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GOVERNMENT OF
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Marine Aquarium Fish Resource of Western Australia Harvest Strategy 2018 – 2022

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1 INTRODUCTION

Harvest strategies for aquatic resources managed by the Department of Primary Industries and Regional Development (the Department) are formal documents that are prepared based on a formal policy (Department of Fisheries 2015) to support the decision-making processes and ensure consistency with the principles of Ecologically Sustainable Development (ESD; Fletcher 2002) and Ecosystem Based Fisheries Management (EBFM; Fletcher et al. 2010). The objectives of ESD are reflected in the objects of the *Fish Resources Management Act 1994* (FRMA), Section 3, and the *Aquatic Resources Management Act 2016* (ARMA), Clause 9, which will replace the FRMA once enacted.

The publication of harvest strategies is intended to make the decision-making considerations and processes for the management of specified aquatic resources publicly transparent and provide a basis for informed dialogue on management actions with resource users and other stakeholders (Department of Fisheries 2015).

These strategies provide guidance for decision-makers, but do not derogate from or limit the exercise of discretion required for independent decision-making under the FRMA by either the Minister for Fisheries, the Director General (as Chief Executive Officer) of the Department of Primary Industries and Regional Development or other delegated decision-makers in order to meet the objects of the FRMA.

Harvest strategies make explicit the objectives, performance indicators, reference levels, and harvest control rules for each defined ecological asset taken into consideration by the Department when preparing advice for the Minister for Fisheries (Department of Fisheries 2015). They also indicate the scope of management actions required in relation to the status of each resource in order to meet the specific long and short-term management objectives and the broader goals of ESD and EBFM. Finally, they specifically outline the expected performance of the fisheries that access each resource.

1.1 Review Process

The Western Australian (WA) harvest strategy policy (Department of Fisheries 2015) recognises that fisheries change over time and that a review period should be built into each harvest strategy to ensure that it remains relevant. This harvest strategy will remain in place for a period of five (5) years, after which time it will be fully reviewed. However, given that this is the first harvest strategy for this resource, this document may be subject to review and amended as appropriate within this five-year period.

2 SCOPE

This harvest strategy relates to the marine aquarium fish[1] resource of WA and the fishing activities that impact this resource. The overall resource comprises of all species captured for

[1] Fish has the same meaning as Section 3 of the *Fish Resources Management Act 1994*.

marine aquarium ornamental display purposes throughout Western Australian waters, including finfish, hard coral, soft coral, tridacnid clams, Syngnathiformes (seahorses and pipefish), other invertebrates (including molluscs, crustaceans, echinoderms etc.), algae, seagrasses and 'live rock'[2]. These species are targeted, to varying degrees, by the commercial, aquaculture and recreational sectors. The key commercial fishery that operates on a state-wide basis is the Marine Aquarium Fish Managed Fishery (MAF). From time to time, operators in the aquaculture and public aquarium sector are also permitted to collect relatively small amounts of specific marine aquarium species for broodstock or public display purposes respectively. Marine aquarium species are primarily collected by hand while wading or diving on SCUBA or hookah. Fish are generally caught using hand-held nets; invertebrates are collected by hand; and live rock and corals are prised off the reef manually by hand using a metal lever.

Monitoring and assessment of the marine aquarium resource is undertaken via a risk based approach that calculates the current or likely future 'sustainability risk' of the marine aquarium species. In accordance with this approach, this harvest strategy focuses on maintaining the 'sustainability risk' of all marine aquarium species at a level which ensures that the risk status of these species remains acceptable.

This harvest strategy has been developed in line with Fisheries' over-arching *Harvest Strategy Policy for Aquatic Resources* (Department of Fisheries 2015) as well as relevant national policies/strategies (ESD Steering Committee 1992) guidelines (e.g. Sloan et al. 2014) and international best practice (Fletcher et al. 2016). The harvest strategy also covers impacts on bycatch[3], endangered, threatened and protected (ETP) species, habitats and other ecological components. This ensures risks to these elements as well as consideration of fishing impacts from all fishing activities are managed effectively.

This document has been developed via a consultative process with industry members and is subject to approval by the Director General of the Department and the Minister for Fisheries.

[2] As defined in Schedule 7 of the *Fish Resource Management Regulations 1995*: Family Corallinaceae; Classes Polychaeta, Crinoidea, Ascidiacea and Ophiuroidea; Phyla Bryozoa and Porifera; and dead fish of Classes Anthozoa and Hydrozoa

[3] *Bycatch* is described as the part of the catch which is returned to the sea (usually referred to as non-retained or discarded) either because it has no commercial value or because legislative requirements preclude it from being retained.

2.1 Environmental Context

The marine aquarium fish resource includes species that inhabit intertidal and nearshore waters of WA from the South Australian border to the Northern Territory border (total gazetted area of 20 781 km^2).

The waters of WA are heavily influenced by the warm, low-nutrient, southward-flowing Leeuwin Current. The northern tropical regions have a variety of habitats, including sand/mud flats, mangroves, seagrasses, macroalgae, filter-feeding communities, corals, soft-bottom areas, and high species diversity (DEWHA 2008).

Further south, the waters along the Gascoyne Coast represents a transition between the tropical waters of the North West Shelf and the temperate waters of the West Coast. The majority of fish stocks are tropical in nature, although some temperate species can be found at the northern extent of their range. The transition in ocean currents, climate and the range of coastal landforms in this region provide varied and complex marine habitats and associated species (Roberts et al. 2012).

South of Kalbarri, the waters of the West Coast Bioregion are predominately temperate. However, the warm Leeuwin Current provides for the existence of coral reefs at the Houtman Abrolhos Islands and the extended southward distribution of many tropical species. From a global perspective, the West Coast is characterised by low levels of nutrients and high species diversity, including a large number of endemic species (CoA 2008).

The waters of the South Coast are also low in nutrients, due to the seasonal winter presence of the Leeuwin Current and limited terrestrial run-off. Fish stocks in this region are predominantly temperate, with many species' distributions extending across southern Australia. The South Coast is a high-energy environment and is heavily influenced by large swells generated in the Southern Ocean. A mixture of seagrass and kelp habitats occur along the South Coast, and the benthic invertebrate communities, e.g. sponges, ascidians and bryozoans, found in the eastern stretches of the coast are among the world's most diverse soft sediment ecosystems (CoA 2008).

2.2 Retained Species

The MAF has the capacity to target more than 950 species of marine aquarium finfish, including Syngnathiformes (seahorses and pipefish). Operators in the MAF are also permitted to take hard and soft corals, 'live rock', algae, seagrass and other invertebrates. The number of species targeted and/or landed by the fishery varies from year to year largely due to changes in market demand (e.g. in the period from 2008 to 2015 the number of marine aquarium fish species landed ranged from 317 to 822).

In 2015, 352 species or species groups were reported in the landed catch of the MAF, including 164 species of finfish.

An Environmental Risk Assessment (ERA) for the MAF was undertaken in 2014 (see 3.5.2.1). The ERA gave specific consideration to several species and species groups on the basis that

they had characteristics which might result in a higher level of risk (i.e. level of take, biology, conservation status or endemic species etc.). A summary of the biology of several key target species or species groups that received specific consideration by the ERA is outlined below.

2.2.1 Finfish

The MAF targets tropical finfish species in areas such as Exmouth and the Dampier Archipelago, the majority of which are widely distributed across the indo-west pacific region. Dominate species groups include chromis (*Chromis spp.*), blennies (Family Blenniidae), angelfish (Families Chaetodontidae and Pomacanthidae), gobies (Family Gobiidae), wrasse (Family Labridae), damselfish (Family Pomacentridae) and butterflyfish (Family Chaetodontidae).

The MAF also targets anemonefish (*Amphiprion spp.*) such as the Clark's anemonefish (*A. clarkii*) which inhabits lagoons and outer reef slopes. Anemonefish live in association with sea anemones and have a mucus coat that protects them from anemone stings; often depending on them for habitat and nesting sites. Anemonefish occur in small family groups consisting of a breeding pair and several juvenile males. They are known to be protandous hermaphrodites, with the dominant male changing sex in the absence of a dominant female.

The MAF also targets temperate finfish species off the Perth metropolitan area including the blue-lined hulafish (*Trachinops brauni*) and yellow-lined hulafish (*T. noarlungae*); both endemic to southern WA (Recherche Archipelago to the Houtman Abrolhos Islands). Hulafish are observed in small aggregations on in-shore coral reefs and in larger schools near the entrance to caves and large overhangs to depths of at least 30 metres. In at least one species of *Trachinops*, males brood relatively low numbers of eggs by wrapping their body around the egg mass.

2.2.2 Syngnathiformes

The MAF is permitted to take species from the Order Syngnathiformes (i.e. seahorses, sea-dragons and pipefish) which are listed under Part 13 of the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), from state waters only (within 3 nautical miles). All *Hippocampus* species are listed under Appendix II of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES), indicating that they are not necessarily threatened with extinction, but may become so unless trade is closely controlled.

The WA seahorse (*Hippocampus subelongatus/elongates)* is restricted to the west coast of Australia. It ranges from Cape Leeuwin north to the Houtman Abrolhos Islands. It is most abundant in muddy habitats and typically estuarine conditions often found on man-made structures such as jetty piles or moorings, in depths between 1–25 m. Age at sexual reproduction is between 9 and 12 months with breeding occurring during the warmer months (October to March).

Mating is preceded with an elaborate courtship ritual. Females deposit eggs into the abdominal pouch of the male, which are then fertilised. Young seahorses develop within the pouch and gestation is around three weeks. For *H. subelongatus* an average of around 360 young are born at around 12 mm in length.

2.2.3 Hard corals

Hard corals (Order Scleractinia) are also listed on CITES Appendix II. Hard corals are targeted by the MAF in the tropical waters off Exmouth and the Dampier Archipelago. Key species include *Duncanopsammia axifuga, Euphyllia ancora, Trachyphyllia geoffroyi, Euphyllia glabrescens, Catalaphyllia jardinei, Moseleya latistellata* and *Plerogyra sinuosa*, most of which are widely distributed across the indo-west pacific region.

Most of the coral species targeted by the MAF occur in turbid 'off reef' environments, as opposed to 'blue water' reef environments where the majority of research and scientific literature is based (Pers. Comm., MAF fishers). There is little published information about the age (or size) at maturity for corals, however the information available indicates it is highly variable amongst species and affected by environmental conditions. Corals, which are colonial organisms, can reproduce both sexually and asexually. Asexual reproduction occurs through budding and/or fragmentation, resulting in two or more genetically identical individuals.

Sexual reproduction typically occurs through broadcast spawning. Most corals are hermaphrodites, and coral fecundity is typically correlated with size, with more polyps producing more eggs. Corals mass spawn by releasing eggs and sperm synchronously over several nights at particular times of the year. On the west coast of Australia, this tends to be in March – April (Veron 2000).

Most coral species have two different feeding mechanisms. The majority of their diet is provided from zooxanthellae which live inside the coral polyps in a symbiotic relationship. The zooxanthellae are single celled algae, which share their photosynthetic products with the coral host. In return the coral provides the zooxanthellae with a safe place to live and essential metabolic products for photosynthesis such as carbon dioxide and nitrogenous waste. Corals also feed via polyps which capture a variety of small organisms from demersal plankton to small fish (Veron 2000).

2.2.4 Tridacnid Clams

Giant clams in the Family Tridacnidae occur from the Red Sea and eastern Africa, through the Indian Ocean, to South-east Asia, Australasia, Melanesia, Micronesia and Polynesia in the eastern Pacific (Copland and Lucas 1988; CITES 2006; Othman et al. 2010). Two species of tridacnid clams have been reported by the MAF; the elongate giant clam (*Tridacnea maxima*) and the fluted giant clam (*T. squamosa*), however, it is likely that catches have also comprised of a recently discovered species *T. ningaloo*, which is similar in appearance to *T. maxima* (Penny and Willan 2014).

T. maxima and *T. squamosa* are both widely distributed throughout the Indo-Pacific and there are suggestions that the distribution of *T. ningaloo* extends from Ningaloo Reef, Western

Australia, to the Solomon Islands, and possibly even to higher northern latitudes (Huelsken et al. 2013). All Tridacnidae species are listed on CITES Appendix II.

Adult tridacnid clams are usually simultaneous hermaphrodites. They become sexually mature as males at two or more years of age and subsequently become hermaphrodites with gonads containing spermatogenic and oogenic tissue. The initial growth of tridacnid clam juveniles is relatively slow, and they may reach 20 – 40 mm in the first year. Thereafter growth is rapid in larger species.

Similar to corals, tridacnid clams have a symbiotic relationship with a photosynthetic dinoflagellae (zooxanthellae) which live in the mantle tissues. Adult clams receive 70 – 100 % of their nutrients from the algae and the rest is from filter feeding.

A study on the abundance of *T. maxima* on intertidal rocky platforms in the Ningaloo Marine Park observed densities varying between 0.04 to 8.27m^2 (Black et al. 2011). Furthermore, an assessment of available benthic habitat data[4] indicates over 50 km^2 of intertidal bare reef habitat exists in the Ningaloo Marine Park, Barrow Islands and Montebello Islands, and the Dampier/Karratha region. Based on the lower density range observed in the Ningaloo Marine Park (0.04m^2), the population of *T. maxima* occurring on intertidal bare reef habitat in these three areas is estimated at over 2 million individuals. Noting that tridacna clams are also found in other habitat types (including subtidal bare reef and intertidal and subtidal coral reef) and as they are also widely distributed outside of the three areas listed above, this population estimate for *T. maxima* is likely to be conservative.

Only a small proportion of the population of tridacnid clams is targeted by the MAF based on size (up to 30cm width) and colour to meet market demand. An annual capacity of 2,400 tridacnid clams has been in place since 2005. This level is consistent with the management strategy outlined in Section 3.3 in that the annual catch level is relatively small compared to stock levels and therefore unlikely to affect normal levels of recruitment variation.

2.2.5 'Live Rock'

'Live rock' is the common term used to describe either the skeletal remains of hard corals or naturally occurring limestone rock which has become encrusted in coralline algae and various other invertebrate species. 'Live rock' is defined under schedule 7 of the *Fish Resource Management Regulations 1995* (FRMR) as 'Family Corallinaceae; Classes Polychaeta, Crinoidea, Ascidiacea and Ophiuroidea; Phyla Bryozoa and Porifera; and dead fish of Classes Anthozoa and Hydrozoa'.

[4] Marine habitat data sourced from Department of Parks and Wildlife (DPaW) based on studies undertaken by various organisations in marine parks and marine management areas between 1985 and 2002. Habitat mapping for all of the studies has been classified into eleven broad categories based on the Shallow-water Marine Habitat Classification Scheme (Bancroft, 2003).

'Live rock' forms the foundations of 'living reef' aquariums, with common ratios of 'live rock' and live coral in the order of 10:1. 'Live rock' also forms an important part of the filtration system in marine aquaria, providing a natural refuge for denitrifying bacteria. The calcium carbonate in 'live rock' also assists in maintaining desired water chemistry parameters in aquaria, in particular by helping to maintain constant pH by releasing calcium carbonate.

'Live rock' is a renewable resource with reefs accumulating considerable amounts of calcium carbonate every year. Studies on the Great Barrier Reef (GBR) estimate that the 2,500 reefs that make up the GBR accumulate more than 5 million tonnes of calcium carbonate per year (Harriott 2001). Many of the branching species of corals, such as *Acropora spp.* are known to grow very quickly at up to 20 cm per year. These species make up the bulk of loose rubble or 'live rock' because they are easily broken off during storms and are affected by bleaching events (Veron 2000).

2.3 Fishing Activities

2.3.1 Governance

The marine aquarium fish resource is targeted by the commercial, aquaculture and recreational fishing sectors. These fishing sectors are managed by the Department under the following legislation:

- *Fish Resources Management Act 1994* (FRMA, will be replaced by the *Aquatic Resources Management Act 2016* once enacted);
- *Fish Resources Management Regulations 1995* (FRMR);
- FRMA part 6 – *Marine Aquarium Fish Managed Fishery Management Plan 2018*; and
- FRMA section 7 (Ministerial Exemptions).

Fishers must also comply with the requirements of the:

- *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) and associated Non-Detrimental Finding (NDF) reports by the Australian CITES Scientific Committee;
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Western Australian Marine Act 1982*;
- Western Australian *Wildlife Conservation Act 1950*; and
- Western Australian *Conservation and Land Management Act 1984*.

2.3.2 Commercial Fishing

The MAF is a low-volume, high-value fishery that supplies both domestic and international marine aquarium markets with different species targeted each year based on market demand. The fishery dates back to the 1960's when operators fished under permits or conditions on

Professional Fishing Licences (PFLs). In 1986, the number of commercial licences endorsed to operate in the MAF was limited to 20, however, this number increased to 25 following a review of the MAF in 1991. During this period the fishery primarily focused on the take of marine finfish (Class Osteichthyes - bony fishes, or the Class Chondrichthyes - cartilaginous fishes) for the domestic aquarium trade.

Commercial management arrangements for the take of coral were introduced in the mid to late 1980's when five PFLs were issued with endorsements to take up to 2,000 kg of coral per year (i.e. Total Allowable Commercial Catch (TACC) of 10,000 kg) via an expression of interest process.

With the introduction of the FRMA, the authority to take marine aquarium species under a PFL endorsement was transitioned to a Commercial Fishing Licence (CFL) condition.

In 1995, the marine finfish component of the fishery became formally managed through the introduction of the *Marine Aquarium Fish Management Plan 1995*. Fourteen Managed Fishery Licences (MFLs) were subsequently granted in accordance with access criteria outlined in Fisheries Management Paper 63 '*Management of the Marine Aquarium Fishery*'. The number of MFLs was reduced to 13 soon after due to the non-renewal of one MFL.

As the *Marine Aquarium Fish Management Plan 1995* only applied to 'finfish', the take of coral and other invertebrates continued to be managed via CFL condition. In 1997, the coral TACC was reduced to 8,000 kg following the expiry of one CFL. The coral TACC was further reduced to 7,500 kg in the early 2000's as a result of an industry proposal aimed at redistributing coral amongst all 13 MFL holders in the MAF.

The take of all other invertebrate species was managed via CFL condition until 2005 when a Ministerial Exemption was granted under section 7 of the FRMA. This Exemption enabled all MFL holders in the MAF to take invertebrates (other than coral), seagrass and algae with legislated limits applying to most species or species groups.

In 2007, the authority to fish for coral under a CFL condition was replaced by the *Prohibition on Fishing (Coral, 'Live Rock' and Algae) Order 2007* (the Order). The Order restricted the take of coral to six MFL holders in the MAF based on the quantities previously endorsed on CFLs (within the existing 7,500 kg TACC). The Order also provided for the take of up to 500 kg of 'live rock' by each of the 13 MFL holders (total of 6,500 kg).

In 2010, the number of licences in the MAF reduced from 13 to 12 when one MFL was surrendered as a result of the expansion of the Ningaloo Marine Park. This resulted in the overall TACC for 'live rock' being reduced by 500 kilograms to 6,000 kg. In the same year, the 'live rock' TACC was increased on a trial basis to 5,000 kg per MFL (TACC of 60,000 kg) on the basis of research advice on the productivity of the marine environment in producing 'live rock' and licence holder's views regarding market demand.

A comprehensive review of the fishery was completed in 2017 which resulted in the existing legislative framework (i.e. the Management Plan, Exemption, Order and licence conditions)

for the MAF being consolidated and replaced by the *Marine Aquarium Fish Managed Fishery Management Plan 2018*. All existing MFL holders will be subsequently granted a new MFL under the new Management Plan.

Under the new Management Plan, species with a high conservation value, including CITES listed species (i.e. hard and soft corals, tridacnid clams, Syngnathiformes) and 'live rock' are managed via output controls in the form of individual transferable quota. The remaining 'non-quota' species are managed via input controls in the form of limited entry and restrictions on permitted gear, numbers of vessels and numbers of collectors.

The TACC for coral (hard and soft combined) is set at 15,000 kg, twice the previous limit based on the outcomes of an Environmental Risk Assessment (ERA) undertaken in 2014, while the TACC for tridacnid clams, Syngnathiformes and 'live rock' is set at the existing limits, i.e. 2,400 individuals, 2,000 individuals and 60,000 kg respectively. In addition, target catch levels have been developed for individual species within each quota group, as well as all other 'non-quota' species based on the outcome of the ERA (as contained in this Harvest Strategy).

There are currently 12 MFLs in the MAF, all of which can hold entitlement for quota species. Fishers are only permitted to use a net (including a barrier net) or nets held in the hand to capture finfish. Other specimens are collected by hand or by hand held tools. Licensees are not permitted to operate within any waters closed to fishing e.g. reef observation areas and sanctuary zones. However, the licensees are permitted to operate in general-purpose zones of marine parks for the collection of fish and some invertebrates (except for coral and 'live rock' in some marine parks).

Fishers must also comply with any species restrictions in place, including size limits or totally protected species. Fish caught in the MAF may not be used for food purposes, and operators are not permitted to take non-finfish species covered by other specific commercial management arrangements or management plans (e.g. western rock lobster).

Given the diversity of the target species, the MAF operates across a number of aquatic ecosystems including coral reefs, lagoons, coastal embayments and intertidal areas. Fishing operations are heavily weather-dependent due to the small vessels used and the potentially hazardous conditions (e.g. waves and swell) encountered. In addition, human constraints (i.e. physiological effects of decompression) limit the amount of effort exerted in the fishery, including the depth of water (generally less than 30 metres depth) and the offshore extent where collections can occur.

In 2015, 8 licences reported some level of activity (effort). Effort in the fishery has decreased from 981 fishing days (2007) to 393 fishing days in 2015. Effort is concentrated in a number of discrete areas adjacent to the limited number of boat landing sites along the WA coastline. During the past three years the fishery has been active in waters from Esperance to Broome, with popular areas being around the Capes region, Perth, Geraldton, Exmouth and Dampier.

Given that specimens are collected for a live market, licences are restricted in terms of the quantities that they can safely handle and transport (for example, by boat to shore, by vehicle

to the holding facility and then on to the retailer) without impacting on the quality of the product. The size of the holding facility and access to regular freight and infrastructure services (such as airports, particularly in the remote northern locations of WA) restricts the levels of effort that can be expended in the fishery at any given time.

2.3.3 Aquaculture Broodstock Collection

Several commercial aquaculture licences have been granted in WA under section 92 of the FRMA, authorising the culture of marine aquarium fish species (e.g. coral, tridacnid clams, 'live rock' and finfish) for ornamental display purposes.

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

Generally, there are three options by which broodstock may be obtained for aquaculture:

1. purchase from commercial fishers;
2. purchase from other aquaculture licence holders or retail outlets; or
3. making an application for a Ministerial Exemption under section 7 of the FRMA.

Aquaculture licence holders that are interested in culturing marine aquarium species are encouraged to source broodstock via options 1 and 2, however, this may not be possible or practical in many instances. Applications to source broodstock via a Ministerial Exemption have been considered on a case-by-case basis and approved on the basis that there is no elevation in risk category of the relevant species.

2.3.4 Public Benefit and Other Commercial Purposes

Each year small volumes of marine aquarium species are collected for public benefit and other commercial purposes via Ministerial Exemptions issued under section 7 of the FRMA on the basis that there is no elevation in risk category of the relevant species. These Exemptions are typically granted on a case-by-case basis for research, education or for public aquarium display purposes where sourcing specimens from the MAF is not practical.

2.3.5 Recreational Fishing

There is no documented recreational fishery for marine aquarium species in WA, however, the level of take is believed to be negligible. If members of the public wish to collect specimens for their own private aquariums they are permitted to do so, but are restricted to normal recreational bag limits and, for some species, size limits. There is a total prohibition on the recreational take of coral, live rock and protected fish such as leafy and weedy sea dragons.

2.3.6 Customary Fishing

There is no documented customary fishery for marine aquarium fish species in WA.

2.4 Catch-Share Allocations

The marine aquarium fish resource in Western Australia is fished by the commercial, aquaculture and recreational sectors without any explicit catch share allocation between sectors. A formal sectoral allocation process (designated as Integrated Fisheries Management, IFM, in Western Australia) to define and assign long-term sectoral shares of the permitted catch of the resource has not yet been undertaken.

3 HARVEST STRATEGY

This harvest strategy is structured to describe, hierarchically:

1) the high-level, long-term objectives of management;
2) the short-term, operational objectives;and
3) how these translate into the management approach used for this fishery.

This is followed by a more detailed description of:

4) the processes for managing stock status;and
5) the specific monitoring and assessment procedures used to ascertain if objectives are being met.

3.1 Long-Term Objectives

In addition to ensuring the biological sustainability of all captured aquatic resources (through the use of the risk-based approach), this harvest strategy includes broader ecological objectives for each ecosystem component relevant to the MAF. This also includes social and economic objectives for the fishery as a whole. It is important to note that the social and economic objective is applied within the context of ESD.

3.1.1 Ecological Sustainability

1) To maintain spawning stock biomass of each retained species at a level where the main factor affecting recruitment is the environment;
2) To ensure fishing impacts do not result in serious or irreversible harm[5] to bycatch species populations;
3) To ensure fishing impacts do not result in serious or irreversible harm to ETP species populations;
4) To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function; and

[5] Serious or irreversible harm relates to a change caused by the fishery that fundamentally alters the capacity of the component to maintain its function or to recover from the impact.

5) To ensure the effects of fishing do not result in serious or irreversible harm to ecological processes.

3.1.2 Economic and Social Benefits

1) To provide flexible opportunities to ensure fishers can maintain or enhance their livelihood, within the constraints of ecological sustainability; and

2) To provide fishing participants with reasonable opportunities to maximise cultural, recreational and lifestyle benefits of fishing, within the constraints of ecological sustainability.

3.2 Operational Objectives

Long-term management objectives are often operationalised by using shorter-term (e.g. annual or periodic) fishery-specific objectives for which one or more performance indicators (that can be measured) are identified. Identification of performance indicators enables performance to be assessed against pre-defined reference levels. Consequently, the commercial fisheries that access the Marine Aquarium Fish Resource have operational objectives designed to maintain each resource/component above the threshold level (and where relevant close to the target level), or to rebuild the resource if it has fallen below the threshold or the limit levels.

3.3 Overview of Management Approach

The harvest strategy for the Marine Aquarium Fish Resource in Western Australian is based on a *constant catch approach*, where the annual catch level is relatively small compared to stock levels and therefore unaffected by normal levels of recruitment variation.

In line with this harvesting approach, the main commercial fishery that targets this resource (MAF) is managed via a combination of input and output controls. The MAF is a limited entry fishery with controls on the number of vessels and the number of divers operating under each licence. Key species groups identified as being of higher sustainability risk or economic value (i.e. corals, tridacnid clams, Syngnathiformes and 'live rock') are managed under an Individual Transferable Quota (ITQ) system.

Persons permitted to take marine aquarium species for aquaculture broodstock purposes or public display purposes under Exemption are managed to explicit short term harvest levels for specific species. Recreational fishing for marine aquarium species is managed as part of the broader recreational fishing management arrangements using a mix of input and output controls, including a recreational boat-fishing licence, minimum legal lengths (MLL) and bag limits. Recreational fishers operating from a boat are required to hold a current Recreational Fishing from Boat Licence (RFBL).

3.4 Performance Indicators, Reference Points and Control Rules

Suitable indicators have been selected to describe performance of the fishery in relation to each management objective, with a set of reference levels established to separate acceptable and unacceptable performance. Where relevant, these levels include:

- A target level (i.e. where you want the indicator to be);
- A threshold level (i.e. where you review your position); and
- A limit level (i.e. where you do not want the indicator to be).

Control rules define what management actions should occur based on the value of each performance indicator relative to the limit, threshold or target levels, taking into consideration the uncertainty around its estimation. A summary of the management objectives, performance indicators, reference levels and control rules for the resource is provided in Table 1.

3.4.1 Identifying Performance Indicators and Reference Levels

3.4.1.1 Target Species

The performance indicator used to evaluate the status of each of the target species (or species groups) that collectively form the marine aquarium fish resource of WA is the annual commercial catch from the MAF as well as any additional take for aquaculture broodstock or public benefit purposes.

Reference levels have been calculated from commercial catches observed during the reference period (2008 to 2013). They have been set to differentiate acceptable fishery impacts from unacceptable fishery impacts according to the risk levels defined in Fletcher (2012) as determined by the 2014 ERA.

The target range for all species (or species groups) extends up to the maximum annual catch value which maintains the risk level at or below moderate risk, which in turn represents the threshold level. A review will be triggered if the annual catch for each target species (or species groups) exceeds the threshold level (see Table 1).

The ERA assessed the existing catch levels of all species taken by the MAF over the next five years as having negligible risk, with the exception of one hard coral species (*Duncanopsammia auxifuga*) which was considered low risk. A further assessment based on doubling the maximum reported hard coral catch observed during the reference period for a five-year period did not result in an elevation of the risk score.

To maintain a risk category level at or below moderate risk, a threshold level for all target species (or species groups) of twice the maximum reported catch over the reference period has been determined based on the ERA of hard coral. Although the ERA only assessed a doubling of the hard coral catch, given hard coral species scored a higher (but acceptable) risk score than all other species taken by the MAF, the same principle has been applied to all (lower risk) species.

Where a new species (i.e. a species not recorded during the reference period) is reported or where the maximum reported catch of an existing species (during the reference period) is relatively small (i.e. less than 50 kilograms, 50 litres or 50 individuals), a threshold level of 100 kilograms, 100 litres or 100 individuals (respectively) has been established as a practical means to allow for a precautionary take or growth in the level of take. Any new species will then be formally assessed as part of the next periodic risk assessment. Threshold levels for all marine aquarium fish species based on this approach are contained in Appendices 1 to 7.

Applications for Exemptions to collect marine aquarium fish species for aquaculture broodstock purposes, public benefit or other commercial purposes outside of the management framework of the MAF will be considered on a case-by-case basis. Exemptions may be granted provided that the total catch of each target species (i.e. by the MAF and by Exemption holders) is managed within the threshold level.

3.4.1.2 Other Ecological Assets

Other ecological assets incorporated in this harvest strategy include bycatch and ETP species, habitats and ecosystem processes. Only impacts of the MAF on these ecological components are currently assessed within this harvest strategy. Reference levels used to monitor the performance of the MAF against management objectives relating to these assets have been set to differentiate acceptable fishery impacts from unacceptable fishery impacts according to the risk levels defined in Fletcher (2012).

3.4.1.3 Economic and Social Benefits

In line with the principles of ESD, this harvest strategy also includes objectives and performance indicators for the economic and social amenity benefits of fishing. These objectives relate to the provision of opportunities to ensure (1) commercial fishers can maintain / enhance their livelihood and (2) that all fishers can maximise cultural, recreational and/or lifestyle benefits of fishing. It is important to note that management actions relating to these objectives are applied within the constraints of ecological sustainability.

The economic and social objectives do not currently have explicit performance measures within this harvest strategy. Rather, it is through formal consultation processes that regulatory impediments to maintaining or enhancing economic return, and maximising social benefits of fishing, are discussed. Where possible, and in due consideration of ecological sustainability, fisheries management arrangements can be adjusted or reformed to help meet these objectives.

Once suitable and measurable indicators for monitoring performance against the economic and social objectives have been identified, these will be included in future revisions of this harvest strategy.

3.4.2 Control Rules

A review of management arrangements is triggered if evaluation against the operational objectives indicates the potential need for a management response (i.e. when the threshold level

is breached). This facilitates a precautionary approach to management, with potential issues recognised and addressed in a timely manner prior to the following fishing season.

When a threshold or limit reference level is breached, management responses are likely to vary depending on the extent and circumstances related to the variation. Examples of management responses include restricting effort via spatial, temporal or additional gear restrictions. The ability to, and timeframe for, implementing these changes depends on the legal instrument under which the management measure occurs. Further information on the management measures in place for this fishery is provided in Section 4.

Table 1. Harvest strategy reference levels and control rules for the Marine Aquarium Fish Resource and associated assets that may be impacted by fishing activities undertaken by the MAF while targeting this resource within Western Australia

Component	Management objectives	Resource / Asset	Performance Indicators	Reference Levels	Control Rules
	Ecological				
Retained species	To maintain spawning stock biomass of each retained species at a level where the main factor affecting recruitment is the environment.	• Coral (hard and soft coral species) • Tridacnid clams (*Tridacna spp.*) • Syngnathiformes (i.e. seahorses and pipefishes etc.) • 'Live Rock' • Finfish (Class Osteichthyes and Class Chondrichthyes) • All other invertebrate and plant species[6]	Periodic risk assessments incorporating current management arrangements, catch levels, species information and available research.	**Target:** Fishing impacts expected to generate an acceptable risk level to retained species, e.g. moderate risk or lower. **Threshold:** Fishing impacts are considered to generate an undesirable level of risk to any retained species' populations, i.e. high risk. **Limit:** Fishing impacts are considered to generate an unacceptable level of risk to any retained species' populations, i.e. severe risk	No management action required. A review is triggered to investigate the reasons for the increased risk. Appropriate management action will be taken to reduce the risk to an acceptable level. Appropriate management action will be taken to reduce the risk to an acceptable level.
Bycatch (non-ETP) species	To ensure fishing impacts do not result in serious or irreversible harm to bycatch species populations.	All bycatch species.	Periodic risk assessments incorporating current management arrangements, catch levels, species information and available research.	**Target:** Fishing impacts expected to generate an acceptable risk level, e.g. moderate risk or lower.	No management action required.

[6] Includes; Ascidians (Class Ascidiacea); Algae and Seagrass; Brittle Stars (Class Ophiuroidea); Decapods (Order Decapoda); Feather Stars (Class Crinoidea); Jellyfish (Class Scyphozoa); Mantis shrimp (Order Stromatopoda); Molluscs (Phylum Molusca); Polychaetes (Class Polychaeta); Sea Anemones (Order Actiniaria); Sea Cucumbers (Class Holothuroidea); Sea Stars (Class Asteroidea) Sea Urchins (Class Echinoidea) and Sponges (Phylum Porifera).

Component	Management objectives	Resource / Asset	Performance Indicators	Reference Levels	Control Rules
				Threshold: Fishing impacts are considered to generate an undesirable level of risk to any bycatch species' populations, i.e. high risk.	A review is triggered to investigate the reasons for the increased risk. Appropriate management action will be taken to reduce the risk to an acceptable level.
				Limit: Fishing impacts are considered to generate an unacceptable level of risk to any bycatch species' populations, i.e. severe risk.	Appropriate management action will be taken to reduce the risk to an acceptable level.
Endangered, threatened and protected (ETP) species	To ensure fishing impacts do not result in serious or irreversible harm to endangered, threatened and protected (ETP) species populations.	All ETP species	Periodic risk assessments incorporating current management arrangements, number of reported interactions, species information and available research.	**Target:** Fishing impacts expected to generate an acceptable risk level to ETP species' populations, i.e. moderate risk or lower.	No management action required.
				Threshold Fishing impacts are considered to generate an undesirable level of risk to any ETP species' populations, i.e. high risk.	A review is triggered to investigate the reasons for the increased risk. Appropriate management action will be taken to reduce the risk to an acceptable level.
				Limit: Fishing impacts are considered to generate an unacceptable level of risk to any ETP species' populations, i.e. severe risk.	Appropriate management action will be taken to reduce the risk to an acceptable level.

Habitats	To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function.	All habitats.	Periodic risk assessments incorporating current management arrangements, extent of fishing activities, habitat distribution and available research.	**Target:** Fishing impacts are considered to generate an acceptable level of risk to all benthic habitats, i.e. moderate risk or lower.	No management action required.
				Threshold: Fishing impacts are considered to generate an undesirable level of risk to any benthic habitats, i.e. high risk.	A review is triggered to investigate the reasons for the increased risk. Appropriate management action will be taken to reduce the risk to an acceptable level.
				Limit: Fishing impacts are considered to generate an unacceptable level of risk to any benthic habitats, i.e. severe risk.	Appropriate management action will be taken to reduce the risk to an acceptable level.
Ecosystem	To ensure the effects of fishing do not result in serious or irreversible harm to ecological processes.	Trophic interactions.	Periodic risk assessments incorporating current management arrangements, catch levels, extent of fishing activities, ecosystem information and available research.	**Target:** Fishing impacts are considered to generate an acceptable level of risk to ecological processes within the ecosystem, i.e. moderate risk or lower.	No management action required.
				Threshold: Fishing impacts are considered to generate an undesirable level of risk to any ecological processes within the ecosystem, i.e. high risk.	A review is triggered to investigate the reasons for the increased risk. Appropriate management action will be taken to reduce the risk to an acceptable level.
				Limit: Fishing impacts are considered to generate an unacceptable level of risk to any ecological processes within the ecosystem, i.e. severe risk.	Appropriate management action will be taken to reduce the risk to an acceptable level.

3.5 Monitoring and Assessment Procedures

3.5.1 Information and Monitoring

3.5.1.1 Commercial Catch and Effort Reporting

Commercial fishers are required to report all retained species catches (kilograms, litres or number of individuals), effort (time fished), location (10x10nm blocks) and all ETP species interactions. This information has been reported in statutory monthly catch and effort (CAES) returns (from 1977) as well as separate daily logbook returns (from 2008) where the location reporting moved to the recording of GPS co-ordinates. From late 2017, the monthly and daily logbooks will be combined into a new electronic daily logbook.

3.5.1.2 Aquaculture Broodstock and Public Aquarium Collection Reporting

As part of the Exemption conditions, all persons permitted to collect marine aquarium fish species for aquaculture broodstock purposes or for a public aquarium display are required to maintain and submit accurate records of all fishing activity. This includes all retained species catches (kilograms, litres or number of individuals), effort (time fished), location (10x10nm blocks) and all ETP species interactions.

3.5.1.3 Recreational Catch and Effort Information

Estimates of recreational fishing effort and demersal scalefish catches is available via biennial surveys of boat-based recreational fishing (Ryan et al. 2013). Three state-wide recreational fishing surveys have been completed to date using this approach, in 2011/12 (Ryan et al. 2013), 2013/14 (Ryan et al. 2015) and 2015/16 (insert reference).

3.5.2 Assessment Procedures

3.5.2.1 Risk Assessments

The Department uses a risk-based Ecosystem Based Fisheries Management (EBFM) framework to assess the impacts of fishing on all parts of the marine environment, including the sustainability risks of retained species, bycatch, ETP species, habitats and the ecosystem. This framework has led the development of a periodic risk assessment process for the MAF, which is used to prioritise research, data collection, monitoring needs and management actions and to ensure that fishing activities are managed both sustainably and efficiently.

The fishery was first assessed against the Ecologically Sustainable Development (ESD) policy in 2004 (Department of Fisheries, Western Australia - ESD Report Series No. 8, October 2010).

In October 2014, an ecological risk assessment (ERA) workshop was held to assess the impact of the MAF on the marine aquarium fish resource of Western Australia. Outcomes of the ERA are contained in Fisheries Management Paper No. 293 - Ecosystem-Based Fisheries Management (EBFM) Risk Assessment of the Marine Aquarium Fish Managed Fishery (Department of Primary Industries and Regional Development 2018 in press).

3.5.3 Reports and Publications

Information on the current status of WA fisheries and aquatic resources is reported annually in Fisheries' *Status Reports of the Fisheries and Aquatic Resources of Western Australia: the State of the Fisheries* (e.g. Fletcher and Santoro 2015). Other comprehensive information on fisheries management and the findings and recommendations from research and monitoring activities are also regularly compiled and published in a number of publicly-available documents[7], including:

- The Department's *Annual Report* to Parliament;
- The *Research, Monitoring, Assessment and Development Plan 2015-2020*; and
- Fisheries Research Reports, Fisheries Management Papers, Fisheries Occasional Publications, and peer-reviewed scientific journal articles. Examples include:
    - ESD Report Series No. 8: *Marine Aquarium Managed Fishery* (Smith et al 2010);
    - Fisheries Management Paper No. 293: Ecosystem-Based Fisheries Management (EBFM) Risk Assessment of the Marine Aquarium Fish Managed Fishery (Department of Primary Industries and Regional Development 2018 in press).

4 MANAGEMENT MEASURES AND IMPLEMENTATION

There are a number of management measures in place for managing the marine aquarium fish resource in WA (Table 2). These can be amended as needed to ensure the management objectives are achieved, however, these do not preclude the consideration of other options.

[7] Fisheries reports are available at http://www.fish.wa.gov.au/About-Us/Publications/Pages/default.aspx

Table 2. Management measures and instrument of implementation for the MAF

Measure	Description	Instrument
Limited Entry	A limited number of Managed Fishery Licences (12) are permitted to operate in WA.	MAF Management Plan 2018
Effort Restrictions	No more than one 'fishing unit' consisting of one primary vessel and up to two tender vessels can operate under the authority of a licence at any time; and No more than one nominated operator and three nominated collectors can operate under the authority of a licence at any time.	MAF Management Plan 2018
Gear Controls	Restricted to the use of hand lines, held nets and hand operated tools.	MAF Management Plan 2018
Catch Restrictions	The take of coral, tridacnid clams, Syngnathiformes and 'live rock' is managed under an Individual Transferable Quota (ITQ) system.	MAF Management Plan 2018
Species Restrictions	Species specifically covered by another managed fishery (e.g. western rock lobster) and totally protected species (e.g. weedy sea dragon) may not be taken.	Relevant Management Plans and Schedule 2 FRMR
Spatial Closures	Parts of WA are permanently closed to commercial and recreational fishing activities to preserve sensitive habitats. The fishery is excluded from operating in Marine Park sanctuary zones and taking coral and live rock from some Marine Parks.	MAF Management Plan 2018 Section 43 FRMA
Size Limits	Species-specific size limits are in place for some finfish species.	FRMR
Reporting	Fishers are required to report all retained species catches, effort, ETP species interactions and fishing location in statutory daily logbooks.	MAF Management Plan 2018

4.1 Implementing Changes to the Management Arrangements

Decision-making processes can be triggered following the identification of new or potential issues as part of a risk assessment (generally reviewed every 3-5 years), results of research, management or compliance projects or investigations, monitoring or assessment outcomes (including those assessed as part of the harvest strategy) and/or expert workshops and peer review of aspects of research and management.

There are two main processes for making decisions about the implementation of management measures and strategies for the marine aquarium fish resource:

- Periodic decision-making processes that may result in measures to meet the short-term, operational fishery objectives (driven by the control rules); and
- Longer-term decision-making processes that result in new measures and/or strategies to achieve the long-term fishery objectives (i.e. changes to the management system).

However, if there is an urgent issue, consultation with stakeholders may be undertaken to discuss the issue and determine appropriate management action, as needed.

4.1.1 Consultation

Management changes are generally given effect through amendments to legislation, such as the commercial fishery management plan, regulations and orders. These changes generally require the approval of the Minister for Fisheries. In making decisions relevant to fisheries, the Minister for Fisheries may choose to receive advice from any source, but has indicated that:

1) The Department is the primary source of management advice; and
2) Peak Bodies (Western Australian Fishing Industry Council [WAFIC] and Recfishwest) are the primary source of industry advice and representation.

The peak bodies are funded by Government under Service Level Agreements (SLAs) to undertake their representation / advisory and consultation roles.

4.1.1.1 Commercial Sector Consultation

Under its SLA with the Department, WAFIC has been funded to undertake statutory consultation functions related to fisheries management plans and the facilitation of management meetings (MMs) for licensed fisheries.

The FRMA requires the Minister to consult with affected parties when changes to a Part 6 management plan are being considered. In the case of the MAF, this includes all licence holders. MMs between the Department, WAFIC and licence holders are used as the main forum to consult with stakeholders and licence holders on the management of the fishery. During these meetings current and future management issues that may have arisen during the previous fishing season, and any proposed changes to the management plan, are discussed. Follow-up meetings may be held as required.

4.1.1.2 Recreational Sector Consultation

Under the SLA with Recfishwest, the Department is required to consult with Recfishwest as the recognised peak body for recreational fishing in Western Australia. Recfishwest is required to engage and consult with recreational fishers as necessary in order to meet its obligations.

4.1.1.3 Consultation with Other Groups

Consultation with non-fisher stakeholders including Government agencies, conservation sector non-government organisations, customary fishers, statutory advisory committees and other affected/interested parties is undertaken by the Department in accordance with the Department's *Stakeholder Engagement Guideline* (Department of Fisheries, 2016). The Department's approach to stakeholder engagement is based on a framework designed to assist with selecting the appropriate level of engagement for different stakeholder groups. It includes collaborating with and involving key stakeholders, seeking input from interested parties

through a public consultation process and keeping all parties fully informed through the provision of balanced, objective and accurate information. Key fishery-specific documents such as harvest strategies, recovery plans and bycatch action plans are subjected to both formal key stakeholder consultation and public consultation processes.

4.2 Compliance and Enforcement

The key objective of the Department regarding compliance is to encourage voluntary compliance through education, awareness and consultation activities.

4.2.1 Operational Compliance Plan

Management arrangements are enforced under an Operational Compliance Plan (OCP). The OCP is informed and underpinned by a compliance risk assessment conducted for the fishery. The OCP has the following objectives:

- To provide clear and unambiguous direction and guidance to Fisheries and Marine Officers for the annual delivery of compliance in this fishery;
- To protect the fisheries' environmental values, whilst providing fair and sustainable access to the fisheries' commercial and social values;
- To encourage voluntary compliance through education, awareness and consultation activities; and
- To provide processes which ensure that the fisheries are commercially viable in the international market yet environmentally sustainable in the local context.

The OCP is reviewed every 1-2 years.

4.2.1.1 Compliance Strategies for the MAF

Compliance strategies and activities that are used in the fishery include:

- land and sea patrols;
- inspections of MAF species at wholesale and retail outlets;
- inspection in port;
- at-sea inspection of fishing boats;
- aerial surveillance;
- undertaking covert operations and observations;
- monitoring of entitlement and vessel movements; and
- intelligence gathering and investigations.

Inspections may involve:

- inspection of all compartments on board the vessels;

- inspection of all authorizations;
- inspection of associated paperwork;
- inspections of fishing gear; and
- inspection of catch on board the boat.

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APPENDIX 1 - THRESHOLD LEVELS FOR HARD CORAL SPECIES

Hard Corals (Kilograms)		2008	2009	2010	2011	2012	2013	Maximum Value (MV)	Threshold Level (i.e. MV x 2)
Scientific Name	**Common Name**								
Acanthastrea echinata	Echinata Acanthastrea	66	58	93	66		1	93	186
Acanthastrea spp.	Acanthastrea	123	100	72	102	130	175	175	349
Acropora spp.	Acropora Staghorn	337	333	194	286	186	98	337	673
Blastomussa merleti	Blastomussa merleti	19	38	18	67	16		67	133
Catalaphyllia jardinei	Catalaphyllia Elegant	78	63	154	239	265		265	530
Cynarina spp.	Cynarina		10	84	119	35	7	119	237
Dendrophylliidae - undifferentiated	Dendrophylliidae	51			1			51	103
Dipsastraea spp.	Dipsastraea	296	481	267	244	141	136	481	962
Duncanopsammia axifuga	Whisker	22	405	777	290	456	327	777	1,555
Duncanopsammia spp.	Duncanopsammia	417	143	100	118			417	834
Echinophyllia spp.	Echinophyllia	163	511	293	222	197	109	511	1,022
Euphyllia ancora	Hammer	371	415	606	600	492	345	606	1,211
Euphyllia glabrescens	Torch	199	150	374	402	505	247	505	1,009
Euphyllia paraancora	Branching Hammer					29	269	269	538
Euphyllia spp.	Euphyllia		31	46	150		10	150	300
Favites spp.	Favites	0	46	60	8	2	44	60	121
Fungia spp.	Fungia	77	140	67	105	58	57	140	279
Goniastrea spp.	Goniastrea	33	89	32	38	31	28	89	178
Goniopora spp.	Goniopora	265	103	68	156	145	236	265	530
Homophyllia spp.	Homophyllia	125	152	84	139	70	23	152	304
Leptastrea purpurea	Leptastrea purpurea		81	9	21		1	81	162
Lithophyllon spp.	Lithophyllon		37	33	58	10	9	58	116
Lobophyllia hemprichii	Lobophyllia hemprichii	10		88	37			88	176
Lobophyllia spp.	Lobophyllia	261	463	430	439	293	556	556	1,112
Merulinidae - undifferentiated	Merulinidae	131	54	55	83			131	261

Montipora spp.	Montipora	73	118	33	31	18	6	118	236
Moseleya latistellata	Moseleya latistellata	110	189	294	79	11	57	294	588
Order Scleractinia - undifferentiated	General	19	16	4	16	18	222	222	445
Paragoniastrea australensis	Paragoniastrea australensis	72		0	13	4		72	144
Platygyra daedalea	Platygyra daedalea	196	108	64	52	12	39	196	392
Plerogyra sinuosa	Green Bubble Plerogyra	11		22	380	30	60	380	760
Pocillopora spp.	Pocillopora	42	49	48	58	27	9	58	116
Symphyllia spp.	Symphyllia	23	169	290	226	190	75	290	580
Symphyllia wilsoni	Symphyllia wilsoni	126	556	283	83	2	30	556	1,112
Trachyphyllia geoffroyi	Trachyphyllia	397	504	640	471	266	230	640	1,281
Tubastrea spp.	Tubastrea	149	80	9	9	61	28	149	297
Turbinaria spp.	Turbinaria	205	165	271	169	94	149	271	543
All other species		-	-	-	-	-	-	-	100

Data: DoF FishCube May 2017

APPENDIX 2 - THRESHOLD LEVELS FOR SOFT CORAL SPECIES

Soft Corals (Kilograms)		2008	2009	2010	2011	2012	2013	Maximum Value (MV)	Threshold Level (i.e. MV x 2)
Scientific Name	**Common Name**								
Anthelia spp.	Anthelia	77	12	9	13	25	6	77	154
Cladiella spp.	Cladiella Colt	50	52	6	5	3	16	52	104
Corallimorphidae - undifferentiated	Corallimorphidae Coral-like Anemones	3			216			216	432
Corallimorphus spp.	Corallimorphus Coral-like Anemones				45	73	1,869	1,869	3,738
Dendronephthya spp.	Dendronephthya Flower	114	106	30	43	41	72	114	227
Lobophytum spp.	Lobophytum	57	23	65	51	7		65	131
Order Alcyonacea - undifferentiated	General & Sea Fans	14	6	0	1	11	243	243	486
Order Corallimorpharia - undifferentiated	General Coral-like Anemones	1,378	1,929	2,233	2,932	3,815	1,009	3,815	7,630
Order Zoantharia - undifferentiated	General Zoanthid Anemones	180	56	105	35	737	404	737	1,473
Palythoa spp.	Palythoa Zoanthid Anemones	1,366		65	70			1,366	2,731

Rhodactis spp.	Rhodactis Coral-like Anemones	275		6				275	550
Rumphella spp.	Sea Rod	40	39	8	22	71	2	71	142
Sarcophyton spp.	Toadstool	301	166	174	203	119	315	315	629
Sinularia spp.	Sinularia	165	59	28	14	21	2	165	331
Zoanthidae - undifferentiated	Zoanthidae Anemones	239	2,184	1,606	799	528	1,712	2,184	4,368
Zoanthus spp.	Zoanthus Anemone	812	744	669	558	513	395	812	1,623
All other species		-	-	-	-	-	-	-	100

Note: A commercial TACC of 15,000 kg for corals (hard and soft coral combined – excluding Corallimorpharia and Zoanthidae spp.) applies; Data: DoF FishCube May 2017

APPENDIX 3 - THRESHOLD LEVELS FOR GIANT CLAM SPECIES

Giant Clams (Individuals)		2008	2009	2010	2011	2012	2013	Maximum Value (MV)	Threshold Level (i.e. MV x 2)
Scientific Name	**Common Name**								
Tridacna maxima	Elongate Giant Clam	854	768	1,180	864	426	425	1,180	2,360
Tridacna squamosa	Fluted Giant Clam	16	44	69	53	30	77	289	578
All other species		-	-	-	-	-	-	-	100

Note: A TACC of 2,400 tridacnid clams applies; Data: DoF FishCube April 2017

APPENDIX 4 – THRESHOLD LEVELS FOR SYNGNATHID SPECIES

Syngnathids (Individuals)		2008	2009	2010	2011	2012	2013	Maximum Value (MV)	Threshold Level (i.e. MV x 2)
Scientific Name	**Common Name**								
Hippocampus subelongatus	Western Australian Seahorse	1,089	165	196	913	1,155	1,463	1,463	2,000*
Hippocampus angustus	Western Spiny Seahorse	52	83	59	164	31	68	164	328
All other species		-	-	-	-	-	-	-	100

*A TACC of 2,000 Syngnathiformes applies; Data: DoF FishCube April 2017

APPENDIX 5 – THRESHOLD LEVELS FOR FINFISH SPECIES

Finfish (Individuals)		2008	2009	2010	2011	2012	2013	Maximum Value (MV)	Threshold Level (i.e. MV x 2)
Scientific Name	**Common Name**								
Acanthuridae, Zanclidae	General Surgeonfishes & Moorish Idols	124	9	27	72	31		124	248
Acanthurus grammoptilus	Inshore Surgeonfish	71	21	84	130	31	50	130	260
Acanthurus nigricans	Velvet Surgeonfish	5		51	14	3	5	51	102
Acanthurus triostegus	Convict Surgeonfish	35	56	157	190	18	28	190	380
Amblygobius bynoensis	Bynoe Goby	85	7	12				85	170
Amblygobius phalaena	White-barred Goby	132		33	11	9	71	132	264
Amphiprion clarkii	Clark's Anemonefish	846	573	935	452	326	280	935	1,870
Amphiprion frenatus	Tomato Anemonefish	5	10	85	55	19	2	85	170
Anampses lennardi	Blue And Yellow Wrasse	30	31	213	657	1,046	223	1,046	2,092
Anoplocapros amygdaloides	Western Smooth Boxfish	18	69	23	17	17	4	69	138
Anoplocapros lenticularis	Whitebarred Boxfish	248	322	148	77	171	93	322	644
Anthias spp.	General Anthias Rockcods			8	134			134	268
Apistidae, Neosebastidae, Pteroidae, Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae & Tetrarogidae	General Scorpionfishes	30	15	128	86	56	8	128	256
Apogonidae, Dinolestidae	General Cardinalfishes & Longfin Pikes	3,451	1,766	94	54		500	3,451	6,902
Aracana aurita	Shaw's Cowfish	88	105	80	52	58	19	105	210
Atherinidae, Dentatherinidae	General Hardyheads & Tusked Silversides	50		800				800	1,600
Bathygobius fuscus	Dusky Frillgoby	50		100		25	80	100	200
Blenniidae	General Blennies	400	38	75	82	128	282	400	800
Bodianus frenchii	Western Foxfish	34	48	52	77	36	15	77	154
Caesio cuning	Yellowtail Fusilier					27	255	255	510
Caesionidae, Lutjanidae, Symphysanodontidae	General Fusiliers, Tropical Snappers & Slopefishes	2	57	101	15		30	101	202

Centropyge joculator	Yellowhead Angelfish	582	633	554	584	594	494	633	1,266
Chaetodon assarius	Western Butterflyfish	11	6	15	295	49	33	295	590
Chaetodon aureofasciatus	Goldenstriped Butterflyfish	66	72	110	78	41	34	110	220
Chaetodontoplus duboulayi	Scribbled Angelfish	590	492	1,333	2,275	2,527	1,938	2,527	5,054
Chaetodontoplus personifer	Yellowtail Angelfish	68	76	198	139	175	128	198	396
Cheilio inermis	Sharpnose Wrasse	3		6		310		310	620
Chelmon marginalis	Margined Coralfish	542	682	1,266	1,506	1,048	1,429	1,506	3,012
Chelmonops curiosus	Western Talma	90	162	134	184	114	35	184	368
Chromis atripectoralis	Black-axil Chromis	3,065	50	1,350	1,550	1,010	1,200	3,065	6,130
Chromis cinerascens	Green Chromis	873	790	2,998	1,941	2,203	1,052	2,998	5,996
Chromis klunzingeri	Black-headed Chromis	115	220	480	575	421	150	575	1,150
Chromis spp.	General Chromis		2,849	2,650	2,320	400	2,039	2,849	5,698
Chromis viridis	Blue-green Chromis			230		109	126	230	460
Cirrhilabrus temminckii	Peacock Wrasse			31	600	749	10	749	1,498
Cirripectes filamentosus	Dusky Blenny	23	9	27	8	52	87	87	174
Congrogadus subducens	Carpet Eel-Blenny	505	2		3		3	505	1,010
Coradion chrysozonus	Orangebanded Coralfish	8	1	2	10	94	4	94	188
Coris auricularis	Western King Wrasse	46	165	132	150	395	25	395	790
Cryptocentrus leptocephalus	Pink-spot Shrimpgoby	54					138	138	276
Dactylosurculus gomoni	Cuskeel	130	4	24				130	260
Dascyllus trimaculatus	Three-spot Humbug	7	138	24	2	20	53	138	276
Dendrochirus zebra	Zebra Lionfish	25	75	12	21	92	84	92	184
Diademichthys lineatus	Striped Clingfish					23	60	60	120
Diodontidae	General Porcupinefishes	12	13	45	108	140	87	140	280
Ecsenius bicolor	Bicolor Combtooth Blenny	31	2	25	172	210	73	210	420
Enoplosus armatus	Old Wife	105	86	81	221	469	15	469	938
Entomacrodus decussatus	Wavy-lined Blenny	8				159		159	318
Glaucosoma magnificum	Threadfin Pearl Perch	18		5		80	119	119	238
Gobiidae	General Gobies	553	447	580	979	967	628	979	1,958

Haemulidae	General Grunter Breams	7	3	19	63	2	1	63	126
Halichoeres brownfieldi	Brownfield's Wrasse	29	18	65	56	43	10	65	130
Halichoeres melanochir	Purple Wrasse	25	51	81	17	3	7	81	162
Heniochus diphreutes	Schooling Bannerfish	58		44	88	18	2	88	176
Heterodontus portusjacksoni	Port Jackson Shark	247	389	197	664	489	270	664	1,328
Istiblennius meleagris	Spotted Blenny	1,730	2,846	1,040	2,081	1,468	1,075	2,846	5,692
Istigobius decoratus	Decorated Sandgoby	30		174	80	59	85	174	348
Istigobius ornatus	Ornate Sandgoby	1		62	2		109	109	218
Labridae	General Wrasses	312	111	477	189	238	3	477	954
Labroides dimidiatus	Common Cleanerfish	257	40	304	279	328	153	328	656
Lactoria cornuta	Longhorn Cowfish	129			25		1	129	258
Macropharyngodon ornatus	Ornate Leopard Wrasse	107	15	10	118	71	24	118	236
Microcanthus strigatus	Stripey	10	152	42		30	30	152	304
Monodactylus argenteus	Diamondfish	61	2					61	122
Mugilidae	General Mullets	100	1,028					1,028	2,056
Mullidae	General Goatfishes	71	97	49	87	51	8	97	194
Naso spp.	General Unicornfishes	3		100	72	1	2	100	200
Neatypus obliquus	Footballer Sweep	18	44	43	287	88	26	287	574
Nemipteridae	General Threadfin Breams				76	7	18	76	152
Neopomacentrus azysron	Yellowtail Demoiselle	697	513	10	61	13	257	697	1,394
Omegophora cyanopunctata	Blue-spotted Toadfish	14	21	54	45	61	24	61	122
Opistognathidae	General Jawfishes			14		29	60	60	120
Opistognathus darwiniensis	Darwin Jawfish	1			19	12	79	79	158
Order Anguilliformes/Synbranchiformes	General Eels	67		2	4	1		67	134
Ostorhinchus angustatus	Striped Cardinalfish	179	6					179	358
Ostorhinchus cyanosoma	Orangelined Cardinalfish						174	174	348
Ostorhinchus endekataenia	Candystripe Cardinalfish			248	32		100	248	496
Ostorhinchus rueppellii	Western Gobbleguts	200	80	520				520	1,040

Ostorhinchus victoriae	Western Striped Cardinalfish	14	24	147	26	10	5	147	294
Oxymonacanthus longirostris	Harlequin Filefish		3	14	71	3	3	71	142
Paragobiodon echinocephalus	Redhead Goby	6	2	95				95	190
Paraplesiops meleagris	Western Blue Devil	102	144	138	114	92	31	144	288
Paraplotosus butleri	Sailfin Catfish	24	162	105	66	28	31	162	324
Parioglossus formosus	Yellowstriped Dartfish	130						130	260
Parupeneus barberinoides	Bicolour Goatfish	38	88	383	71	197	78	383	766
Pegasidae	General Seamoths	16		15			51	51	102
Pegasus volitans	Slender Seamoth			120	27		37	120	240
Pempheridídae, Leptobramidae	Bullseyes & Beach Salmons	55						55	110
Pempheris schwenkii	Silver Bullseye			120	56			120	240
Pentapodus emeryii	Purple Threadfin Bream			258	5		1	258	516
Periopthalmus argentilineatus	Silverlined Mudskipper	370	388	81				388	776
Pinguipedidae	General Grubfishes	292		2		2		292	584
Plotosus lineatus	Striped Catfish	4	416	607	1,142		900	1,142	2,284
Pomacentridae	General Damselfishes	40	7	218	60	201		218	436
Pomacentrus coelestis	Neon Damsel	499	140	19	45	232	175	499	998
Pomacentrus moluccensis	Lemon Damsel	1	4	55	20		40	55	110
Pomacentrus pavo	Blue Damsel		50	91	117	1		117	234
Ptereleotris evides	Arrow Dartfish	7	6	69	399	46		399	798
Pterois volitans	Common Lionfish	80	58	67	87	205	95	205	410
Pterosynchiropus splendidus	Mandarinfish			6			76	76	152
Salarias fasciatus	Banded Blenny	102	51	45	2		472	472	944
Scartelaos histophorus	Bearded Mudskipper	11	1	75	15		20	75	150
Scatophagus argus	Spotted Scat	103						103	206
Siganidae	General Rabbitfishes	7	25	183	125	543	383	543	1,086
Siganus virgatus	Doublebar Rabbitfish			6	2	8	140	140	280
Sillaginidae	General Whitings	12	204					204	408

Superclass pisces	Unknown Aquarium Fish	41	12	5	27	83		83	166
Thalassoma lunare	Moon Wrasse	132	82	116	139	94	67	139	278
Thalassoma lutescens	Green Moon Wrasse	38	4	28	62	32		62	124
Trachinops brauni	Blue-lined Hulafish	150	300	992	2,019	531	455	2,019	4,038
Trachinops noarlungae	Yellow-headed Hulafish	100	420	670	1,525	580	230	1,525	3,050
Trimma okinawae	Orange-red Pygmygoby	47	8	46	27	245	2	245	490
Valenciennea muralis	Mural Glidergoby	98	286	574	765	345	288	765	1,530
Valenciennea puellaris	Orange-spotted Glidergoby	100	26	440	1,559	1,250	562	1,559	3,118
Yongeichthys nebulosus	Hairfin Goby	34	11	9			75	75	150
Zanclus cornutus	Moorish Idol	65	11	7	47	34	21	65	130
All other species		-	-	-	-	-	-	-	100

Data: DoF FishCube May 2017

APPENDIX 6 – THRESHOLD LEVELS FOR ALGAE

Algae and Seagrasses (Litres)		2008	2009	2010	2011	2012	2013	Maximum Value (MV)	Threshold Level (i.e. MV x 2)
Scientific Name	**Common Name**								
Caulerpaceae	Caulerpaceae Green Algae	30	11	7	16	68	50	68	136
Class Phaeophyceae	General Brown Algae					54	3	54	108
Phylum chlorophyta	General Green Algae	432	384	184	46	85	45	432	863
Order Alismatales	General Seagrass	59	5	3		0		59	118
Caulerpa racemosa	Sea Grapes	189		1	120		120	189	378
Chaetomorpha spp.	Spaghetti Algae	60						60	120
All other species		-	-	-	-	-	-	-	100

Data: DoF FishCube May 2017

APPENDIX 7 – THRESHOLD LEVELS FOR SPONGES (PHYLUM PORIFERA)

Sponges (Individuals)		2008	2009	2010	2011	2012	2013	Maximum Value (MV)	Threshold Level (i.e. MV x 2)
Scientific Name	**Common Name**								
Phylum porifera	General Sponges	288	555	44	588	5	1	588	1,176
Trikentrion flabelliforme	Whiteline Sponge	2,589	4,282	2,812	2,466	2,476	3,631	4,282	8,564
All other species		-	-	-	-	-	-	-	100

Data: DoF FishCube May 2017

APPENDIX 8 – THRESHOLD LEVELS FOR OTHER INVERTEBRATES

Invertebrates (Individuals)		2008	2009	2010	2011	2012	2013	Maximum Value (MV)	Threshold Level (i.e. MV x 2)
Scientific Name	**Common Name**								
Actinia tenebrosa	Waratah Anemone	211				181		211	422
Actiniaria	General Anemones	3,799	3,287	1,382	2,984	3,095	3,906	3,906	7,812
Ancylomenes holthuisi	Holthuisi Anemone Shrimp					2	268	268	536
Aplysiidae	General Sea Hare						51	51	102
Astraea spp.	Astraea Snail	97						97	194
Astropecten polyacanthus	Astropecten polyacanthus Seastar						459	459	918
Ceratosoma trilobatum	Orange Nudibranch		57					57	114
Cercodemas anceps	Warty Sea Cucumber	162	155	233	7			233	466
Cerianthidae	Cerianthid Tube Anemones	532	71	308	94			532	1,064
Cerithiidae	General Creeper Snails	4,696	1,012					4,696	9,392
Chromodorididae	Chromodorididae Nudibranch	117						117	234
Class Ascidiacea	General Ascidians	4	2	26	37	37	73	73	146
Class Asteroidea	General Starfish	2,510	883	1,143	1,338	1,155	673	2,510	5,020
Class Crinoidea	General Featherstars	234	225	108	176	103	307	307	614
Class Echinoidea	General Sea Urchins	271	431	184	160	194	191	431	862
Class Gastropoda	General Gastropods	800	1	325	869	105	360	869	1,738
Class Holothuroidea	General Sea Cucumber	4	60	36	67	122	97	122	244
Class Ophiuroidea	General Brittlestars	57	187	228	295	40	27	295	590
Class Polychaeta	General Polychaete Worms	280	18	25	10	20	2	280	560
Clibanarius spp.	General Clibanarius Hermit Crabs	17,930	1,000	500	500	24		17,930	35,860
Colochirus quadrangularis	Cubic Sea Cucumber	116	75		120	30	9	120	240
Diadema setosum	Long-spined Sea Urchin	211	162	223	193	124	137	223	446
Diogenidae	General Hermit Crabs (Marine)	1,306	105	1,719	288	1,772	4,309	4,309	8,618

Entacmaea quadricolor	Bubbletip Anemone	2,578	1,180	1,467	1,253	907	1,407	2,578	5,156
Entacmaea spp.	Entacmaea Anemone	140		1				140	280
Fromia indica	Fromia indica Seastar					153	218	218	436
Fromia polypora	Fromia polypora Seastar	373	169	16	108	180	88	373	746
Heliocidaris tuberculata	Black Sea Urchin	1	60			35		60	120
Heteractis crispa	Leathery Anemone	1,290			1		3	1,290	2,580
Heteractis malu	Delicate Anemone	1,933	1,389	1,301	610	913	646	1,933	3,866
Hexabranchus sanguineus	Spanish Dancer Nudibranch	66	9	2	2			66	132
Hippolytidae	General Hump-backed Shrimps	244	387	20			24	387	774
Holothuria (halodeima) edulis	Burnt Sausage Sea Cucumber	222	26	61	179	68	76	222	444
Holothuria (mertensiothuria) leucospilota	Black Sea Cucumber	173	259	173	259	20	77	259	518
Holothuriidae	Holothuriidae Sea Cucumber	209	14	70		40		209	418
Hormathiidae	Hormathiidae Anemone	99						99	198
Infraorder anomura	General Hermit, Porcelain, Half, & Stone Crabs	12,792					400	12,792	25,584
Infraorder brachyura	General Crabs	24,740	552	512	1,255	1,860	13,191	24,740	49,480
Infraorder caridea	General Shrimps	121	285	105	156		21	285	570
Linckia laevigata	Blue Linckia Seastar			9	21	37	127	127	254
Linckia multifora	Linckia multifora Seastar			71	7	51		71	142
Linckia spp.	Linckia Seastar	3	29	22	86	60	171	171	342
Lysmata amboinensis	Cleaner Shrimp		16		67	9	1	67	134
Lysmata vittata	Red-striped Shrimp		45	80				80	160
Mysidae	General Mysids			1,000				1,000	2,000
Nassariidae	General Dog Whelks	100					1,665	1,665	3,330
Nectria spp.	Nectria Seastar		150	73	48			150	300
Nemanthus spp.	Nemanthus Tree Anemone	188	12					188	376
Neopetrolisthes maculatus	Neopetrolisthes maculatus Porcelain Crab			128	60			128	256
Neopetrolisthes spp.	Neopetrolisthes Porcelain Crabs					76	206	206	412

Octopodidae	Octopodidae Octopus	65	30	18	38	42	18	65	130
Order Decapoda	General Decapods		78	124	57			124	248
Order Nudibranchia	General Nudibranchs	352	131	175	56	136	107	352	704
Palaemon intermedius	Striped River Shrimp				1,000		6	1,000	2,000
Palaemonidae	General Palaemonid Shrimps	3,000	7,000	600	250			7,000	14,000
Pentagonaster dubeni	Pentogaster dubeni Seastar	206	508	311	289	347	253	508	1,016
Periclimenes brevicarpalis	Egg-shell Anemone Shrimp	1,134		3	1	6		1,134	2,268
Porcellanidae	General Porcelain Crabs	241	125	149	167	125	47	241	482
Pseudocolochirus violaceus	Red Sea Apple	56	23	1	20	22	45	56	112
Rhynchocinetidae	General Hinge-beaked Shrimps		21		175		2	175	350
Sabellariidae	General Fan & Featherduster Polychaete Worms	135	12	61	22	204	53	204	408
Serpulidae	General Tube Worms		2	8	95	395	352	395	790
Spirobranchus corniculatus	Christmas Tree Rock Worm	15	254	55	69	27	106	254	508
Stenopus hispidus	Banded Coral Shrimp	564	227	411	183	255	287	564	1,128
Stichodactyla haddoni	Haddon's Anemone	35	18	17	10	45	72	72	144
Stichodactyla tapetum	Miniature Carpet Anemone		17	22	5	24	99	99	198
Stichodactylidae	General Carpet Anemones	101	19	51	43	16	124	124	248
Tectus fenestratus	Tectus fenestratus Top Shell		266					266	532
Tectus spp.	Tectus Top Shell			1,714				1,714	3,428
Tegula spp.	Tegula Snail	101		1				101	202
Tripneustes gratilla	Collector Sea Urchin	1,037	106	141	111	136	225	1,037	2,074
Trochidae, Margaritidae, Solariellidae, Tegulidae	General Top Shells (Trochus Snails)	12,095	10,649	10,585	13,287	14,807	16,278	16,278	32,556
Trochus maculatus	Spotted Top Shell	8,578				803	1,389	8,578	17,156
Turbinidae	General Turban Shells	138	19	1	160			160	320
Turbo petholatus	Smooth Turban						210	210	420
Turbo spp.	General Turbo Shells	980	179	96	285	865	32	980	1,960
All other species		-	-	-	-	-	-	-	100

Data: DoF FishCube May 2017