured and intensity and scale of operations. In land-based closed recirculating or flow-through systems, tank systems are the likely method of culture; however, in open systems, a range of techniques may be utilised. Both suspended culture using longlines and bottom culture on racks, tables or other methods may be appropriate. Whatever system is proposed, the application for an aquaculture licence needs to adequately describe the proposed method of culture, to provide sufficient details to enable persons providing comment on the application and understanding of the relevant issues.

The licence application is assessed on the information provided by the proponent and conditions are drafted appropriate to the system proposed. If adequate information is not provided, appropriate assessment of the application is not possible and this impacts on the time taken to assess a proposal.

Over time, systems design may change radically through improvements to early types or complete revisions of the technology (for example, a move from racks and trays to fence lines or suspended longlines) may occur.

Industry Comment

Proponents within the coral and live rock aquaculture industry require confidential treatment of the intellectual property during the public consultation process. By provision of detailed technical explanations of the proposed culture systems, they may provide competitors with the requisite information to develop the same or similar systems but need to recognize that sufficient information is required by referral agencies to assess applications.

Policy Management Arrangements

The types of culture equipment may be similar from farm to farm, using equipment designs and specifications that are widely known or available. However, the Department of Fisheries will assess each application on a case-by-case basis. The licence conditions drafted will be based on those with similar culture systems and take into consideration the advice of other Government agencies.

The management arrangements are:

- Applicants will be required to clearly describe the proposed culture method in the aquaculture licence applications and provide a detailed site plan.
- Where the applicant proposes to aquaculture non-endemic species, information must be provided that demonstrates the aquaculture facility is biosecure.
- The proposed method(s) of culture described in the aquaculture licence application will be assessed on a case-by-case basis.
- The Aquaculture Licence will generally specify the approved method of culture.
- Alterations to the approved culture method may require a variation to the aquaculture licence and reassessment by the appropriate regulators, unless approved in the initial assessment process.

6.8 Broodstock Issues

For the purposes of this document, the word “broodstock” has been used to define an individual animal or colony that is used to propagate more of the species in subsequent generations. In relation to coral, this is essentially carried out through asexual reproduction where the colony may be broken up into many fragments that will be identical to the parent, donor and, or, broodstock colony.

Issue and Risk

In order to grow any animal in an intensive system, the aquaculturists need a starting point whether that be for sexual or asexual reproduction. This requires access to ‘broodstock’ that may be spawned or, alternatively, used as donor colonies for asexual reproduction through fragmentation.

Applicants sourcing broodstock need to consider the risks associated with moving organisms from one area to another and the potential impact on the genetic integrity of local populations,

introduction and spread of other non-endemic organisms and impact on the natural environment and biodiversity of native species.

Industry Comment

Industry requires a reliable source of accessing culture stock that will provide a starting point for the culture of the various target species. Industry needs to know how much product it can source from where and how long they have this authorisation in order to plan the production on the farm, develop the business and undertake appropriate marketing activities. Industry also needs to know when it must be self-sustaining from within the aquaculture system and is 'weaned' off accessing new culture stock from the wild.

Policy Management Arrangements

The Department of Fisheries seeks to provide industry access to coral to develop the industry without impacting on existing wild fisheries activities and the market they support. This process will also ensure the development of this industry is consistent with community values regarding the take of coral from the wild.

Under the current legislative framework, the grant of an aquaculture licence provides authority to conduct aquaculture activities for commercial purposes. An aquaculture licence does not however, confer approval to collect fish from the wild for farming purposes. To conduct aquaculture activities, aquaculturists usually need to collect a small number of broodstock to produce a large number of juveniles. In the case of coral aquaculture, the donor colonies for fragmentation (asexual propagation) would be essentially 'broodstock'.

The management arrangements to collect coral broodstock are:

A. Purchase from commercial fishers

Aquaculturists may purchase coral from licensees of the Marine Aquarium Fishery. It is noted that in general purchasing stock from commercial fishers poses a number of constraints and limitations on the development of the aquaculture industry including:

- Aquaculturists usually need to control the collection of stock to ensure that they are obtaining the requisite stock.
- Commercial fishing activities may not occur at the time of the year when the stock is required for aquaculture purposes.
- In order to minimise environmental impact and translocation concerns, aquaculturists are encouraged to source their stock from the vicinity in which they intend to conduct farming activities. Commercial fishing for the species they require may not always occur in the locality of the farming operations.

In such cases that the aquaculture licence holder is also the holder of a Marine Aquarium Managed Fishery Licence, they are able to 'sell', trade or transfer some of the coral to the aquaculture licence under the following conditions:

- The transfer is recorded in quota management paperwork from the Marine Aquarium Managed Fishery to the aquaculture licence, in exactly the same fashion as they would record the transaction to another aquaculture licence holder or aquarium wholesaler.
- The colony transferred is identified with a tag with a unique numeric code. All frags from that donor will share the tag number of the donor. As they are clones, biotechnology can verify whether the frag is a clone of the parent colony or another colony introduced from the wild.

- There would be no limit (within quota) on the volume traded by Marine Aquarium Managed Fishery licence holders to aquaculture licence holders - the entire quota may be sold or traded to holders of the appropriate aquaculture licence.

B. Purchase from other aquaculture licence holders or retail outlets

Aquaculturists may source broodstock or juvenile fish (coral) from the holder of an aquaculture licence endorsed for that species, or may purchase the required stock from a retail outlet if it is unavailable through other means (e.g. some ornamental species). Applicants wishing to source stock from a retail outlet will only be permitted to import stock into a biosecure facility.

C. Ministerial Exemptions under Section 7 of the FRMA

Aquaculturists can make applications for the granting of an Exemption under Section 7 of the FRMA for the purpose of sourcing broodstock. The Minister for Fisheries may grant an Exemption for any purpose, including the take of broodstock for aquaculture purposes. The Department would be hesitant to support the use of Exemptions in its recommendation to the Minister and considers this option to be considered only for applicants unable to demonstrate they can access stock from other avenues (Option A or B).

Aquaculture licence holders that do not hold a Marine Aquarium Managed Fishery licence and are unable to purchase stock from such a licensee, may be able to source stock under a Ministerial Exemption subject to the following conditions:

- The quantity of coral permissible to be collected will be assessed on a case-by-case basis.
- Coral collected under an exemption can only be used to produce coral progeny in a hatchery.
- Exemptions would be authorized for three years.
- Annual reporting of total take, survival, growth and production.
- Requirement to notify the local Department of Fisheries office when exemption holders intend to fish for coral, and advise of information outlining the vessel and vehicle used, the intended location of collection and landing, the species and intended volume to be taken and who will be undertaking the collections.
- Applications will be assessed in accordance with all existing government management plans and jurisdictions i.e.: *Conservation and Land Management Act 1984*.

Holders of a Marine Aquarium Managed Fishery licence will not be eligible to collect under a Ministerial Exemption unless under exceptional circumstances (cyclone damage etc).

6.9 Convention on International Trade in Endangered Species

Issue and Risk

International trade in coral and coral reef animals continues to be dominated by largely unregulated, unreported, and illegal activity. Over 400 coral reef species have been identified as inappropriate species for the aquarium trade, such as those that do not survive well in aquariums or are highly poisonous. Despite this, these species continue to be traded.

The Convention on International Trade in Endangered Species (CITES) Coral Working Group has noted a lack of agreement on marking systems to distinguish cultured from wild corals and the application of source codes. The application of CITES source codes for cultured corals would provide consistent language and understanding in this global trade.

The CITES Coral Working Group proposed the following source codes:

- "w" for wild, maricultured or farmed corals (maintenance or growth of wild coral clippings or fragments in marine-based aquaculture systems);
- "f" for aquacultured corals (first-generation cultured corals produced in aquaculture systems);
- "c" for captive bred or cultured corals (second-generation cultured corals produced in closed systems); and
- "r" for ranched corals (rearing of whole corals or larvae taken from the wild in a controlled environment).

The group also considered techniques and marking systems to distinguish cultured from wild-taken corals, and called for an ecosystem approach to the management of corals harvested for export. The working group also addressed:

- Recognition of coral at either the species or genus level;
- Taxonomic reference to corals;
- Identification guides; and
- Synergy with other initiatives and agreements.

Industry Comment

Industry needs to be globally recognised as sustainable and using world best practice in collection, culture and marketing. Alignment with existing global standards would provide immediate recognition of achieving these values.

Non-compliance with CITES treaties and codes of conduct may jeopardise the ongoing global market and distribution of these products.

Policy Management Arrangements

The Department of Fisheries requires advice regarding the development of CITES approved source codes and marking systems. Incorporation of the appropriate source codes into producers tag numbers and consignment paperwork would provide a consistent standard that may facilitate greater acceptance of the WA product and improve management.

In addition, the Department of Fisheries provides information to the Commonwealth regarding the sustainability of fisheries (and aquaculture) industries in order to get the appropriate export approvals from the Department of the Environment, Water, Heritage and the Arts (DEWHA). (http://www.environment.gov.au/coasts/fisheries/)

The implementation of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides the Commonwealth Government with a stronger role in promoting ecologically sustainable management of fisheries and assessing their environmental performance.

The Sustainable Fisheries Section (SFS) of the DEWHA is responsible for the assessment of fisheries managed under Commonwealth legislation and state export fisheries to ensure that, over time, fisheries are managed in an ecologically sustainable way.
The DEWHA primary role is to evaluate the environmental performance of fisheries, including:

- the strategic assessment of fisheries under Part 10 of the EPBC Act;
- assessments relating to impacts on protected marine species under Part 13; and
- assessments for the purpose of export approval under Part 13A.

The management arrangements are:

- The industry in Western Australia may seek certification or recognition of compliance with requisite CITES regulations and maintain this as an additional 'brand'.
- The Department expects to submit a statement to the DEWHA requesting that in addition to products sourced from the Marine Aquarium Fish Managed Fishery, aquaculture live rock, coral and associated products (i.e.: live sand) be included in the List of Exempt Native Species (LENS) on the basis that they are products that were lawfully produced by the aquaculture industry in accordance with the FRMA.

6.10 Compliance

Issue and Risk

Compliance effort in this developing industry is required to monitor risks including interactions with the wild capture sector. The proposed management arrangements, relationships with an existing quota managed fishery and access to culture stock through exemptions introduces several compliance pressure points not found in other aquaculture industries. This will necessitate a greater effort to ensure conditions are adhered to and both industry and the Department of Fisheries can demonstrate the industry is operating in a sustainable manner.

Industry Comment

Industry needs to work in an environment where the rules are clear and practical and there are incentives to be compliant rather than disincentives to non-compliance through a heavily punitive regulatory environment.

Policy Management Arrangements

The Department requires industry and its individual operators operate within the regulatory framework outlined within policy and licence conditions. If there are breaches of the legislation, the Department of Fisheries will act and through prosecution of these offences, the courts may impose fines or the Department of Fisheries may cancel licences.

Given the links with another closely related commercial managed fishery (the Marine Aquarium Managed Fishery) and the unknown issues surrounding the development of a new industry, the Department of Fisheries will maintain close scrutiny of the coral and live rock aquaculture industry.

Subject to available resources, the management arrangements are:

- The Department of Fisheries will review the Aquaculture Compliance Risk Assessment Manual and Compliance Plan, to incorporate the introduction of a new suite of species.
- Adequate training will be provided to Fisheries and Marine Officers in the relevant regions in order to ensure compliance risks are reduced.
- A program of compliance around the coral and live rock industry will be developed and implemented in Western Australia in accordance with the Compliance Plan.

REFERENCES

Allen G.R., & Steene R., 1996. Indo Pacific Coral Reef Field Guide. Tropical Reef Research Singapore 378pp. ISBN 981-00-5687-7

Babcock R.C., Willis B.L., and Simpson C.J., 1994. Mass Spawning of Corals on a High Latitude Coral Reef. *Coral Reefs* 13: 161-169.

Braley R.D., 1992. The giant clam: hatchery and nursery culture manual. ACIAR Monograph No. 15, 144p. ISBN 1 86320 070 3.

CITES 2002. Coral Production Systems – Report of the Coral Working Group. 18th Meeting of the CITES Animals Committee, San Jose, Costa Rica. April 2002.

Ellis, S. and L. Sharron. 1999. *The Culture of Soft Corals (Order: Alcyonacea) for the Marine Aquarium Trade*. 73 pp CTSA #137.

Ellis, S. and E. Ellis. 2001. *Recent Advances in Lagoon-based Farming Practices for Eight Species of Commercially Valuable Hard & Soft Corals - A Technical Report*. 59 pp CTSA #147.

Fabricius K., & Alderslade P., 2001. Soft corals and sea fans - A comprehensive guide to the tropical shallow-water genera of the Central-West Pacific, the Indian Ocean and the Red Sea. Australian Institute of Marine Science.

Falls W.W., Enringer J.N., Herndon R., Herndon T., Nicholls M.S., Nettles S., Armstong C., and Havercamp D. 2003. Aquaculture of live rock: An ecofriendly alternative. *World Aquaculture* June 2003.

Gosliner T.M., Behrens D.W., & Williams G. C., 1996. Coral Reef Animals of the Indo-Pacific – Animal life from Africa to Hawaii exclusive of the vertebrates. Sea Challengers, Monterey, California 314pp. ISBN 0-930118-21-9.

Hargreaves V.B., 2004. The Complete Book of the Marine Aquarium. Thunder Bay Press 304pp. ISBN 1-57145-762-3.

Mahoney M., Steinberg C., and Skirving W., 2003. Sea Surface Temperature Atlas of the Great Barrier Reef: A tool to map coral bleaching. *Proc. 2003 Australian Marine Science Association - Marine Biocomplexity. Brisbane, Queensland Australia.* Hooper J.N.A, Hall N., and Degnan B.M., Eds.

Morse, A.N.C., Iwao, K., Baba, M., Shimioke, K., Hayashibara, K & Omori, M. 1996. An ancient chemosensory mechanism brings new life to coral reefs. *Biological Bulletin* 191: 149-154.

Ruppert E.E., and Barnes, R.D., 1994. Invertebrate Zoology. 6th Edition, Fort Worth: Saunders College Pub.

U.S. Coral Reef Task Force 1999. International Trade in Coral and Coral Reef Species: The role of the United States. Report of the Trade Subgroup of the International Working Group to the U.S. Coral Reef Task Force. Washington, D.C..

Willis S., and O'Sullivan D., 2004. Coral Plantation Growing in Queensland. *Austasia Aquaculture* June July 2004.

Veron J.E.N., 1986. Corals of Australia and the Indo-Pacific. The Australian Institute of Marine Science 644pp. ISBN 0-8248-1504-1.

APPENDICES

APPENDIX 1 GLOSSARY

Amino acids:	the basic components of protein.
Aquarium:	a fish tank.
Arborescent:	branched or treelike in appearance.
Asexual:	reproduction that occurs without the union of male and female gametes.
Asexual budding:	a form of reproduction where a soft coral polyp forms an exact replica of itself without releasing gametes.
Asphyxiation:	death induced by lack of oxygen.
Benthic:	the community of organisms living on or in the seabed.
Bioerosion:	the breakdown of organic and inorganic matter through the action of animals or plants.
Biofilm:	the layer of bacteria, algae and protozoans that form on and coat various surfaces. That may be a food source for grazing animals or may a chemical cue to encourage larval settlement.
Biosecurity:	systems and policies put in place to manage potential exotic pest, disease and genetic quarantine issues identified through risks analysis.
Brand:	a trademark or indicating identity or ownership or a distinctive name identifying a product or a manufacturer.
Broodstock:	an individual animal or colony that is used to propagate more of the species in subsequent generations. For sexual reproduction, this animal will be spawned and the gametes collected mixed with another's to produce embryos. For asexual reproduction, the colony may be broken up into many fragments which will be identical to the parent/donor/ broodstock colony.
Calcium carbonate:	the chemical from which hard corals and shells are made.
CITES:	Convention on the International Trade in Endangered Species.
Clone:	an organism descended asexually from a single ancestor.
Coenenchyme:	material secreted by soft corals as they grow which houses and is fed by the polyps.
Colonies:	a group of corallites grown from a single parent polyp.
Competence:	physically capable and physiologically prepared to settle and metamorphose.
Consignment books:	records that document the delivery of aquaculture product for sale or disposal.
Crustose:	algal or coral having a thin crusty growth form that adheres closely to the surface on which it is growing.
Digitate:	having fingerlike growth form or projections.

Embryogenesis:	the development and growth of an embryo.
Endemic:	prevalent in or peculiar to a particular locality or region.
Fatty acids:	one of the basic components in fats or lipids.
Fission:	process of splitting into parts.
Foliose:	an appearance or growth form like a leaf or sheet.
Foot valve:	also called a check-valve, a spring loaded valve placed in an intake pipe that closes when suction is lost and traps the remaining water in the pipe. This is used to assist in priming pumps after power outages and pump maintenance.
Fragmentation:	the process by which small pieces are taken from a parent soft coral to form a new colony. These small bits are called 'frags'.
Genotype:	the genetic makeup, as distinguished from the physical appearance, of an organism or a group of organisms.
Geothermal:	relating to the internal heat of the earth.
Hookah:	a diving apparatus where the diver is supplied with air through a hose from a surface based compressor.
In vivo:	Within a living organism.
Larval:	referring to one of the earliest stages of an animal's development (immediately following the embryonic stage).
Larviculture:	the care and cultivation of coral larvae
Lobate:	a body part having rounded projections or divisions.
Massive:	consisting of a large mass; generally rounded and solid without branching.
Mono Specific:	a community that is composed of a single species. Multiple species in a community are considered multispecific.
Motility:	moving or having the power to move spontaneously.
Mucus:	a slippery coating produced by corals as natural protection. Mucus is often produced in response to handling and cutting and can contribute to bacterial infection if not removed.
Neap (tides):	the lowest tides of the lunar month, which occur in the second and fourth quarters of the moon - opposed to spring tides.
Necrosis:	localized death of living tissue, in the case of soft corals around the cut after fragmentation.
Nematocyst:	stinging cell used by the polyp to capture planktonic prey.
Ornamental:	serving an aesthetic rather than a useful purpose; e.g. any plant or animal grown for its beauty or ornamental value.
Phenotype:	the observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.
Photosynthesis:	the ability to convert sunlight into energy.

Pinnate:	having featherlike side branches.
Plankton:	microscopic animals (zooplankton) and plants (phytoplankton) that occur naturally in the ocean and freshwater.
Planktonic:	phase in aquatic organisms life history when the swimming larvae are part of the plankton.
Planula:	free-swimming, ciliated larvae.
Polyp:	any individual animal of the soft coral colony.
Propagation:	the act or action of propagating leading to an increase (as of a kind of organism) in numbers.
Reef tank:	a home or commercial closed system tank display, designed to replicate life on coral reefs. These generally contain soft and hard corals, fish, live rock and other invertebrates.
SCUBA	(Self Contained Underwater Breathing Apparatus) a diving apparatus where all the equipment needed for breathing underwater is attached to the diver, including a tank containing pressurized air.
Sessile:	permanently attached or fixed; not free-moving.
Settlement:	phase of life when the planktonic larvae move out of water column and onto benthic surface.
Sexual reproduction:	reproduction characterized by the union of male and female gametes.
Spat:	when larvae settles and undergoes metamorphosis, the juvenile coral (and more commonly oyster) is known as a spat.
Spawn:	the eggs and sperm of aquatic animals such as bivalve molluscs, other invertebrates and fishes.
Spawning:	the reproductive event of many sessile invertebrates where the release of gametes (sperm and eggs) occurs with many individuals simultaneously.
Spicules:	calcium carbonate structures that help support soft coral colonies. Occurring in different shapes and sizes, spicules are used to speciate soft corals.
Spiculose:	having spicules.
Stolon:	an elongated ribbon like part of a soft coral colony that lies flat on the substrate and links polyps.
Substrate:	a surface on which an organism grows or is attached. In the case of live rock ‘culture’, this substrate may be concrete (perhaps cast into shapes or sizes most suited to the market) or natural rock cut or quarried to suit the application.
Suite:	a group of related things intended to be used together; a set.
Symbiotic:	a biological relationship between two organisms that is mutually beneficial.
Taxa:	a taxonomic category or group, such as a phylum, order, family, genus, or species

Taxonomy:	the classification of organisms in an ordered system that indicates natural relationships.
Tentacle:	one of the eight arm-like projections surrounding the mouth of a polyp. Tentacles are generally used for gathering food.
Translocation:	the movement of organisms (or genetically distinct stocks) to areas outside of their natural range. These may include species from within the state, from interstate or those introduced from an international source.
Undulating:	having a wavy surface or edge.
Zooxanthellae:	any of various yellow-green algae that live symbiotically within the cells of other organisms, such as marine invertebrates e.g. giant clams and corals.

(some entries sourced from Ellis and Sharron 1999 and Dictionary.com)