# EXPERT ADVICE FOR THE ASSESSMENT OF AUSTRALIAN CORAL FISHERIES – QUEENSLAND CORAL FISHERY 2006-2007 TO 2019-2020

Report prepared for Australia's Scientific Authority for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

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**Cataloguing Data**

This publication (and any material sourced from it) should be attributed as: Expert advice for the assessment of Australian coral fisheries – Queensland Coral Fishery 2006-2007 to 2019-2020, Department of Agriculture, Water and the Environment (DAWE), Wildlife Trade Assessments Section of the Wildlife Trade Office, Canberra, 2021.



This report has undergone peer review.

On the cover: *Trachyphyllia geoffroyi*. Photograph: Ciemon Caballes Ultra Coral Australia.

## *i. Executive Summary*

The Queensland Coral Fishery (QCF) is the largest of four Australian coral fisheries, each operating within different jurisdictions. Scleractinian (hard) corals form a significant and important component of the take from the QCF, many of which are exported and subject to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The export and international trade in CITES-listed hard corals is contingent on determinations of non-detriment findings (NDF) by Australia's CITES Scientific Authority (the Wildlife Trade Assessments Section of the Wildlife Trade Office, Australian Government Department of Agriculture, Water and the Environment), which are required to provide assurances that such export (and corresponding harvest levels) will not be detrimental to the survival, distribution, or function of the harvested species, nor adversely affect relevant habitats and ecosystems. The purpose of this study was to assess current management arrangements and fishery operations for the QCF to objectively assess whether the risk posed by the current and proposed harvesting of CITES-listed corals is negligible or acceptable, while also considering the current environmental, social and political context that may necessitate greater scrutiny and caution in NDF determinations.

The QCF is managed using a combination of input and output controls that limit the overall amount (weight) of coral that can be removed. Most notably, there is an overall annual coral quota (Total allowable Commercial Catch) of 60,000 kg for specialty corals, with a further allowance (140,000kg) for other coral products (e.g., live rock), which also includes fast growing corals (Acroporidae and Pocilloporidae). The QCF is a dive-based, hand-collection fishery, which minimises risks to non-target species and habitats, and also imposes inherent constraints on the amount of coral that can be harvested, especially during periods of adverse weather. The area of operation for this fishery encompasses the entire geographical extent the Great Barrier Reef (GBR), though a large proportion (>33%) of this area is designated Marine National Park or Special Management Areas, which are closed to coral harvesting. There are, however, persistent concerns regarding concentrated harvesting in specific areas, potentially resulting in localised depletion of heavily targeted and highly

vulnerable coral species. Moreover, reported harvested levels of live hard corals (order Scleractinia) have increased >40%, from 305,106 colonies of fragments harvested 2017-2018 to 441,003 in 2018-2019. At the same time, there have been escalating external (fisheries-independent) pressures, including increasing incidence and severity of mass coral bleaching (linked to marine heatwaves) that impact on coral stocks. Potential effects of increasing harvest levels are also being compounded by increasing environmental pressures (including coral bleaching, population irruptions of crown-of-thorns starfish, and other escalating human pressures), which may affect the abundance or resilience of harvested coral species.

Aside from well-established input and output controls, the QCF makes use of a risk-based approach for managing harvest levels of individual species (or species groups) and the spatial distribution of fishing effort. This is intended to not only constrain sustained or rapid growth in harvest levels of individual species, but respond to changing external pressures that may make corals more vulnerable. The recently developed Harvest Strategy (2021-2026) proposes that harvest limits (catch triggers) for individual coral species be constrained to 80-150% of recent reported harvest levels (averaged over 3-years from 2016-2017 through 2018-2019), depending on their perceived risk to harvesting. These catch triggers for individual coral species or species groups are administered outside of legislated quota (Total Allowable Commercial Catch of 200,000 kg), though management actions intended to constrain harvesting below these catch triggers (e.g., species-specific TACC, trip limits, or spatial closures) are not specifically outlined. In the absence of demographic data, there is also no biological or scientific basis for proposed catch triggers for individual species, such that, even if harvesting is suitably constrained, this does not guarantee the sustainability of current and future fishing operations.

Rigorous and ongoing stock assessments to clearly establish and implement sustainable harvest limits for all individual species of CITES-listed corals is the foremost management action that will assure positive NDF determinations and WTO approvals. This will however, require considerable research and monitoring specific to each coral species, involving comprehensive surveys to establish distribution and abundance, as well as experimental studies and detailed monitoring to determine population dynamics and turnover. Meanwhile and in the absence of such information, precautionary harvest limits need be imposed and maintained until there is necessary information to establish sustainable harvest limits and justify increased harvest levels.

There are not currently prescribed harvest limits for any individual coral species in the QCF, and there have been substantial increases in reported harvest levels for many species (especially since 2017-2018), including CITES species of concern. Harvest limits are needed (Table i.1), not only to constrain escalating harvest levels, but also to reduce harvest levels for several of the most heavily targeted coral species below reference harvest levels.

**Table i.1**. Proposed harvest limits for individual species and genera to constrain future harvest levels at or below reference harvest levels. Harvest limits are required to address escalating growth in reported harvest levels of these taxa, at least until there is relevant information to establish sustainable harvest limits.

| Taxa | Reference harvest level | Multiplier | Harvest limit (no. pieces) | Harvest limit (kg) |
|---|---|---|---|---|
| *Acropora* spp. | 105,977 | 0.8 | 84,782 | 19,500 |
| *Micromussa lordhowensis* | 33,169 | 0.8 | 26,535 | 3,715 |
| *Homophyllia* cf. *australis* | 22,190 | 0.8 | 17,752 | 1,065 |
| *Trachyphyllia geoffroyi* | 14,609 | 0.8 | 11,687 | 701 |
| *Acanthophyllia deshayesiana* | 4,177 | 0.8 | 3,341 | 368 |
| *Catalaphyllia jardinei* | 17,715 | 1.0 | 17,715 | 1,772 |
| *Euphyllia ancora* | 15,525 | 1.0 | 15,525 | 1,863 |
| *Euphyllia glabrascens* | 10,288 | 1.0 | 10,288 | 926 |
| *Duncanopsammia axifuga* | 9,661 | 1.0 | 9,661 | 966 |
| *Cycloseris cyclolites* | 8,684 | 1.0 | 8,684 | 521 |
| *Montipora* spp. | 6,106 | 1.0 | 6,106 | 1,099 |

The recommendations presented herein (Table i.1) differ from proposed harvest limits (catch triggers) within the QCF Harvest Strategy (2021-2026), which allows for increased harvest levels of all coral species, except *Homophyllia* cf. *australis*. Despite recent research on the biology and ecology of major target species (including *Homophyllia* cf. *australis*), there is insufficient information to justify or support the recent increases in harvest levels of these species or genera, let alone allow for further increases in annual harvest levels. Proposed harvest limits for individual corals also need to be implemented as soon as practicable given the rate at which reported harvest levels are increasing.

To prevent further, even more widespread, increases in harvest levels for individual coral species, proportionate harvest limits (150% of reference harvest levels) should be applied to all coral species for which there is relevant catch history information. However, a minimum provisional harvest limit should be considered across all coral species, such that individual harvest limits are only developed and implemented for coral species that are harvested at levels above the minimum provisional harvest limit. Based on the estimated weights for different corals harvested in 2019-2020, 600kg is most appropriate as the minimum provisional harvest limit across all different coral species and genera.

Recommendations to better align the QCF management arrangements and fishery operation with CITES (specifically, NDF) requirements, include:

i) *Species-level reporting categories to be used for all hard (scleractinian) corals, except where there are specific allowances and clear justification for reporting to genus* – Export of CITES-listed hard corals is conditional upon species-level reporting, with some allowance for certain species (e.g., *Acropora* spp.) to be reported to genera. However, the QCF currently reports harvest levels of some CITES-listed hard corals to family-level (e.g., Faviidae), which are particularly problematic given recent changes in taxonomy and nomenclature. For example, 4.6% (27,207/585,484 pieces) of coral reported in 2019-2020 was not assigned to any taxonomic category (species, genus or family). All harvested corals need to be reported to species (or allowable genera), necessitating increased research (wherever necessary) to resolve taxonomic uncertainties;

ii) *Consistent recording and reporting of harvest levels based on both number of pieces (colonies or fragments) and weight (kg)* – Weight-based harvest limits must be established, thereby necessitating recording and reporting of weight for all individual species/ genera. However, information on the number of coral colonies or fragments that have been harvested is also important to understand the nature of fishing operations and also reconcile reported harvest levels of individual species (or species groups) against export data of live corals (reported based on number of pieces due to logistical constraints associated with confirming weight). Since 2016-2017, harvest level reporting for individual reporting categories (e.g., species) in the QCF was limited to number of pieces, with no recording or reporting of weight;

*iii) Transparent and well-justified overarching quota limits for all hard corals* – The annual Total Allowable Commercial Catch (200,000 kg) for the QCF is split (30:70) to limit harvesting of “specialty” coral to 60,000 kg, which was previously regarded to represent the majority of the allowable harvest of live hard (order Scleractinia) corals. However, some hard corals (Acroporidae and Pocilloporidae) collected as live aquarium specimens are reported under “other” or “ornamental” coral, which effectively means that the Total Allowable Commercial Catch of live corals is 200,000 kg. The combined weight of live corals harvested in 2019-2020 was 75,001 kg, including 40,865 kg of specialty coral and 34,136 kg of Acroporidae and Pocilloporidae. With escalating harvest levels of live corals, careful consideration needs to be given to overarching quota limits, specifically for live corals;

iv) *Specific harvest-limits for individual coral species (or genera)* – Even though overall QCF coral harvests are well within legislated catch limits (e.g., 60,000 kg for specialty coral species), harvest limits (with clearly defined stopping rules) need be established for all individual coral species (or genera). Depending on data and information available, harvest limits needs to be provisional, precautionary, or demonstrably sustainable;

v) *Assess and report species composition within generic-level reporting categories (where necessary)* - While there is a specific allowance for some corals to be managed and reported at the level of genera, NDF determinations apply to individual coral species. To the extent that it is possible to reliably distinguish species within these genera (especially *Acropora* spp.), it is important that the catch composition is appropriately understood to clearly establish the risk posed by harvesting for any heavily harvested and/ or highly vulnerable coral species;

vi) *More adaptive and responsive management* - Given increasing pressures and anticipated volatility in coral stocks, management frameworks need to be much more agile. Information and data streams also need to be much more efficient. Currently, there is very limited capacity for managers to constrain catches after quotas are set for the current year, and there is also seemingly limited capacity to review harvest levels until after the end of each (financial) year due to inherent delays in current catch reporting;

vii) *Timely, transparent and open reporting of harvest levels and limits* – Given very limited information on the status and trends for harvested coral species and stocks, vulnerability assessments and NDF determinations rely very heavily on fisheries catch and effort data. Timely reporting of harvest levels will be fundamental in enforcing harvest limits (depending on how they are managed), and accordingly, most fisheries are moving to near real-time reporting. It is also important that relevant data and information are readily available and accessible by a wide range of different stakeholders. Limited availability of transparent and real-time information regarding harvest levels and limits for individual coral species constrains the capacity for independent evaluations of management arrangements and fishery operations, and negatively impacts on perceptions of sustainability and management effectiveness.

Substantive messages relevant to each of the subsequent sections of this report are provided as dot-point summaries (within shaded boxes), at the start of each section.

## ii. Table of Contents

## *iii. Abbreviations*

| | |
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| AFMA | Australian Fisheries Management Authority, Australian Government |
| AIMS | Australian Institute of Marine Science |
| CITES | Convention for the International Trade in Endangered Species of Wild Fauna And Flora |
| CSF | Coral Sea Fishery |
| DAWE | Australian Government, Department of Agriculture, Water and the Environment |
| DEEDI | Queensland Government, Department of Employment, Economic Development and Innovation, |
| DITT | Northern Territory Government Department of Industry, Tourism and Trade |
| DPIRD | Department of Primary Industries and Regional Development, Government of Western Australia |
| ERA | Ecological (or Environmental) Risk Assessment |
| GBR | Great Barrier Reef |
| GBRMP | Great Barrier Reef Marine Park |
| GBRMPA | Great Barrier Reef Marine Park Authority |
| GBRWHA | Great Barrier Reef World Heritage Area |
| LTMP | Long Term Monitoring Program, AIMS |
| NDF | Non-Detriment Findings (as pertaining to CITES export approvals) |
| NTAF | Northern Territory Aquarium Fishery |
| OC | Other coral (quota category) |
| QCF | Queensland Coral Fishery |
| QDAF | Queensland Government, Department of Agriculture and Fisheries |
| SC | Speciality coral (quota category) |
| TACC | Total Allowable Commercial Catch |
| WA MAFMF | Western Australian Marine Aquarium Fish Managed Fishery |
| WTO | Wildlife Trade Operation |

# 1. Background

Unconstrained and unregulated fisheries exploitation has long been considered one of the foremost threats to coastal ecosystems, such as coral reefs (Roberts, 1995; Pandolfi et al., 2003; Fenner, 2012; MacNeil et al., 2015; Bellwood et al., 2019). Principal concern relates to devastating impacts of industrialised fishing activities or destructive fishing practices (McManus et al., 1997; Berkes et al., 2006), though even relatively low and diffuse levels of fisheries exploitation (e.g., sustained artisanal fisheries) can have significant effects on the abundance of heavily targeted and/ or vulnerable species (Wells, 1997; Russ, 2002), with major effects on ecosystem structure and function (Jennings and Polunin, 1996; Hawkins and Roberts, 2004; Fenner, 2012). Most coral reef fisheries focus on harvesting fishes and mobile invertebrates for food (Pratchett et al., 2011), whereby sustained coral loss and reef degradation is expected to compound upon effects of fishing, through habitat loss (Wilson et al., 2008). Effective fisheries management is also increasingly considered as a key strategy to promote the resilience of reefs, reflecting the functional importance of some fisheries target species, such as herbivores and apex-predators (Adam et al., 2015; Bellwood et al., 2019). However, there are also some fisheries that explicitly target reef-building corals (e.g., marine aquarium and ornamental fisheries), which directly affect the biological and physical structure of coral reef habitats (Daley and Griggs, 2008; Bruckner, 2000).

Aquarium fisheries (for both fishes and corals) have been the subject of significant controversy and environmental concerns in several developed and developing countries, linked to widespread use of poisonous chemicals and other destructive fishing practices (e.g., cyanide-fishing, Barber and Pratt, 1998), and the introduction of non-native and potentially invasive organisms (e.g., Wiedenmann et al., 2001; Semmens et al., 2004). Moreover, aquarium fisheries account for the localised extirpation, and even extinction, of several different heavily harvested species, especially from freshwater systems (Andrews, 1990). The effects of aquarium collectors on coral reef species were highlighted by documented declines in the abundance of yellow tang (*Zebrasoma flavescens*), and other heavily harvested aquarium fishes, in Hawai’i (Tissot and Hallacher, 2003). Similarly, for the Banggai cardinalfish (*Pterapogon kauderni*), which are endemic to a small number of islands in Sulawesi, intensive and largely unregulated fishing has reduced wild stocks by up to 90% in less than a decade (Vagelli, 2008) following international exports of up to 1 million fish per year. These examples demonstrate the capacity of extensive and sustained fishing pressure, and/ or inappropriate fishing methods to pose significant risk to wild stocks of species that are harvested for the marine aquarium and ornamental industry. Most importantly, the high value attached to marine aquarium specimens, especially those perceived to be limited or rare, encourages continued fishing long after declining yields would normally make fishing unviable (Fulton et al., 2011). For reef-building corals, rapid (seemingly unconstrained and unregulated) growth in reported harvest levels from many tropical countries is generating environmental concern (e.g. Rhyne, 2009; Thornhill, 2012; Jones et al., 2017), mainly given the ecological importance of corals and increasing pressures facing coral reef ecosystems (Bruckner, 2000). It is fundamentally not possible to assess the sustainability of coral harvesting on the GBR, given very limited relevant research and monitoring (Harriot, 2001), though there is evidence that even low levels of harvesting can impact the abundance, population structure and viability of harvested corals (Ross, 1984; Knittweis and Wolff, 2010).

## 1.1 *The Queensland Coral Fishery*

- *Coral harvesting has been undertaken in Queensland since the 1840s, but the nature of harvesting has changed considerably throughout this period*
- *In 2006, a maximum of 30% of the QCF coral quota (60,000 kg) was permitted to be taken as “live coral”, but gradual softening of the distinction and original intent of quota categories means that it is now technically possible for 200,000 kg of live coral to be harvested annually from the Great Barrier Reef*
- *Previous management assessments may be largely outdated, especially given escalating harvest levels, and increasing environmental pressures*

In Australia, there are four distinct fisheries (operating across different jurisdictions and managed by relevant State or Territory Government fisheries management authorities) that harvest and export hard (order Scleractinia) corals, contributing to the international marine aquarium trade: i) the Western Australia Marine Aquarium Fish Managed Fishery (WA MAFMF managed by DPIRD); ii) the Northern Territory Aquarium Fishery (NTAF managed by DITT); iii) The Queensland Coral Fishery (QCF managed by AFMA), and iv) the Coral Sea Fishery (CSF managed by AFMA). State-based management is however, subject to assessment by the Australian Government Department of Agriculture, Water and the Environment (DAWE), especially in regard to conservation, and international exports, of endangered species. Most notably, DAWE is Australia's Scientific Authority responsible for meeting Australia's responsibilities as a Party to the Convention for the International Trade in Endangered Species (CITES), whereby all hard corals, including reef-building (order Scleractinia) corals, black corals (order Antipatharia), blue corals (family Helioporidae), and fire corals (family Milleporidae) are listed in Appendix II of CITES.

The QCF is the largest and most-established coral fishery in Australia. Licensed coral collecting has been undertaken in Queensland coastal waters since 1932 (Harriott, 2001; McCormack, 2005), though unregulated and unlicensed coral removal was occurring as far back as the 1840s, with large-scale and indiscriminate removal of coral, coral sand, and consolidate reef carbonate, for raw materials (lime) used in agriculture, manufacturing and construction (Atkinson et al., 2008; Daley and Griggs, 2008). From the 1930s until the 1980s, commercial harvesting was focussed on fast growing branching corals (Acroporidae and Pocilloporidae) that were sold mainly as ornamental corals, or souvenirs (Harriott, 2001). During the formative period of licensed coral collecting, harvesting was permitted only within fixed leases, which were designated based on the abundance of the major target species, *Acropora* and *Pocillopora* spp. (McCormack, 2005). In the late 1980s there was a rapid shift towards harvesting of live corals for the marine aquarium industry (Harriot, 2001), which also motivated a major shift in the types of corals being harvested, most of which were poorly represented within designated collection areas.

Contemporary management arrangements for the QCF largely came into effect on July 1st 2006 (DEH, 2006), including the current Total Allowable Commercial Catch (TACC) and roving harvest arrangements. The area of operation for the QCF includes all Queensland tidal waters and foreshores south of latitude 10°41' South and east of longitude 142°31'49" East, encompassing the entire area of the

Great Barrier Reef Marine Park (GBRMP), which is 344,400 km$^2$, though only 6% (20,664 km$^2$) is coral reef habitat (Wachenfeld et al., 2007). No coral harvesting is permitted in Marine National Park Zones or Special Management Areas, though coral harvesting occurs across a range of coral reef environments and inter-reefal habitats (Atkinson et al., 2008). The TACC of corals was set at 200,000 units (where 1 unit = 1kg), thereby allowing for 200 tonnes of coral to be harvested per annum (McCormack, 2005). However, early accounts of quota arrangements stated that “no more than 60 tonnes [or 30%] may be taken in the form of live coral” (page 29, McCormack, 2005). The remaining 70% (140,00kg) allows for harvesting of coral rock, coral rubble and ornamental corals. However, there is an obvious contradiction whereby ornamental/curio corals (Acroporidae or Pocilloporidae) which are “initially taken live” are not considered to be “live coral” (page 1, DPIF, 2005). The “live” coral component (30% of the TACC) was ultimately renamed as “specialty coral” (DEEDI, 2009), whereby the specialty coral (SC) quota is 60,00kg. However, Acroporidae and Pocilloporidae corals continue to be reported as part of the other coral (OC) component (which has a quota of 140,000 kg), regardless of whether they are harvested live or dead, or for the ornamental or aquarium market. The retention of the original quota split (30:70), has been justified on the basis that Acroporidae and Pocilloporidae are fast growing and should therefore, be treated separately from other specialty corals (e.g., Atkinson et al., 2008). This effectively allows for up to 200,000 kg of live coral (and up to 140,000 kg of Acroporidae and Pocilloporidae) to be harvested each year in Queensland.

Previous independent assessments of the QCF (e.g., Oliver, 1985; Harriott, 2001, 2003; Atkinson et al., 2008) concluded that the QCF was suitably managed, such that risks to individual target species, as well as the broader habitat, were considered negligible. Most notably, the amount of coral removed by the QCF (across all species and groups) was considered trivial compared to the amount of coral that exists across the broad expanse of the GBR (Harriott, 2001; Atkinson et al., 2008), and well within the annual growth potential of major target coral species, especially *Acropora* spp. Harriot (2001) also noted that impacts of harvesting were largely insignificant compared to levels of coral loss caused by cyclones, bleaching and population irruptions of crown-of-thorns starfish, which frequently occur on the GBR. Given consistent application of input and output controls since the late 1990s, Commonwealth assessments of the QCF often refer to these sustainability assessments (e.g., DSEWPAC, 2012). However, these previous assessments were made with a number of assumptions (both implicit and explicit), as listed below. Several of these assumptions are no longer relevant, which questions the conclusions of prior sustainability assessments;

*i) Accurate recording and reporting of overall harvesting* – Commercial harvest records are generally considered to reflect the overall extent of coral harvesting in Queensland, such that all other sources of harvest pressure (e.g., recreational harvesting, non-retained and unreported catch) are considered negligible (Atkinson et al., 2008). However, there are definite and acknowledged issues with the accuracy of the data, notwithstanding unknown levels of compliance. For example, the weight of harvested coral was previously estimated, rather than explicitly recorded (see section 3.1);

*ii) Catch records reflect the abundance of major harvest species* - In the absence of fishery-independent information, monitoring of stocks is entirely reliant on trends in reported catch and effort information. It is widely recognised however, that catch and effort data give very limited insights on stock size or trends (e.g., Walters and Martell, 2002; Fenner, 2012), especially for highly selective, multi-species fisheries, which perfectly characterises the QCF (Harriot, 2001). Importantly, changes in relative harvest levels of different coral species may be attributable to changing market demand, and cannot therefore, necessarily be used as a proxy of abundance or availability of harvested coral species;

*iii) The majority of coral collected comprises dead coral or live rock, whereas removal of "live" coral is much more limited* – It is widely reported that the majority (if not entirety) of the OC quota (70%; 140,000kg pa) comprises live rock or dead coral (Atkinson et al., 2008), while harvests of live coral are mostly limited to SC quota (60,000 kg). However, a large and increasing proportion of the OC quota category (Acroporidae and Pocilloporidae) are harvested live for the marine aquarium industry, contributing to increases in the overall amount of live coral that is harvested (see Section 4.1).

*iv) Fishing pressure is spread across suitably large areas of reef habitat to limit risk of localised depletion* - Previous assessments (Oliver, 1985; Harriott, 2001, 2003) considered quota arrangements imposed at the level of individual lease areas (4 tonne per lease), which moderated fishing effort within limited areas. Since spatial constraints were removed, reported harvest levels and limits are often related to the large area of operation (Atkinson et al., 2008; Roelofs, 2018), which presupposes that fishing pressure is widely distributed across the GBR, to the extent permitted by Marine Park zoning and no-take areas. While there is evidence that coral harvesting is occurring over an ever increasing expanse of the GBR, largely due to catch diversification, there is no monitoring to assess effects of fishing in areas concentrated harvesting. Many coral species are also harvested for inter-reefal habitats, for which there is very limited knowledge of coral abundance or composition;

*v) Fishing pressure is apportioned among species in approximate accordance with their relative abundance* - The purported sustainability of coral harvesting in the 1990s was largely predicated on the disproportionate harvesting of abundant and fast growing corals, mainly Acroporidae and Pocilloporidae (e.g., QMFA, 1999; Harriot, 2001). Given the changing nature and high selectivity of coral fisheries, it is not appropriate to relate overall levels of reported harvest to the high abundance of hard corals on the GBR (e.g., Atkinson et al., 2008). Rather, harvest levels and limits need to be compared to the specific abundance of individual species, and within relevant harvest areas (e.g., Pratchett et al., 2020a);

*vi) Coral assemblages on the GBR are highly dynamic and resilient* – While the impacts of major disturbances (including coral bleaching, population irruptions of crown-of-thorns starfish, and severe cyclonic storms) on coral assemblages are clearly acknowledged, Harriot (2001) suggested that such disturbances cause only temporary and localised reductions in the abundance of coral. It was recommended that coral harvesting should be temporarily suspended in disturbed habitats to facilitate rapid recovery, but no consideration was given to sustained declines in the abundance of corals, nor marked shifts in the relative abundance of different coral species, which are now apparent on the GBR (e.g., Hughes et al., 2018; McWilliam et al., 2020).

Despite the general endorsement of the QCF, Harriot (2001) made several important recommendations, which remain relevant today. Harriot (2001) stated that “a fishery-independent monitoring program would be useful to ensure that coral cover and diversity within sites did not deteriorate over time” (page 27) and that “collection of further information about the distribution and ecology of harvest species” was needed to assess the ecological sustainability of coral harvesting (page 8). It was also suggested that “species-specific quotas” are needed (page 23, Harriot, 2001). These recommendations made 20-years previously are very similar to the key recommendations contained in this report, reflecting limited progress in addressing critical reforms needed to support the growing industry. There have been further calls for fishery-independent monitoring of heavily targeted coral species and especially in areas of concentrated fishing effort, and increased research into the biology (especially rates of colony growth and population turnover) for potentially vulnerable species (DEH, 2006; Donnelly, 2009, 2011). However, there was very limited progress in explicitly assessing the abundance and vulnerability of heavily targeted species within the QCF until very recently (e.g., Pratchett et al., 2020a). Consequently, there are very limited time-series data that would allow for tests of the effects of sustained fishing effort in specific locations. It is therefore, very difficult to defend concerns relating to i) localised or serial depletion of heavily targeted species (e.g., Jones, 2011), and ii) high vulnerability to fisheries exploitation for long-lived and slow-growing coral species (Bruckner, 2000; Harriott, 2003; Garrabou et al., 2017).

Despite the large size of the GBR (344,400 $km^2$) and corresponding area available to licensed coral collectors operating within the QCF, coral harvesting is reported to be highly concentrated in specific areas (e.g., Jones, 2011), potentially resulting in localised depletion of heavily targeted and highly vulnerable coral species (e.g., Harriot, 2003). Previously, areas of concentrated fishing effort were attributed to ease of access and site familiarity, but overall fishing effort has become increasingly widespread as the range of corals that are collected has increased; it is now apparent that collectors target specific corals in different locations and habitats (Pratchett et al., 2020a). This may however, lead to concentrated fishing in limited areas with high abundance of specific (high value) coral species or types (e.g., colour morphs). In particular, concerns have been raised about the intensive harvesting of *Homophyllia* cf. *australis* and *Micromussa lordhowensis* within specific areas in the southern GBR (e.g., Jones, 2011).

The risk posed by harvesting for heavily targeted and highly vulnerable coral species is also changing due to increasing external (fishery-independent) threats, including environmental change (Ferse et al., 2012; Montero-Serra et al., 2018; Pratchett et al., 2020b). On the GBR there have been widespread and sustained declines in the overall cover and abundance of corals throughout the last few decades (De'ath et al., 2012; Mellin et al., 2019). Reported coral loss was further compounded by severe and widespread episodes of mass bleaching in 2016, 2017 and 2020, linked to major heatwaves that affected large areas of the GBR and Coral Sea (Hughes et al., 2017, 2018; Pratchett et al., 2021). Moreover, it has now been shown that some of the major coral species harvested by the QCF (e.g., *Homophyllia* cf. *australis*) are susceptible to elevated temperature and, or prone to bleaching (Pratchett et al., 2020b), though the *in situ* vulnerability of these corals to increasing temperature or coral bleaching is yet to be assessed. Even if harvest levels and practices had not changed during this period, it possible that coral populations and species on the GBR are now much more vulnerable to harvesting.

## 1.2 *Coral bleaching and coral loss on GBR*

- *Climate change poses a significant and increasing threat to coral reefs, including the GBR*
- *The extent and severity of mass-coral bleaching on the GBR has increased in accordance with ocean warming, and the increased frequency and magnitude of marine heatwaves*
- *Corals vary greatly in their susceptibility to heat stress, but even those corals that survive can be severely impacted*

Current levels and long-term trends in live coral cover vary greatly among reefs and regions across the GBR (Emslie et al., 2020), mostly in accordance with spatiotemporal patterns in the occurrence of major disturbances, such as cyclones, population irruptions of the coral-feeding crown-of-thorns starfish, and coral bleaching (e.g., De'ath et al., 2012; Mellin et al., 2019). There are some reefs that have escaped major effects of recent disturbances and have very high levels of coral cover. However, reef-wide estimates of coral loss, based on long-term monitoring data from the Australian Institute of Marine Science (AIMS) show that average coral cover on the GBR declined from 33.3% in 1996 to 18.6% in 2017 (Mellin et al., 2019). Moreover, there have been several major disturbances in the last few years, including very severe and widespread episodes of coral bleaching (Hughes et al., 2018; Pratchett et al., 2021).

Climate change poses a significant and increasing threat to coral reefs (e.g., Hughes et al., 2017; Pratchett et al., 2021); There have been three major episodes of mass-coral bleaching in just the last 5 years; in 2016, 2017, and 2020. The footprint of the 2020 event was however, very different to those of 2016 and 2017 Hughes et al., 2017, 2018; Pratchett et al., 2021). Most critically, the 2020 mass bleaching event was extremely widespread and concentrated in the inshore portions of the southern GBR, where there was limited warming reported during previous heat-stress events (Figure 1.1). The ecological impacts of this latest (2020) bleaching event will not be known for some time, partly due to inherent constraints imposed on field-based sampling due to COVID in 2020, but the combined footprint of these three latest bleaching episodes (2016, 2017, and 2020) is immense. There have also been other major disturbances over this same period, including progressive population irruptions of crown-of-thorns starfish (Westcott et al., 2020), several major cyclones (Madin et al., 2018), and outbreaks of coral disease (Brodnicke et al., 2019). While there is already evidence of coral recovery occurring in the northern GBR in the aftermath of recurrent coral bleaching in 2016 and 2017 (Stuart-Smith et al., 2018; Emslie et al., 2020), the cumulative impacts of major disturbances and other chronic pressures (e.g., sedimentation, eutrophication) operating across the entire GBR are likely to be placing ever more pressure on coral assemblages, increasing vulnerability to future disturbances (Hughes et al., 2018, but see Pratchett et al., 2020c), and also impairing recovery (Osborne et al., 2017; Ortiz et al., 2018; Hughes et al., 2019).

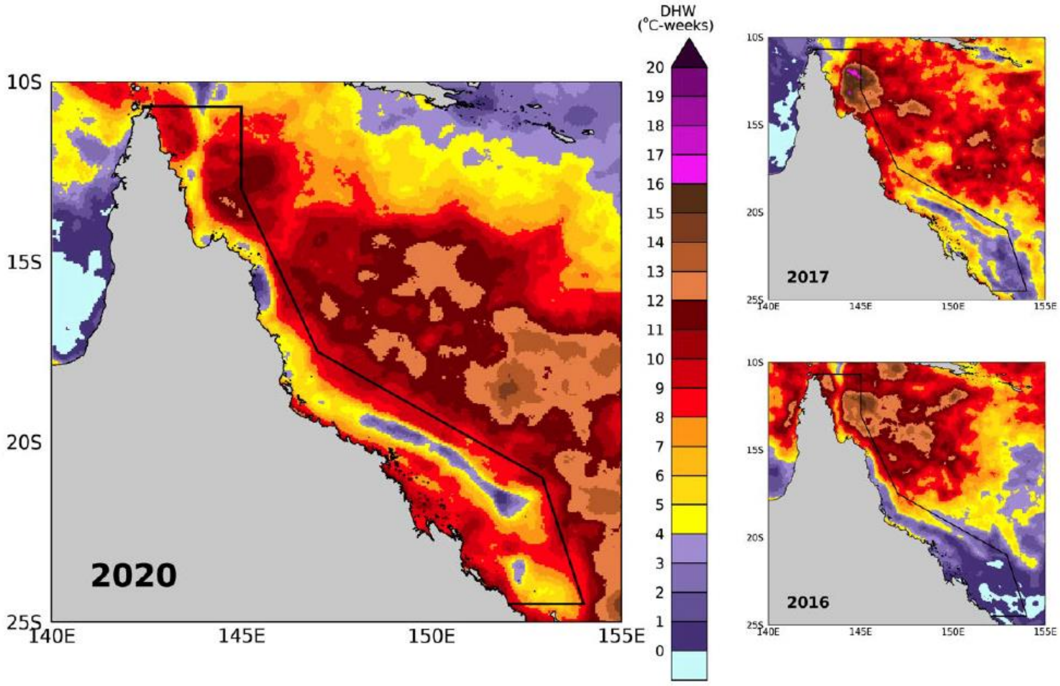



**Figure 1.1**. Annual maximum thermal stress (Degree Heating Weeks) for the three most recent mass bleaching events on the GBR: 2016, 2017 and 2020. Source: NOAA Coral REEF Watch (www.coralreefwatch.noaa.gov).

Hard corals (order Scleractinia) vary greatly in their susceptibility to coral bleaching, reflected in marked shifts in coral composition across many reefs that experienced extreme levels of mass bleaching in 2016 (Hughes et al., 2018). The worst affected corals (Acroporidae and Pocilloporidae) are theoretically capable of rapid recovery, and have contributed to relatively rapid recovery in the aftermath of other major disturbances on the GBR (Linares et al., 2011; Johns et al., 2014; Mellin et al., 2019; McWilliam et al., 2020). However, the increasing frequency of major disturbances may ultimately constrain the recovery capacity of even the most resilient corals, especially if changing environmental regimes suppress growth (e.g., Gold and Palumbi, 2018; Anderson et al., 2019) and reproductive output (Howells et al., 2016) of surviving corals. Even where coral cover has increased in recent years, these coral assemblages have preponderance of fast-growing corals (e.g., *Acropora* spp.), which are particularly susceptible to coral bleaching, cyclones and also population irruptions of crown-of-thorns starfish. This makes these coral assemblages extremely vulnerable to future disturbances (Pratchett et al., 2020c), leading to increased volatility in coral cover.

The extent to which recent bleaching events and other major disturbances have affected specialty coral species that are harvested by the QCF is uncertain. Recent experimental studies (Pratchett et al., 2020b) tested the temperature sensitivity and bleaching susceptibility of six coral species (*Homophyllia* cf. *australis*, *Micromussa lordhowensis*, *Catalaphyllia jardinei*, *Trachyphyllia geoffroyi*, *Duncanopsammia axifuga*, and *Euphyllia glabrescens*), which were intentionally selected given their importance (high harvest levels) for the QCF (see Section 3.3). While all species exhibited bleaching when exposed to elevated temperature, *Homophyllia* cf. *australis* and *Micromussa lordhowensis* were found to be particularly susceptible to experimentally-induced temperature stress (Pratchett et al., 2020b). These experimental studies do not, however, necessarily mean that recent heat-stress events (2020) in the southern GBR will have impacted on wild stocks of these species, but necessitate much more field-based research to establish the vulnerability (or resilience) of these coral to increasing frequency and severity of marine heatwaves (e.g, Oliver et al., 2018). The QCF does recognise the threat posed by coral bleaching (and other major disturbances) to many of the major target species (Donnelly, 2009, 2011) and undertakes to cease harvesting in severely affected areas. There is also general reticence to harvest bleached corals and other zooxanthellate organisms (e.g., anemones), because they are less saleable and can take a long time to regain colour post-harvest. More critically, however, the increasing frequency and severity of mass-bleaching and other major disturbances (Pratchett et al, 2021), would necessitate much more conservative estimates of sustainable harvest limits for all hard corals (Rhyne et al., 2014; Albert et al., 2015), especially in the absence of relevant information to explicitly assess the effects of periodic disturbances on targeted stocks and species.

## 1.3 *Great Barrier Reef Marine Park and World Heritage Area*

- *The GBR is globally recognised as one of the most significant natural ecosystems, but is facing unprecedented pressures*
- *Australia's Commonwealth management agency for the Great Barrier Reef, the Great Barrier Reef Marine Park Authority, downgraded the outlook for the Reef from "poor" in 2014 to "very poor" in 2019*

The GBR is globally recognised as one the most important coral reef environments, and also one of the most significant natural ecosystems (Pratchett et al., 2019). Critically, the GBR is the predominant coral reef ecosystem inscribed on the World Heritage List (IUCN, 1981). The national importance of the GBR is also highlighted by the designation of the Great Barrier Reef Marine Park (GBRMP), and establishment of the Great Barrier Reef Marine Park Authority. A key component of the management of the GBRMP is the statutory Zoning Plan, which designates what activities are permitted and in what areas. Since 2004, the proportion of the GBRMP that is encompassed with Marine National Park zones and effectively closed to fishing (including commercial harvesting of corals) is > 33% (115,000 $km^2$).

The GBRMP is widely regarded as one of the best managed marine parks (McCook et al., 2010; Day, 2016), but like most coral reef systems (e.g., Pandolfi et al., 2003; Sandin et al., 2008), the GBR is facing considerable pressures. Systemic and sustained degradation has occurred since European colonisation (McCulloch et al., 2003; Pandolfi et al., 2003) and there has been further recent, widespread and pronounced ecosystem degradation (e.g., De'ath et al., 2012; Hughes et al., 2015, 2017; Mellin et al., 2019) attributed to increasing cumulative pressures, including increasing effects of anthropogenic climate change and declining water quality (GBRMPA, 2014, 2019). Critically, the Great Barrier Reef Marine Park Authority, downgraded the outlook of the GBR from “poor” in 2014 to “very poor” in 2019, largely due to the recent and increasing impacts from anthropogenic climate change (GBRMPA, 2019). Similarly, the UNESCO World Heritage Committee warned of the possible inscription of the GBRWHA on the “List of World Heritage in Danger”, recognising that the unprecedented pressures facing the GBR and corresponding deterioration of the health and outlook of reef assemblages (Hughes et al., 2015), though the “Outstanding Universal Value” of the reef remains largely intact (GBRMPA, 2019).

The national and international significance of the GBR, as well as widespread recognition of declining reef condition, places considerable pressure on extractive activities and industries operating within the GBRMP and GBRWHA. While overarching concern for the outlook of the GBR is clearly focussed on anthropogenic climate change and declining water quality (Hughes et al., 2015; GBRMPA, 2019), reversing the degradation and deterioration of reef communities is going to require effective management of multiple and diverse threats that otherwise contribute to cumulative impacts, and exacerbate vulnerability to environmental change. While coral harvesting has limited and localised ecological impacts, especially compared to largescale disturbances (e.g., coral bleaching, cyclones and outbreaks of crown-of-thorns starfish), it is undeniable that it is one of the direct threats that is most amenable to management. It is also difficult to justify increasing harvest levels for many individual species of reef-building corals (see Section 4.4) in the face of increasing disturbances and declining reef health (especially since 2017-2018).

## 1.4 *Contradictions between coral harvesting and reef restoration*

- *Queensland coral collectors, with their expertise and well-established coral holding facilities, could make substantial contributions to coral restoration*
- *In situ growing and culturing of coral, in particular, could provide both enormous environmental benefits and a sustainable source of saleable corals*
- *Engaging in coral restoration does, in part, acknowledge the significant threats facing coral populations and species, which directly contradicts the key supposition of NDF determinations necessary to allow for ongoing wild-harvesting and export of CITES-listed corals*

A persistent legacy of the emergent impacts of global climate change on the GBR (e.g., Hughes et al., 2017) and globally (Eakin et al., 2019), has been a concerted push for interventionist (also adaptive) management, ranging from small scale habitat restoration, to coral restoration, and breeding more thermotolerant species (e.g., Anthony et al., 2017; Ceccarelli et al., 2020; Randall et al., 2020; Condie et al., 2021). The restoration agenda in Australia was given a considerable boost through the allocation of extensive Commonwealth funds to the Reef Restoration and Adaptation Program (RRAP) as part of the Reef Trust Partnership (Mead et al., 2019). A key component of this program involves captive maintenance and breeding of reef-building corals (e.g., Randall et al., 2020), which is an endeavour to which Queensland coral collectors could contribute greatly. Moreover, the inevitable shift towards *in situ* coral nurseries and propagation of corals on the GBR (Suggett et al., 2019), would provide opportunities to not only enhance recovery of fast-growing corals on the reef, but also provide a very sustainable source of coral fragments that may then be periodically harvested to supply the marine aquarium industry (e.g., Ferse and Kunzmann, 2009; Barton et al., 2017). Such an approach unequivocally blurs the lines between environmental conservation and commercial mariculture, but even without such developments, the objectives of coral restoration are in direct conflict with the continued wild-harvest of the same coral species or genera.

Reef restoration (and especially, field-based propagation of corals) is largely centred around relatively fast growing coral species, and predominantly *Acropora* spp. (e.g., Suggett et al., 2019). This partly reflects the highly threatened nature of *Acropora* corals (e.g., *Acropora cervicornis* and *Acropora palmata*) in the Carribbean (Young et al., 2012; Chamberland et al., 2015). However, *Acropora* corals are also being propagated throughout the Indo-Pacific (Barton et al., 2017; Boström-Einarsson et al., 2018), largely because they are fast-growing and have relatively high survival, such that they can rapidly transform degraded reef environments, and provide complex habitat for a wide range of coral reef organisms. Similarly on the GBR, interventions and restoration endeavours are heavily focussed on *Acropora* corals (e.g., Hagedorn et al., 2012; Quigley et al., 2019; Howlett et al., 2021). It is acknowledged that this research is focussed on common and fast-growing corals (e.g., *Acropora* spp.) partly to pave the way for comparable work on less common and more difficult coral species. However, concerted efforts to breed, nurture, and outplant *Acropora* corals (Suggett et al., 2019) is directly at odds with increasing harvests of *Acropora* by the QCF. Even more critically, it is difficult to justify NDF determinations necessary to allow continued and increasing exports of *Acropora* corals harvested from the wild, at the same time that there is increasing momentum for restoration and adaptive management to reverse well-documented and widespread declines in the abundance of these same corals. Most importantly, the increasing restoration investment and activity is a fundamental acknowledgement that the coral assemblages and reef ecosystems are subject to unsustainable pressures and ongoing decline (Shaver and Silliman, 2017).

## 2. Objectives

The objectives of this report were to:

i) Analyse the current levels and trends in reported harvest levels for hard corals (order Scleractinia) based on data provided by Queensland Government Department of Agriculture and Fisheries (DAF), focussing on the period 2006-2007 through to 2019-2020. In particular, this report considers:

a) overall trends in the reported weight of coral harvests, including the relative harvest levels of specialty versus other corals,
b) overall trends in the reported number of pieces of live coral harvested, which is then related to trends in reported weight,
c) the taxonomic composition of coral harvests (to the extent permitted given specific reporting categories),
d) trends in the reported harvest levels (based on both number of pieces and weight) of individual coral species, and
e) spatial distribution of reported coral harvests;

ii) Review existing and proposed management arrangements, including the QCF Harvest Strategy (2021-2026), and assess the relevance of these management approaches to moderate risk posed by harvesting on heavily harvested or highly vulnerable CITES-listed coral species;

iii) Review information and advice arising from Ecological Risk Assessments (ERAs), and consider other information that might be used to assess species-specific vulnerability of CITES-listed hard corals, considering both fishery and fishery-independent pressures;

iv) For coral species (or genera) that have been subject to large increases in harvesting, and are also considered at risk to harvesting (e.g., CITES *species of concern*), increased information is likely necessary to support current and future NDF determinations. Detailed information will therefore, be compiled (where available) on:

a) Biology and Ecology,
b) Taxonomy,

c) Geographic range
d) Pressures and Threats,
e) Harvesting,
f) Population status and trends, and
g) Knowledge gaps and Research priorities

v) The suitability of proposed harvest limits (catch triggers) for individual coral species (or genera), and the adequacy of current management arrangements, will also be considered. Where necessary, new and alternative harvest limits will be proposed for individual coral species. These reduced harvest limits are intended to address issues that might arise with NDF determinations, but still do not guarantee widespread endorsement of the management arrangements for the QCF, nor do they necessarily assure that harvest levels will actually be sustainable.

# 3. Methods

## 3.1 Data source(s)

All reported harvest levels (e.g., catch records) used in this study were provided directly (emailed) by the Queensland Government, Department of Agriculture and Fisheries (DAF). Several distinct versions of the data were provided from May 5th, 2021 (DR3253 version 1) until 25th May, 2021 (DR3253 version 4), which provided differing levels of spatial, temporal and taxonomic resolution. The data used for status and trends in overall reported harvest levels (i.e. aggregating catch information across the entire area of operation) was based on data provided on May 17th, 2021 (DR3253 version 3), which included all available information for estimated and recorded weights. To assess temporal trends in reported harvest levels, analyses were conducted separately at both the family level and the species level. The family level incorporated all available data, while the species level focused on available species level/genus level data. A family level variable ('family') was created, whereby a family was assigned to each category in the 'ReportName' variable (which consists of species, genus, and family level groups), and was updated to reflect current taxonomy following WoRMS (World Register of Marine Species; Horton et al., 2021). Similarly, a taxonomically updated category (ReportName.new) was assigned based on the 'ReportName' category, also following WoRMS. The 'ReportName.new' variable was further modified to reflect the 'CAABSpeciesCommonName' category, to further distinguish genera (e.g. Acroporidae into *Acropora* spp. and *Montipora* spp.). To avoid any confusion regarding nomenclature all species will be referred to using their full genus name (e.g., *Acropora microclados*) throughout this report.

Some species and genus level groups (e.g., *Homophyllia bowerbanki*) were not recorded throughout the focal period (e.g., only from 2016-2017 to 2019-2020). To inform the potential historic harvest levels of these species, additional grouping variables were created to identify 'pre-split' and 'post-split' data for these species, where possible. One such variable 'hist' (i.e., history) identified these pre-split and post-split groups individually, while another variable 'facet.groups' identified species groups (i.e., the combinations of the pre- and post-split variables from hist). These groups were created based on initial plotting of

‘Retained Number’ values summarised to year for each unique ReportName using a loess smoother, and knowledge of current and historical taxonomy. For example, inspection of data showed a decline in the ‘*Euphyllia* spp.’ ReportName category, coinciding with the appearance of the *Euphyllia ancora* and *Euphyllia paraancora* categories in 2016 (with both species since being assigned to the genus *Fimbriaphyllia*; Luzon et al., 2017), indicating that prior to being split, these species were likely recorded under the *Euphyllia* spp. category.

### 3.2 *Data analyses*

To represent catch trends, General Additive Models (GAMs) were fit for each family group, and then separately for each group in the ‘hist’ variable (i.e., pre-split and post-split species level groups) for summarised Retained Number data using the package ‘mgcv’ (Wood, 2011) following the formula sum.no ~ s(year.starting, k = 3), where ‘sum.no’ is the total number of retained pieces for each financial year, and ‘year.starting’ is the financial year (converted to a numeric variable). Splines (k) were necessarily limited to 3 due to the maximum data points available for some groups, however, this is an appropriate restriction regardless given the relatively small maximum sample size, with a maximum of 13 points representing financial years between 2006-2007 and 2019-2020 financial years. GAMs were then visualised using the ‘gam’ method with formula ‘y ~ s(x, bs = "cs", k = 3)’ within the ‘geom_smooth’ function of the ggplot2 package (Wickham, 2016).

While it is critically important to explore harvest levels based on weight, given quota limits are weight-based, weight has not been recorded for individual reporting categories since 2016-2017, and reported only for overarching quota categories (i.e. “specialty” versus “other” coral); only the number of pieces was recorded for individual coral species and genera. We therefore, utilised the best available information to determine the individual weight of corals (per piece), which was then used to infer combined annual weight of all corals by species and genera. The individual weight of corals was determined both at the level of species and family level groups, based on data available between 2010-2011 and 2015-2016, where both the number of pieces and combined weight was reported for all species/ genera, albeit using estimates (rather than explicit weights) of the size and weight for individual coral pieces (recorded in size classes) and before the allowance for offcuts from specialty corals (Pratchett and Messmer, 2017) was implemented.

To determine the individual weight of corals for the period 2010-2011 and 2015-2016, the annual reported weight (in kg) was divided by the total number of retained pieces for each group. For all corals harvested as specialty corals, the individual weight of corals was then multiplied by 0.75, based on the agreed allowance for offcuts (Pratchett and Messmer, 2017), thereby better reflecting the relevant weight of these corals that is reported against the specialty coral quota in 2016-2017 through 2019-2020 (DAF, 2016). GAMs were then used to visualise the trend (increasing, decreasing, flat or unclear pattern) for each group in the weight per piece values for each year (between 2010-2011 to 2015-2016 financial year) following the method described above. For species level plots pre-split data were used for this estimation where necessary and considered appropriate. For example, if there was a large numeric difference between the pre-split data and post-split data evidenced by GAMs of retained number (e.g., Pre-split Acroporidae/Montipora spp.), weight was not estimated. For plots displaying all data (i.e., above family level), the estimated family weight results were summed (as the family level incorporated all available data). At the species level, GAMs were then fit to the retained weight (kg) and (where necessary) estimated weight values to indicate the weight trend over time. These estimated weights were also compared to direct measurements of the average weight of live corals recorded by Pratchett and Messmer (2017), based on weighing of 7,418 individual coral colonies or pieces, as collected by the QCF.

Catch composition (%) plots at family and species level were constructed by summarising the total number of pieces for each group for the entire period (2006-2007 to 2019-2020 financial year) and for the 2019-2020 financial year only. All data carpentry was conducted using the ‘tidyverse’ package (Wickham et al., 2019) and all figures (unless otherwise stated) were generated using the ‘ggplot2’ package (Wickham, 2016) within the statistical environment R v.4.0.3 (R Core Team, 2020).

Information regarding the specific location(s) of harvesting is routinely captured in QCF logbooks, whereby catches (number of pieces for each reporting category) are reported separately for each reef and distinct location. Specific location information (e.g., based GPS co-ordinates) is then assigned to relevant 6x6 nautical mile (nm) grid references (or blocks), used for documenting the location of commercial fishing activities within each of 16 distinct commercial fishing areas throughout Queensland (Queensland Government, 2021). Each fishing area is divided into 35 distinct 30x30 nm blocks (each containing 25 distinct 6x6nm blocks), allowing for much coarser examination of the distribution of annual catches for each species or species group. To test for highly concentrated harvesting for individual coral species or species, which might lead to localised depletion of heavily targeted, rare or vulnerable corals, the maximum proportion of the annual catch for each reporting category in a single 6x6 nm and 30x30 nm block was calculated, using annual catch data from 2016-2017 through 2019-2020 (4 years). The broader distribution of catches across different harvest areas was also examined for select coral species (mainly, *Homophyllia* cf. *australis*, *Micromussa lordhowensis*, and *Trachyphyllia geoffroyi*), which have been suggested to be at risk of localised depletion (e.g., Roelofs and Silcock, 2008; Jones, 2011).

# 4. Status and trends in reported harvest levels

## 4.1 Reported harvest levels by weight (kg)

- *Annual reported harvest levels of corals (by weight) had been relatively stable since 2006, but increased substantially (>10%) in 2018-2019*
- *Overall harvest levels of coral (including all components of the 200,000 kg annual quota) exceeded 110,000 kg in 2018-2019*
- *Harvest levels recorded within specialty coral (SC) quota have increased disproportionately to the other coral (OC) quota category, representing >40% of the reported catch in 2019-20*

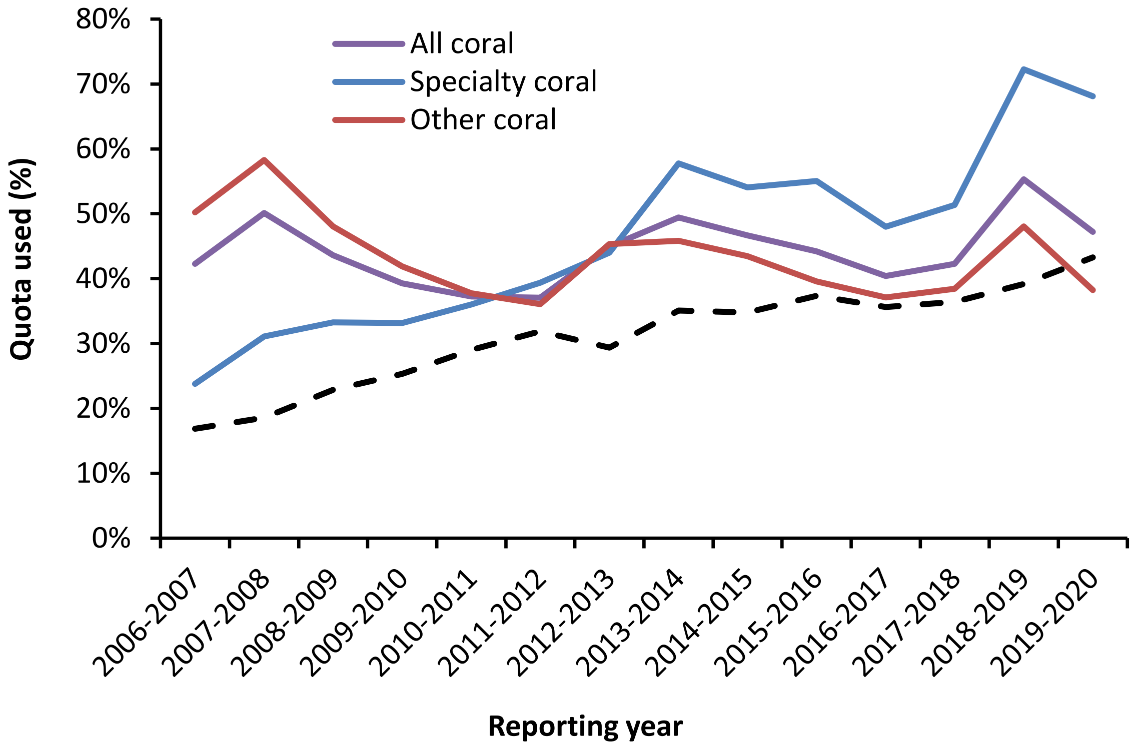



**Figure 4.1**. Annual reported harvest levels (percentage of quota used) for all corals (where annual quota is 200,000kg), as well as specialty coral (60,000kg quota) versus other coral (140,00kg quota). The dashed line indicates the relative portion of specialty coral to other coral, which has been steadily increasing since 2006-2020. Harvest level data (DR3253iii) provided by the Queensland Government Department of Agriculture and Fisheries, on May 17th, 2021.

From 2006-07 until 2017-18 (noting that annual harvest levels are reported for the period from July 1st to June 30th in the following year) annual reported harvest levels of corals (across both specialty and other quota categories) for the QCF fluctuated between 74,131 kg (in 2011-12) and 100,238 kg (in 2007-08) (Table 4.1). In 2018-2019, however, the total reported catch increased to 110,627 kg, an increase of >10% above the highest reported annual harvest levels in the preceding period. This coincided with the highest reported levels of annual fishing effort (1,201 fishing days), which was >20% higher than the previously reported fishing effort. Fishing effort further increased in 2019-20 (1,689 days) but the annual reported harvest levels were more reflective of harvest levels recorded prior to 2018-19 (Table 4.1). It is important to note, however, that reported harvested levels from 2006-2007 through 2015-2016 are based on estimates of weight for coral assigned to different size categories. From 2016-2017 onwards, all specialty and other hard corals were required to be weighed (see section 5.1), and recorded as actual weights. However, weights were recorded only at the level of overarching quota categories (e.g., SC versus OC quota categories), and not for individual species or species groups (e.g., genera).

**Table 4.1**. Annual reported harvest levels (weight and proportion of quota used) of coral (speciality and other) and effort data for the QCF. Harvest level data based on data provided by Queensland Government Department of Agriculture and Fisheries, May 17th, 2021. Effort comes from DAF (2021) Queensland Coral Fishery - Status report for reassessment and approval under protected species and export provisions of the Environment Protection and Biodiversity Conservation Act 1999 (and provided directly in summary statistics). NB. There is a minor discrepancy in the annual reported harvest levels for 2018-19 and 2019-20, compared to what is reported in the aforementioned report.

| Year | SC (kg) | SC (quota used) | OC (kg) | OC (quota used) | **Total (kg)** | **Effort (Days)** |
|---|---|---|---|---|---|---|
| 2006-2007 | 14,271 | 24% | 70,328 | 50% | **84,599** | **663** |
| 2007-2008 | 18,642 | 31% | 81,597 | 58% | **100,239** | **814** |
| 2008-2009 | 19,953 | 33% | 67,283 | 48% | **87,237** | **794** |
| 2009-2010 | 19,894 | 33% | 58,672 | 42% | **78,566** | **796** |
| 2010-2011 | 21,628 | 36% | 52,865 | 38% | **74,493** | **823** |
| 2011-2012 | 23,633 | 39% | 50,498 | 36% | **74,132** | **715** |
| 2012-2013 | 26,403 | 44% | 63,489 | 45% | **89,892** | **792** |
| 2013-2014 | 34,665 | 58% | 64,170 | 46% | **98,836** | **840** |
| 2014-2015 | 32,451 | 54% | 60,871 | 43% | **93,322** | **889** |
| 2015-2016 | 33,019 | 55% | 55,426 | 40% | **88,446** | **964** |
| 2016-2017 | 28,789 | 48% | 51,983 | 37% | **80,772** | **858** |
| 2017-2018 | 30,798 | 51% | 53,808 | 38% | **84,607** | **859** |
| 2018-2019 | 43,358 | 72% | 67,269 | 48% | **110,627** | **1201** |
| 2019-2020 | 40,865 | 68% | 53,562 | 38% | **94,427** | **1689** |

The annual reported harvest levels of SC has increased from 14,271 kg (24% of quota of 60,000kg) in 2006-2007 up to 43,358 kg (72% of quota) in 2018-19 (Table 4.1), which is a more than 3-fold increase. The annual reported harvest of OC (which includes Acroporidae and Pocilloporidae) has remained fairly stable, or even decreased, over the same period (2006-2020), largely due to declines in the amount of live rock being harvested (rather than reduced harvesting of *Acropora* – see Section 2.2). In all, the proportion of coral represented by SC versus OC has been steadily increasing (Figure 4.1; see also Jones, 2011), and now represents >40% of the reported catch (2019-20).

### 4.2 *Reported harvest levels by number of pieces*

- *Annual reported harvest levels by number of pieces increased 705% from 2006-2007 through to 2019-2020*
- *Pronounced increases in the reported number of pieces is difficult to reconcile against moderate increases in the reported weight of coral harvested, unless there have been marked declines in size (weight) of individual coral pieces over time*
- *Apparent discrepancies in reported harvest data highlight the need to accurately record and report on both the number of pieces, and their weight, for all species and species groups*

From 2006-07 until 2019-20 the annual reported number of pieces of hard corals (order Scleractinia) harvested has increased >750%, (Figure 4.2a), whereas the increase in reported weight of corals harvested over this period was only 186% (Figure 4.3). Moderate increases in the reported weight of coral harvested (which includes live rock) may have been partly offset by declining harvests of live rock. There have also been changes in the way that weights are recorded and reported before versus after July 1st, 2016, coinciding with the implementation of new management arrangements (DAF, 2016). Importantly, there is no reporting of weight for individual reporting categories (e.g., species) after this date.

Given the lack of data for weight for individual species and other groups (e.g., genera) for 2016-2017 onwards, we estimated the average weight per piece for each family, using data from the period from 2008-2009 through 2015-2016 where both number of pieces and their combined weight was reported (see Section 4.3). We then multiplied the number of pieces recorded in annual harvest reports for 20016-2017 through 2019-2020 for each species or species group by the relevant estimate of per piece weight (Figure 4.3b). These estimates of weight are subject to considerable vagaries and assumptions. However, the general approach was validated given that estimated weights for the period 2006-2007 through 2015-2016, close reflected actual reported weights during this period (Figure 4.2b). Extrapolating beyond 2015-2016, marked increases in the retained weight of corals would be expected given large increases in the number of pieces harvested. However, the estimated weight of all live corals (for both OC and SC) in 2019-2020 (>90,000kg; Figure 4.2b), assuming relatively constant weight of corals for each species or species group, is very close to the total reported weight of all corals, including live rock and coral rubble (94,427kg; DAF, 2021b). These data suggest that reported increases in the number of pieces of live coral collected (especially in recent years) do not correspond with proportionate increases in the weight of live corals harvested, whereby the size (or weight) of corals harvested must have declined.

Apparent discrepancies in the estimated combined weight versus reported weight for live corals emphasises the need to accurately record and report both the number of pieces harvested and their combined weight across all species and species groups. this is particularly important for understanding changing harvest practices, and the potential sustainability of fishery operations. For example, declines in the mean size of fragments taken from colonial species (e.g., *Acropora* spp.) would be viewed as more sustainable. However, it would be very concerning if the mean size of corals that occur predominantly as solitary polyps (e.g., *Homophyllia* cf. *australis*) or are often harvested in their entirety (e.g., *Micromussa lordhowensis*) has decreased markedly, as this may indicate over-exploitation.

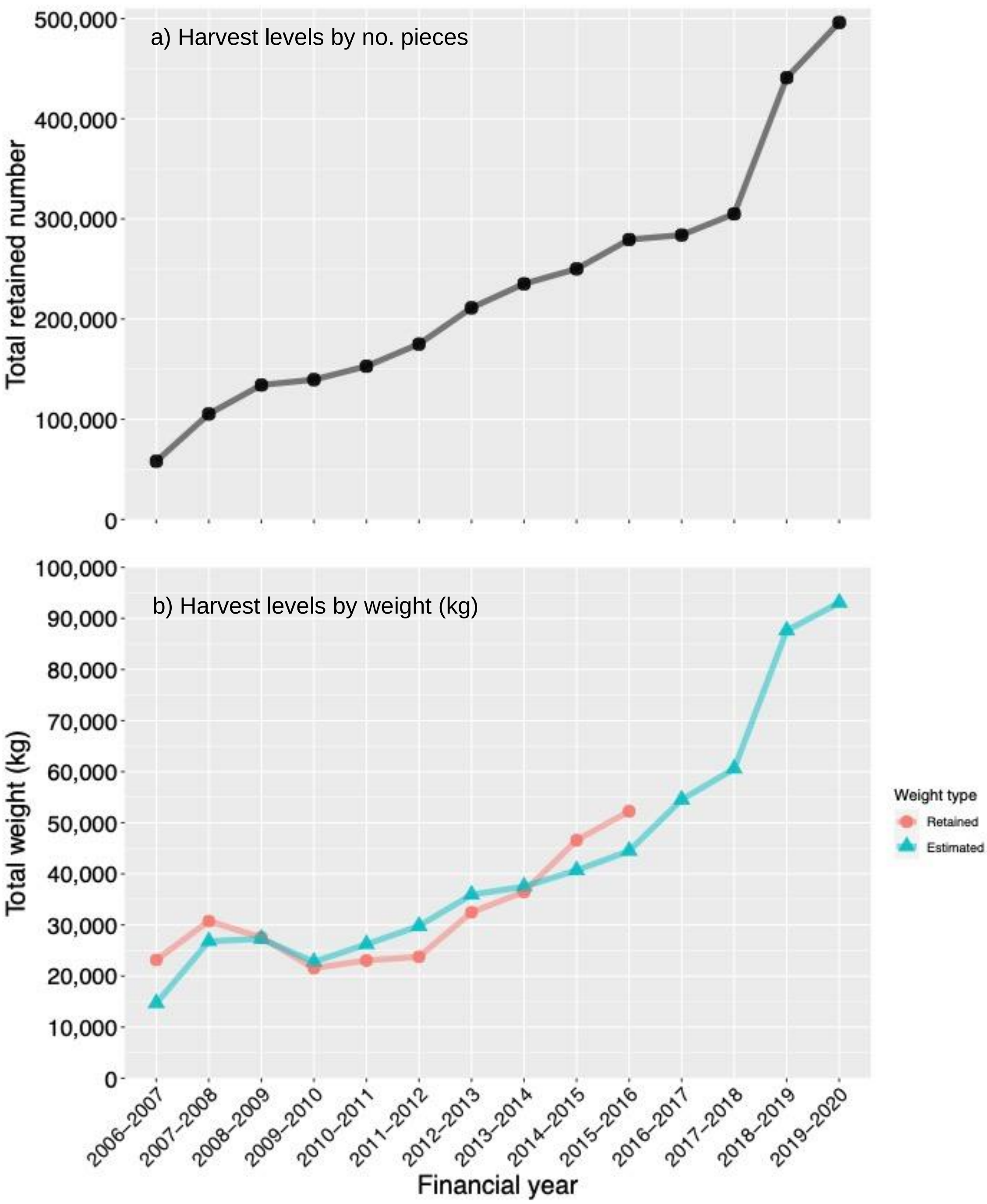



**Figure 4.2**. Annual reported harvest levels, based on a) no. of pieces and b) weight (kg) for live corals. Weight data was estimated by multiplying number of pieces by average weight per species or family, to account for lack of weight data from 2016-2017 onwards. Harvest level data based on data provided (DR3253iii) by Queensland Government Department of Agriculture and Fisheries, on May 17th, 2021.

The number of pieces harvested has increased disproportionately to reported increases in fishing effort (annual number of days fished), whereby catch per unit effort (CPUE) for reported number of pieces was <100 pieces per day in 2006-2007 compared to >350 pieces per day in 2018-2019 (Figure 4.2). Over this same period, the CPUE for weight decreased from >120kg per day in 2006-2007 down to <60kg per day in 2019-2020. These declines in CPUE for weight were largely attributable to declines for OC (Figure 4.3), whereas the weight-based CPUE for SC was fairly stable.

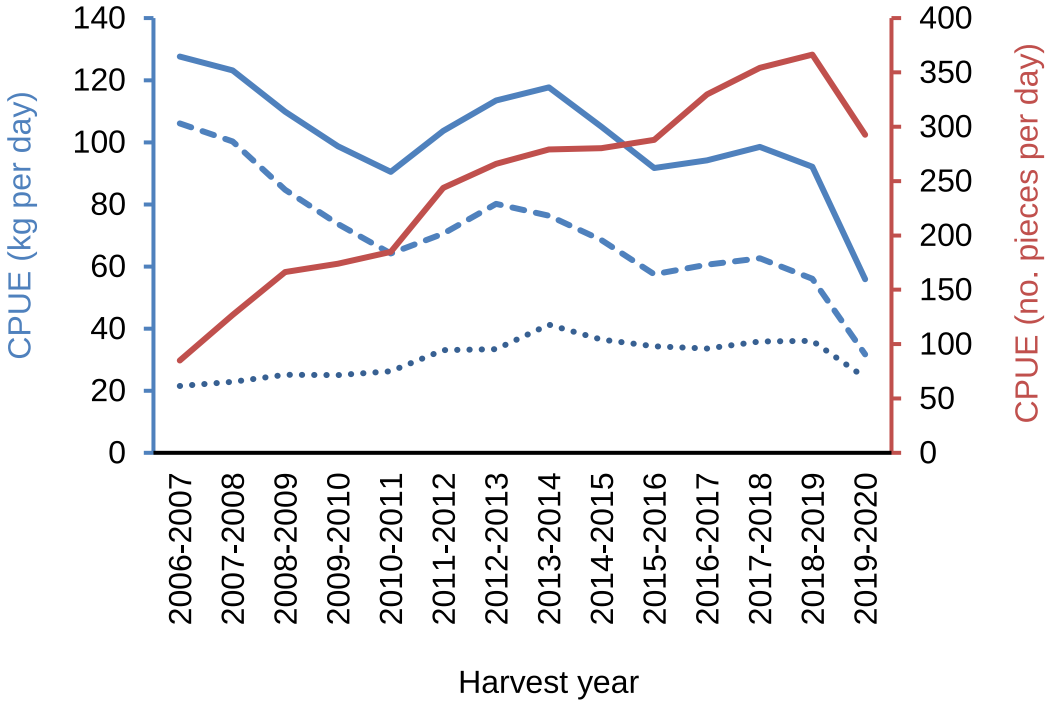



**Figure 4.3**. Catch Per Unit Effort (CPUE) by weight (blue, primary axis) and no. of pieces harvested red, secondary axis) relative to annual number of days fished. For weight, CPUE is shown for all corals (solid line) as well as for OC (dashed line) and SC (dotted line) separately. Harvest level data provided (DR3253i) by Queensland Government Department of Agriculture and Fisheries, May 5th, 2021, which included summary statistics for effort (no. days fished per reporting year).

## 4.3 *Catch composition and key harvest species*

- *The QCF is a multi-species fishery, harvesting as many as 200 different coral species. While catches are recorded for 19 distinct species and a further 11 genera, many corals are reported by family or broad groups.*
- *Acropora is the predominant species/ genera harvested in the QCF, accounting for 25% of all pieces harvested in 2019-2020*

To assess contemporary catch composition for the QCF, data for the latest complete reporting year (2019-2020) was split into relevant families (Figure 4.4) versus species and genera (Figure 4.5). Herein, we considered only corals from the Order Scleractinia; other corals that also have hard (calcified) skeletons are also assigned to the hard coral *Reporting Category*, but contributed relatively little to the to the number of pieces reported in 2019-2020, including 136 pieces

(0.03% of catch) of fire coral (Milleporidae), 301 pieces (006%) of black coral (Antipathidae), 124 pieces (0.02%) of blue coral (Helioporidae) and 1,917 (0.39%) pieces of pipe organ corals (Tubiporidae). We also excluded “other corals” (not to be confused with the OC quota category) on the basis that this group was not assigned to the “hard coral” within the *Reporting Category* variable, in data provided by DAF (May 17th, 2021). We suspect however, that this data does pertain to hard corals, given the only related reporting category in the current logbook (Supplementary Table 9.3) is “other hard corals”. There are also a number of other harvested coral species that are not clearly represented in the current list of reporting categories, including several distinct coral taxa commonly referred to as chalice corals, including *Echinophyllia* spp., *Oxypora* spp. and *Mycedium* spp. There are also additional species (e.g., *Acanthastrea echinata*, *Acanthastrea pachysepta*, *Lobophyllia hemprichii*) that would warrant careful monitoring, which will only be possible if harvest levels are explicitly reported to species.

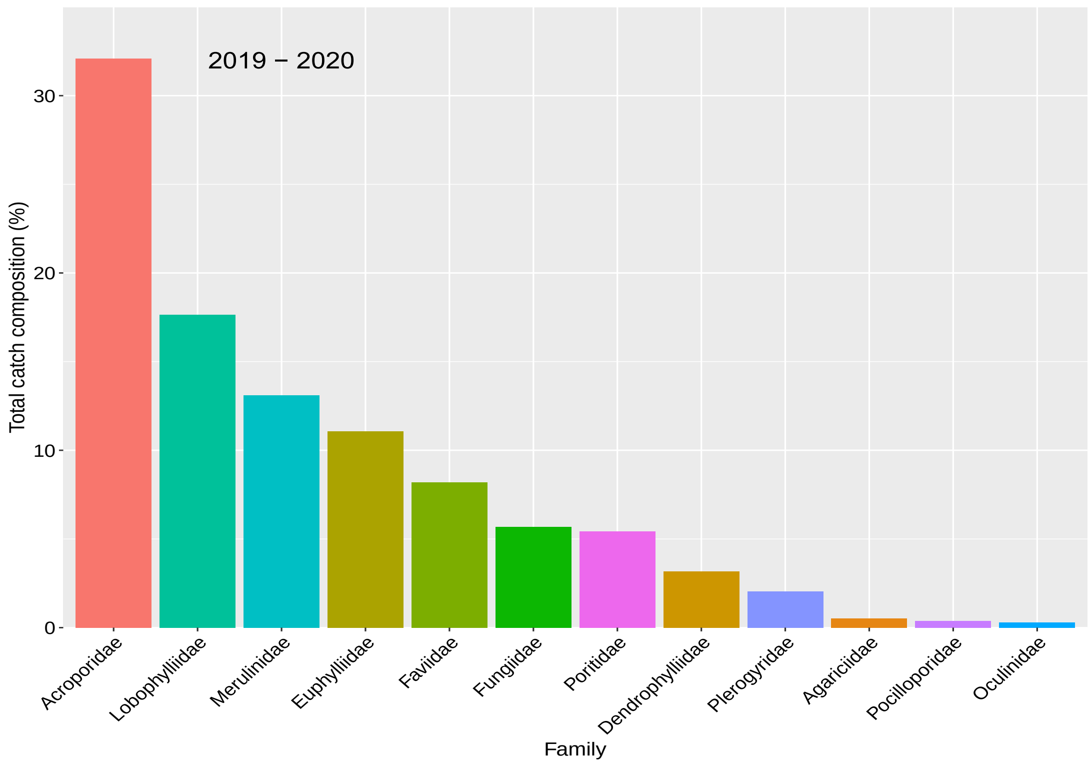



**Figure 4.4**. Catch composition by family (based on % of pieces) for hard corals (order Scleractinia) in 2019-20. Harvest level provided by Queensland Government Department of Agriculture and Fisheries, May 17th, 2021.

Based on the number of pieces recorded in 2019-2020, the reported catch was overwhelmingly dominated by Acroporidae (Figure 4.4), and particularly *Acropora* spp. (Figure 4.5). Other coral species that made an important contribution to the reported harvest levels for the QCF in 2019-2020 were *Homophyllia* cf. *australis* (family Lobophyllidae), *Micromussa lordhowensis* (family Lobophyllidae), *Trachyphyllia geoffroyi* (family Merulinidae), *Fimbriaphyllia (Euphyllia) ancora* (family Euphyllidae), *Catalaphyllia jardinei* (family Merulinidae) and *Euphyllia glabrescens* (family Euphyllidae). These six species, together with *Acropora* spp., accounted for 62.9% of coral pieces harvested in 2019-20.

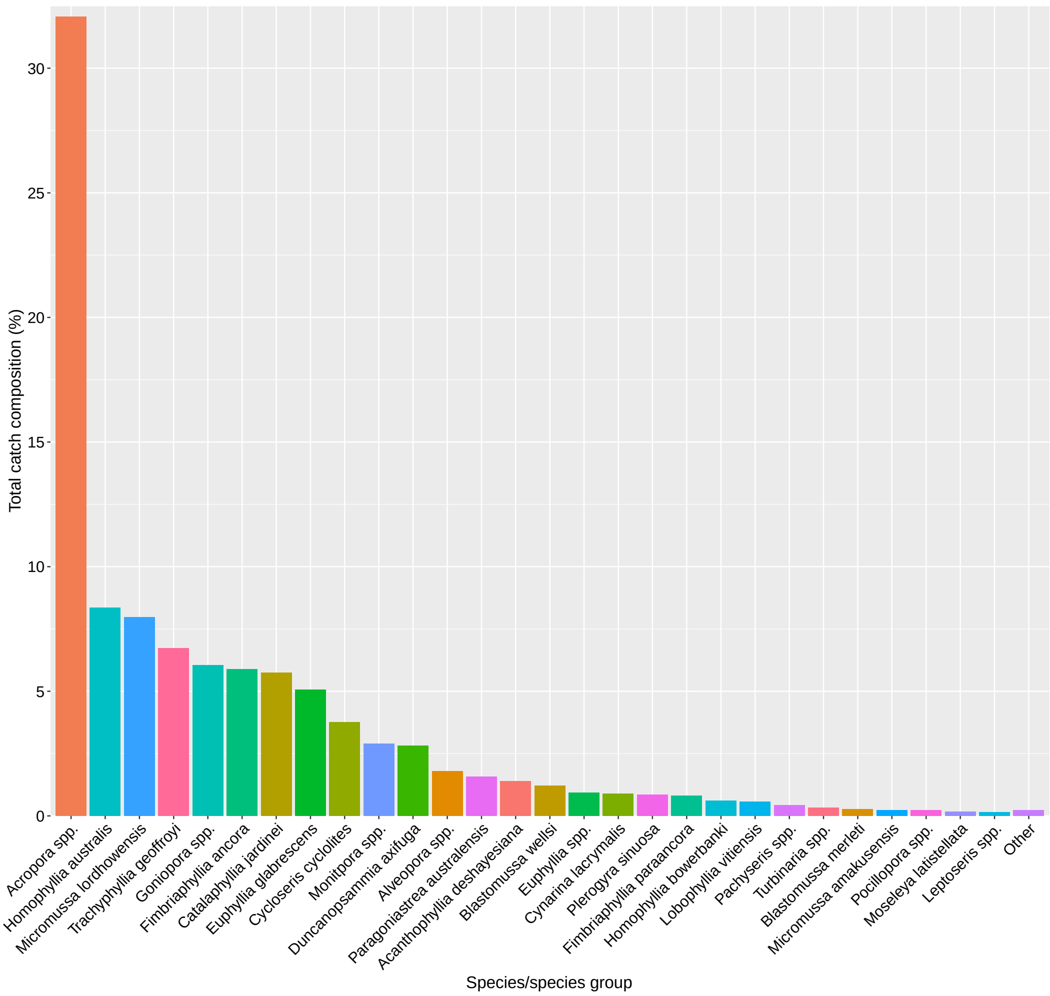



**Figure 4.5**. Catch composition by species/genera (based on % of pieces) for hard corals (order Scleractinia) in 2019-20. Harvest level data provided by Queensland Government Department of Agriculture and Fisheries, May 17th, 2021.

Given inconsistencies in catch reporting (weight versus number of pieces) for other hard corals (Acroporidae and Pocilloporidae) prior to 2016, and no reporting of weights for individual taxa thereafter (since 2016), it is not possible to compare the annual harvest of *Acropora* spp. (nor *Pocillopora* spp.) with estimated retained weight of other coral species or species groups (see Table 4.2). The reported weight of all Acroporidae and Pocilloporidae corals from 2016-2017 through 2019-2020 (ranging from 20,012-34,136 kg), much of which is expected to be *Acropora* spp. This is much higher than the estimated combined weight of any individual species (or species groups) of specialty hard coral (Table 4.2).

**Table 4.2**. Reported harvest levels (number of pieces and estimated weight) for major target species of specialty coral in 2019-2020. Harvest level data was provided by Queensland Government Department of Agriculture and Fisheries, May 17th, 2021. Weight of specialty coral needed to be estimated (as explained in text) using the mean weight of corals estimated (mostly at family level) for the period 2010-2011 through 2015-2016. For comparison, the average weight of live coral specimens recorded during FRDC project 2016-051 (Pratchett and Messmer, 2017) are also shown.

| Species/ species group | Average weight of live coral FRDC 2016-051 | Estimated weight per piece (kg) 2010-2016 | 2019-20 | |
|---|---|---|---|---|
| | | | Retained pieces (no) | **Weight (kg)** |
| *Micromussa lordhowensis* | 0.12 | 0.14 | 34,509 | **4,659.82** |
| *Fimbriaphyllia ancora* | 0.14 | 0.12 | 25,461 | **3,100.90** |
| *Catalaphyllia jardinei* | 0.25 | 0.10 | 24,857 | **2,515.45** |
| *Homophyllia cf. australis* | 0.07 | 0.06 | 36,216 | **2,240.75** |
| *Euphyllia glabrescens* | 0.08 | 0.09 | 21,914 | **1,926.57** |
| *Trachyphyllia geoffroyi* | 0.03 | 0.06 | 29,159 | **1,686.35** |
| *Duncanopsammia axifuga* | 0.15 | 0.10 | 12,204 | **1,174.53** |
| *Cycloseris cyclolites* | 0.01 | 0.06 | 16,236 | **974.16** |
| *Paragoniastrea australensis* | 0.13 | 0.11 | 6,780 | **738.59** |
| *Blastomussa wellsi* | 0.15 | 0.11 | 5,224 | **593.77** |
| *Euphyllia spp.* | 0.09 | 0.12 | 4,037 | **491.67** |
| *Fimbriaphyllia paraancora* | 0.04 | 0.12 | 3,492 | **425.29** |
| *Homophyllia bowerbanki* | 0.11 | 0.13 | 2,639 | **346.35** |
| *Cynarina lacrymalis* | 0.06 | 0.07 | 3,847 | **267.35** |
| *Blastomussa merleti* | 0.28 | 0.17 | 1147 | **190.28** |
| *Micromussa amakusensis* | 0.11 | 0.13 | 981 | **128.75** |

### 4.4 *Trends in reported harvest levels for individual species*

- *There have been sustained and/ or recent increases in reported harvest levels for individual coral species (or species groups) from 2006-2007 through to 2019-2020*
- *Rates of increase in reported harvest levels for individual species are mostly in the order of 20-60% per year, but much higher for some species (e.g., Homophyllia cf. australis)*
- *Caution is needed in interpreting data on changes in weight from 2016-2017, but even before then, there was evidence of marked increases in the overall retained weight for many coral species*

Temporal trends in reported harvest levels for different coral species and species groups were examined throughout the period from 2006-2007 through 2019-2020 (Figure 4.6), though many of these comparisons were constrained by the limited taxonomic resolution, and changes in the number and nature of reporting categories (see Appendix Tables 10.1-10.3). For example, the annual retained number of pieces for *Acropora* spp. (pooling across all species) has only been recorded since 2016-2017, and prior to that, there was inconsistent and irreconcilable differences in the catch reporting, whereby some corals were reported only by weight and others only reported by number of pieces.

Despite issues in comparing across reporting categories through time (Figure 4.6) there is strong evidence of sustained and/ or recent increases in reported harvest levels for several species (and species groups) from 2006-2007 to 2019-2020. For coral species that have been consistently distinguished and recorded to species throughout this period (e.g., *Catalaphyllia jardinei*, *Duncanopsammia axifuga*, *Euphyllia glabrescens* and *Trachyphyllia geoffroyi*), the average annual rate of increase, ranges from 23.7% for *Catalaphyllia jardinei*, up to 63.2% for *Trachyphyllia geoffroyi*. For reference, the QCF Performance Management System) had triggers for constraining growth to <30% "higher or lower that the mean catch over the previous 2 years" (page 5, DPIF, 2009; see also Section 6.1). For *Trachyphyllia geoffroyi*, the reported number of coral pieces increased from 2,916 in 2006-2007 up to 29,159 in 2019-2020, which is an overall increase of 885%, and the rate of increase has been accelerating since 2013-2014. For *Homophyllia* cf. *australis* the rate of increase has been even larger, whereby only 1,141 colonies were recorded in 2006-07 (at that time recorded as *Lobophyllia* *vitiensis*) compared to 36,216 in 2019-20, representing an increase of 3,074% throughout this period. For *Acanthophyllia deshayesiana* harvest levels have increased 69% since 2016-2017. It is likely that this species was previously recorded as *Cynarina* spp., but even so, the recent increase (since 2016-2017) in combined harvest of *Cynarina lacrymalis* and *Acanthophyllia deshayesiana* is 94%.

Increases in the reported number of pieces for different species and species groups (e.g., genera) is expected to translate to increasing retained weight of harvested corals (Figure 4.7), though there has been no recording or reporting of the retained weight for individual taxa since 2016-2017. Assuming that there has not been marked changes in the size (weight) of coral pieces being harvested (since before 2016-2017), the estimated retained weight of *Catalaphyllia jardinei*, *Duncanopsammia axifuga*, *Euphyllia glabrescens* and especially *Trachyphyllia geoffroyi* is estimated to have increased 100-200% from 2006-2007 to 2019-2020. Over the same period, there have been some apparent declines in the estimated weight of some other corals, which is largely attributable to the changes in reporting categories (e.g., splitting most *Euphyllia* species) from 2016-2017 onwards.

Given the inherent challenges and limitations associated with species-level identification and verification of hard corals (order Scleractiania), especially within certain genera that are very difficult to reliably distinguish (e.g., *Acropora* spp., *Montipora* spp., and *Porites* spp.), it is entirely appropriate (and permitted by CITES) that harvesting is reported at the level of genera. It is nonetheless, important to understand the species-specific catch composition within these genera (or other broad reporting categories), especially given that the distribution, abundance and vulnerability varies among species (e.g., Wabnitz et al., 2003). For example, *Acropora* is an extremely diverse genus, and includes some species, such as A*cropora hyacinthus* that are extremely common and dominate coral assemblages in many shallow reef environments across the GBR (Ortiz et al., 2021). Other species (e.g., *Acropora microclados*) appear to occur in very specific habitats, and are rarely common (at least not compared to *Acropora hyacinthus*). If harvesting selectively targets *Acropora microclados* over *Acropora* *hyacinthus*, then this has important ramifications for assessing the risk posed by harvesting, especially given the marked increases in reported levels of harvesting across all *Acropora* spp.

To assess the potential risk posed by harvesting of hard corals that are recorded and reported to genera (e.g., *Acropora* spp.), it will be important to characterise and periodically re-assess the relative proportions of different species being retained. Notably, there was an undertaking to document the range of coral species being collected in the family Acroporidae in 2012 (DEEDI, 2012), in response to marked increases in reported harvest levels. This will likely require specific taxonomic expertise, but will provide important information to address potential concerns regarding the specificity of harvesting within such groups.

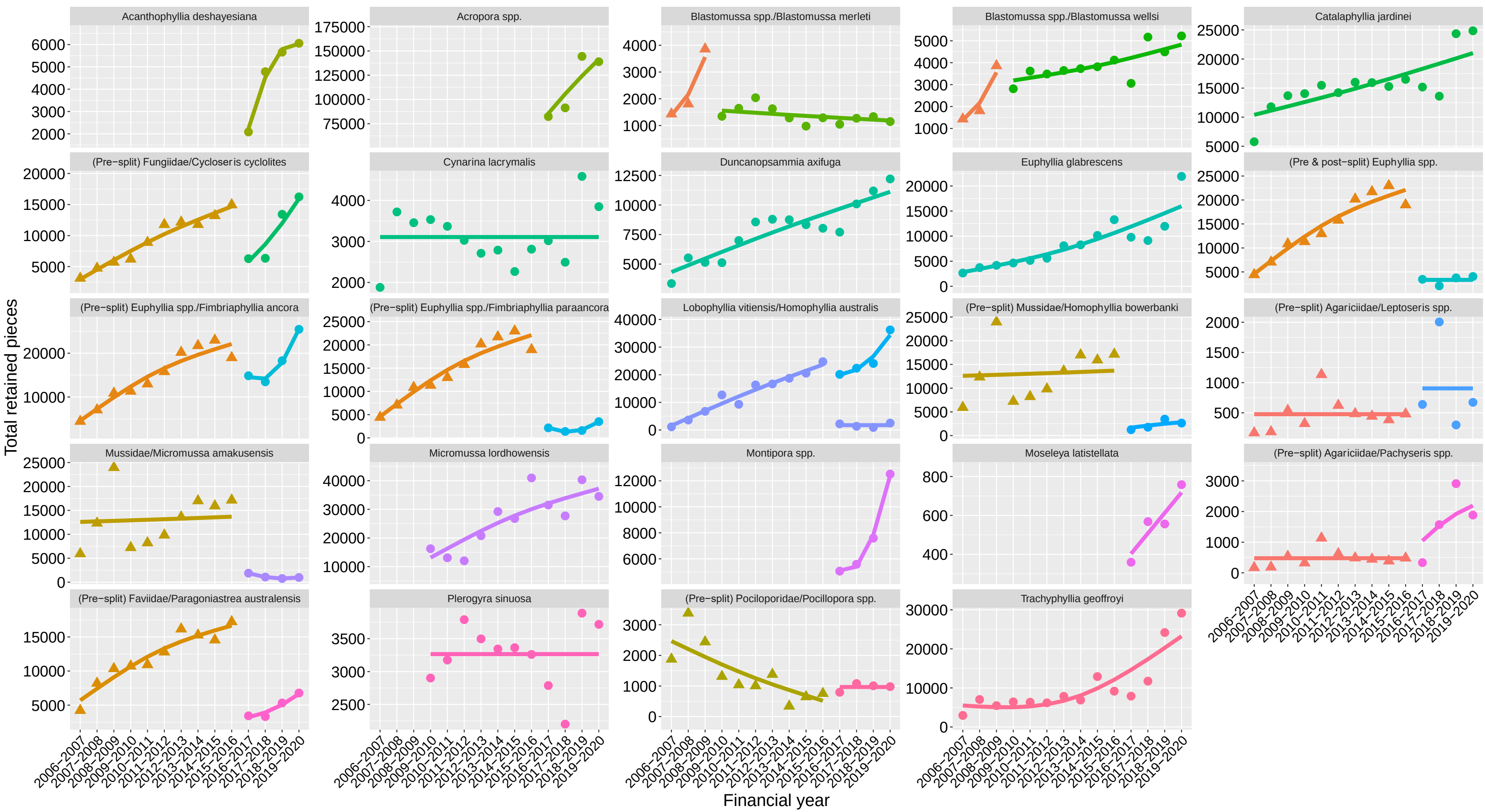



**Figure 4.6**. Annual reported harvest levels (no. of pieces) for hard corals (order Scleractinia) recorded to species/ genera. Where reporting categories changed (in 2016-2017) relevant groupings are shown on the same plot. General Additive Models (GAM) are fitted to all data to represent temporal trends. Harvest level data based on data provided by Queensland Government Department of Agriculture and Fisheries, on May 17th, 2021.

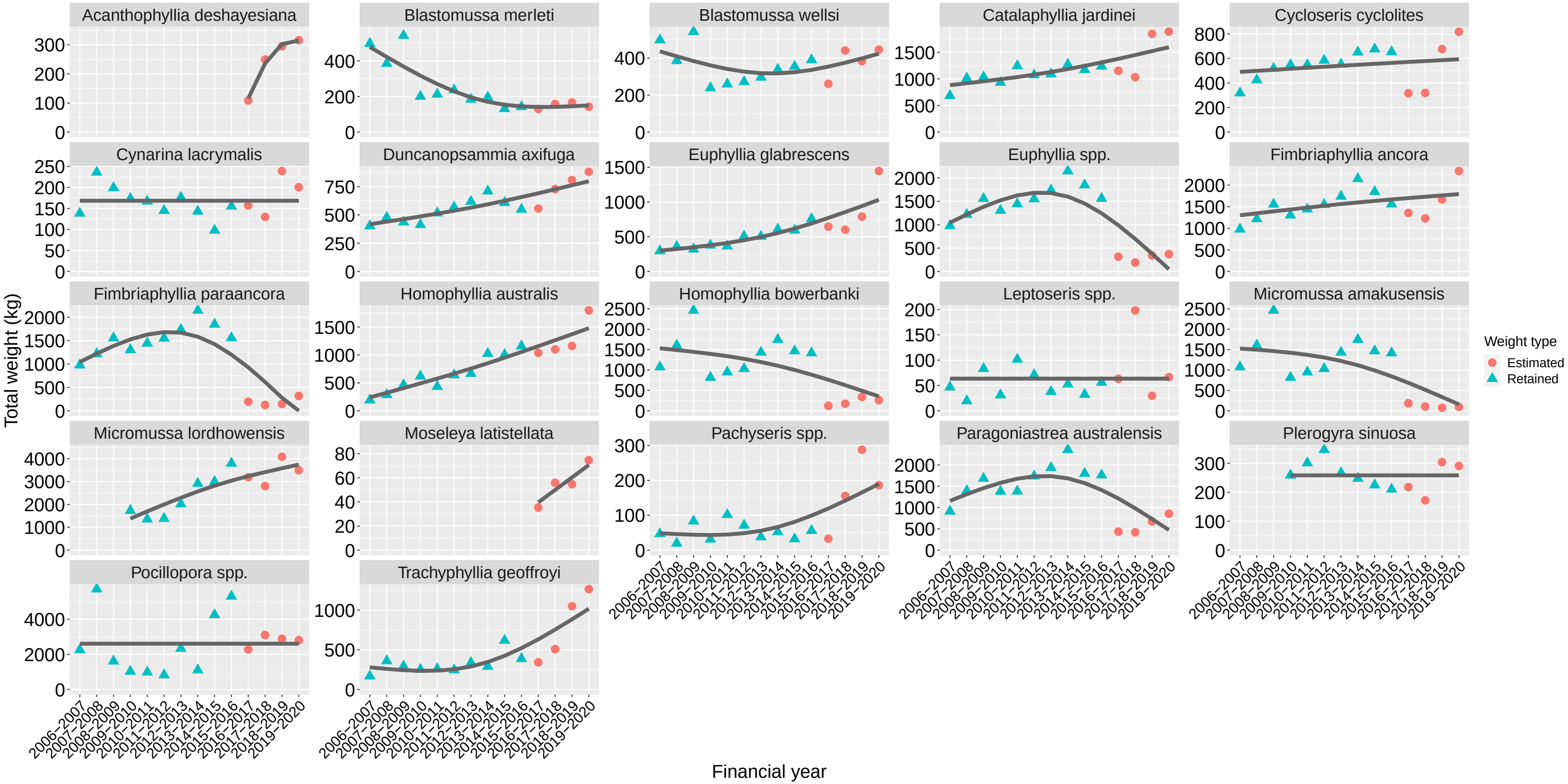



**Figure 4.7**. Estimated retained weight (kg) for hard corals (order Scleractinia) recorded to species/ genera. Due to changes in catch reporting (in from July 1st 2016) weight of coral for species/ genera had to be estimated based on number of pieces recorded and the per piece weight estimated for 2008-2009 to 2015-2016. Harvest level data based on data provided by Queensland Government Department of Agriculture and Fisheries, on May 17th, 2021.

### 4.5 *Spatial distribution of reported harvests*

The spatial extent of reported coral harvests has increased markedly from 2006-2007, when harvesting was reported from only 21 distinct 30x30 nm blocks, to 2019-2020 (Figure 4.8), when harvesting was reported from 95 distinct 30x30 nm blocks. The two most notable periods of fisheries expansion (with first reported harvesting from a number of 30x30 nm blocks) were in 2015-2016 and 2019-2020 (Figure 4.8).

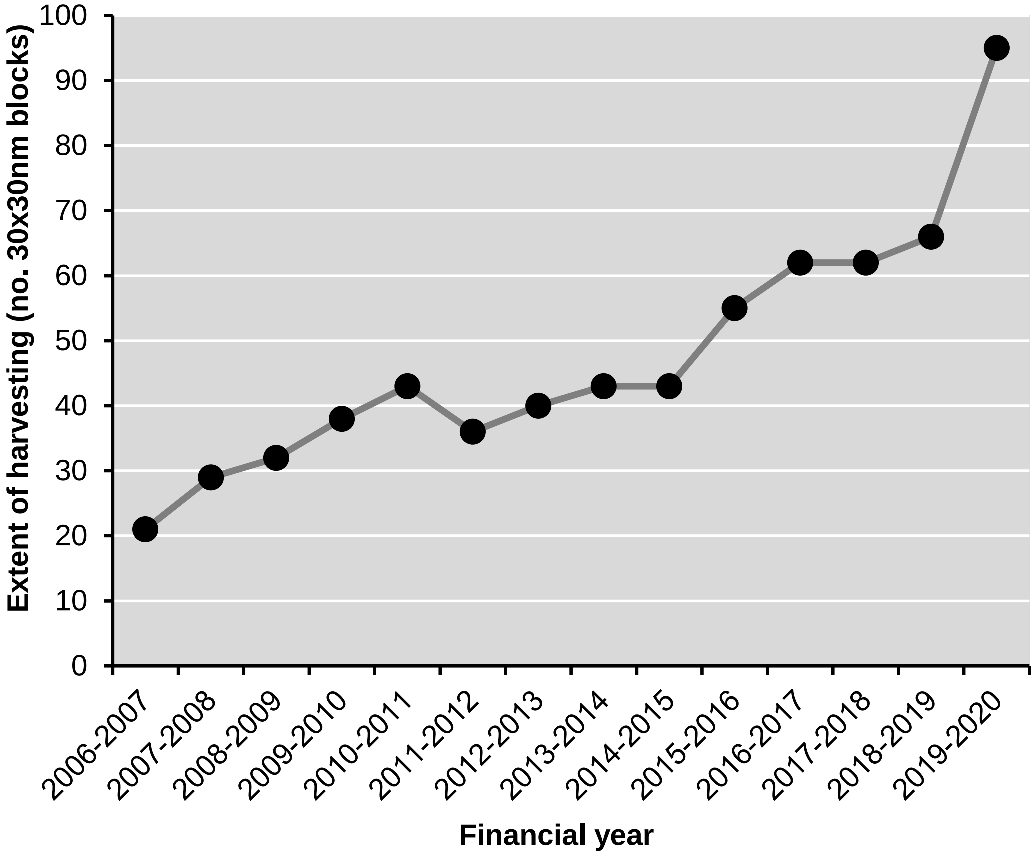



**Figure 4.8**. Spatial extent of reported harvests, based on number of distinct 30x30 nm blocks from where harvests (of any hard corals) were reported. Spatial information for harvesting was provided (DR3253iv) by Queensland Government Department of Agriculture and Fisheries, on May 25$^{th}$, 2021.

Increases in the spatial extent of reported harvest (especially during 2019-2020) were apparent across most heavily targeted coral species (Figure 4.9). For example, harvesting of *Trachyphyllia geoffroyi* was only reported from <12 distinct 30x30 nm blocks from 2006-2007 through 2011-2012, but the spatial extent of harvesting steadily increased from 10 blocks in 2011-2012 up to 22 blocks in 2015-2016, and increased substantially in 2012-2020 (Figure 4.9). Despite concerns that both *Homophyllia cf. australis* and *Micromussa lordhowensis* are abundant in only very restricted areas of the inshore southern GBR (Pratchett et al., 2020a), the number of areas from which these corals have been reportedly harvested has also increased, especially since 2016-2017.

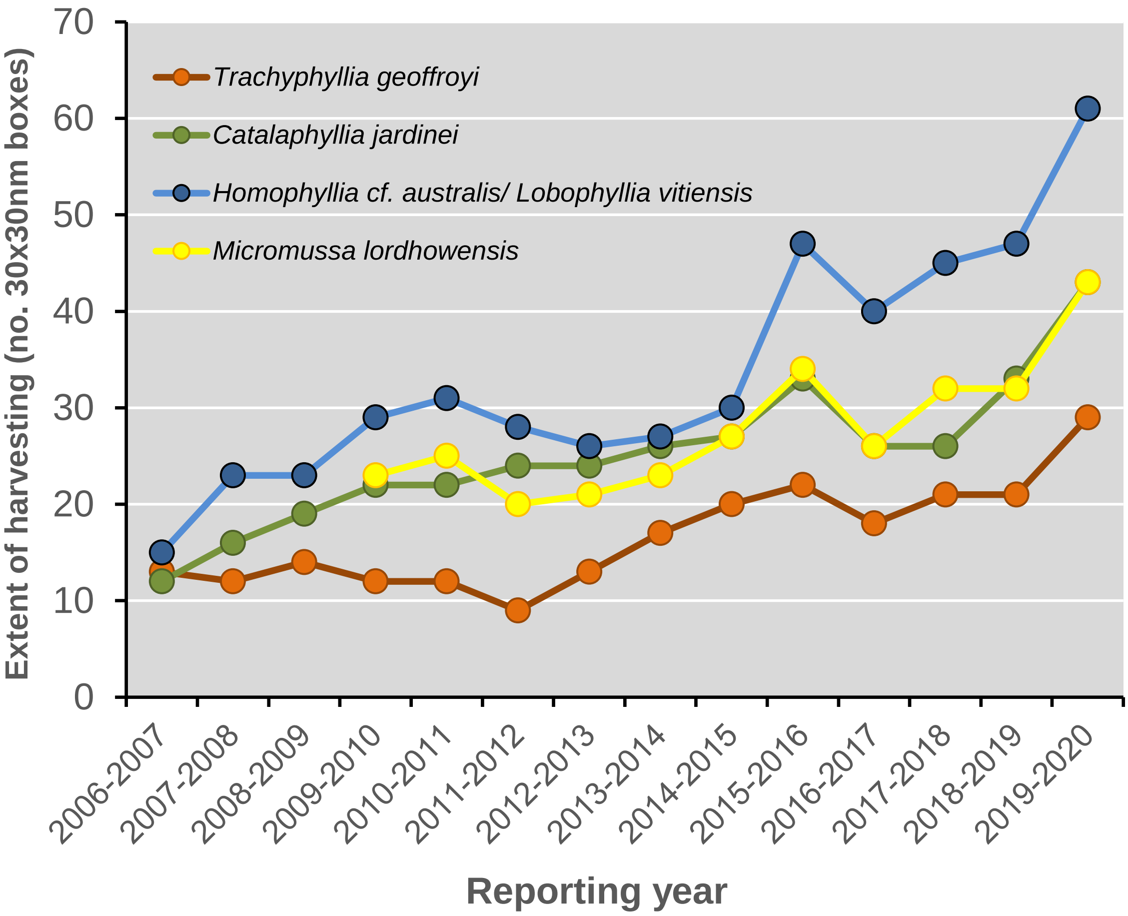



**Figure 4.9**. Spatial extent of reported harvests of distinct coral species, based on number of distinct 30x30 nm blocks from where harvests (of any hard corals) were reported. NB. Data for *Homophyllia* cf. *australis* and *Lobophyllia vitiensis* are combined due to taxonomic uncertainty and inconsistencies in reporting over time. Also, harvest levels of *Micromussa lordhowensis* are only reported since 2009-2010. Spatial information for harvesting was provided (DR3253iv) by Queensland Government Department of Agriculture and Fisheries, on May 25$^{th}$, 2021.

Given the increasing spatial extent of coral harvesting on the GBR, it would be expected that harvesting of any and all coral species would become increasingly diffuse. This pattern is indeed apparent based on the distribution of total annual catches (based on number of pieces) in 2006-2007 (where >53% of reported harvests came from just two distinct 30x30 nm blocks) versus 2019-2020 (where the combined harvests from the two blocks with highest levels of harvesting accounted for just 23% of the overall annual harvest). Nonetheless, it may be possible that some corals may continue to be harvested from only limited areas, owing to their limited distribution or limited areas of high abundance.

While there is evidence that some corals are harvested predominantly in relatively restricted areas, the maximum recorded harvest (based on annual and combined number of pieces) from a single 6x6 nm block was <50% for all coral species or species groups, for which more than 2,000 pieces were harvested in one or more years (Figure 4.10, Table 4.3). Overall (across all years for which data exists), there has been sustained high levels of harvesting for *Micromussa lordhowensis*, where >20% (61,205/ 293,094) of all pieces harvested throughout the last decade (since 2009-2010) have been harvested from the same 6x6 nm block (Figure 4.10). In some years, >40% of *Micromussa lordhowensis* have been harvested from this single 6x6 nm block (Table 4.3). Other corals for which there has been a relatively high (>30%) proportion of the annual harvest taken from a single 6x6 nm block include *Acanthophyllia deshayesiana*, *Fimbriaphyllia paraancora*, *Homophyllia bowerbanki*, and *Micromussa amakusensis*. Without any information on the local abundance of these corals in the relevant areas of concentrated fishing effort, it is impossible to know if this level of harvesting is sustainable (and thereby, justify current or increased harvest levels). Moreover, the proportion of the overall harvest taken from any given 6x6 nm block or 30x30 nm block, is probably less important than the absolute level of harvesting that occurs relative to the abundance and structure of the stock in those blocks.

For most corals (including *Catalaphyllia jardinei*, *Trachyphyllia geoffroyi*, and *Homophyllia* cf. *australis*) harvesting appears to be broadly distributed across a number of different 6x6 nm blocks, though in at least some instances, this represents similar levels of harvesting from a number of adjacent blocks within the same general area (see Figure 4.10). The distribution of reported catches for *Homophyllia cf. australis*, is particularly surprising, given that genetic sequencing of representative colonies from various regions of the GBR, found that *Homophyllia* cf. *australis*, was largely restricted to inshore regions of the southern GBR (Pratchett et al., 2020a). The data presented herein are however, combined with catch reporting for *Lobophyllia vitiensis*, due to inconsistencies in catch reporting. Widespread records of harvesting for *Homophyllia* cf. *australis*, may also be confounded by persistent taxonomic uncertainties. However, given the economic importance of this coral to the QCF, it is also likely that collectors are particularly focussed on detecting and collecting this coral across a broad range of habitats and locations.

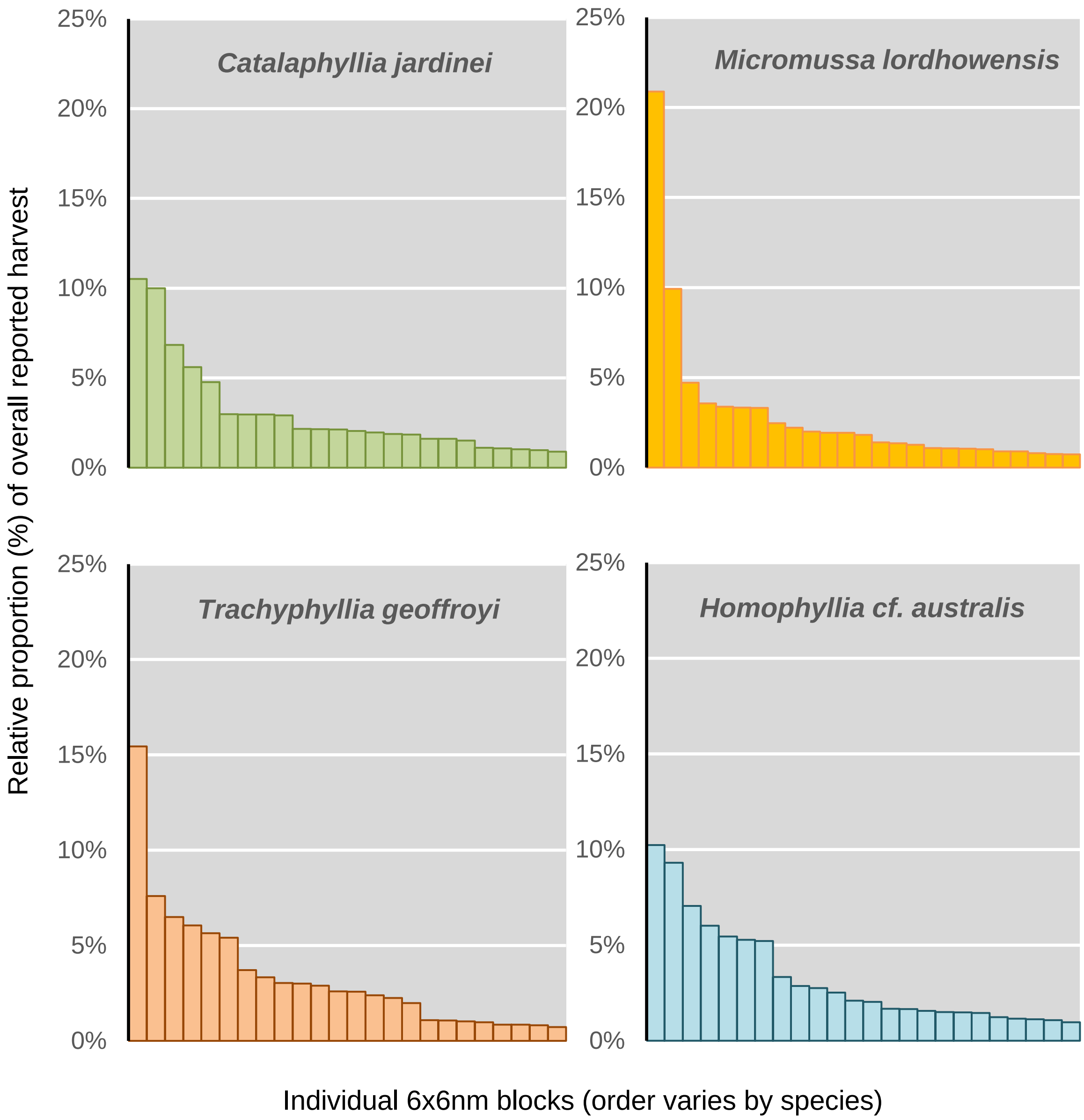



**Figure 4.10**. Distribution of total number of pieces harvested (from 2006-2007 through 2019-2020, where data is available) across each distinct 6x6 nm blocks, for four coral species. NB. Data for *Homophyllia* cf. *australis* included reported harvests of *Lobophyllia vitiensis* due to taxonomic uncertainty and inconsistencies in reporting over time. Spatial information for harvesting was provided (DR3253iv) by Queensland Government Department of Agriculture and Fisheries, May 25th, 2021.

**Table 4.3**. Maximum harvest levels (percentage based on number of pieces) recorded in a single 6x6 nm block in each of the last four catch reporting years. Values in red indicate instances where the maximum annual harvest from a single 6x6 nm block is >30%. Harvest level data based on data provided by Queensland Government Department of Agriculture and Fisheries, May 25th, 2021.

| Species/ Family | 2016-2017 | 2017-2018 | 2018-2019 | 2019-2020 |
|---|---|---|---|---|
| *Acanthophyllia deshayesiana* | 27.8 | 33.2 | 17.9 | 20.8 |
| Acroporidae (F) | 5.9 | 9.2 | 6.0 | 6.6 |
| *Blastomussa merleti* | 13.8 | 19.7 | 17.1 | 18.0 |
| *Blastomussa wellsi* | 9.6 | 14.5 | 6.8 | 5.2 |
| *Catalaphyllia jardinei* | 10.8 | 14.8 | 12.4 | 17.2 |
| *Cycloseris cyclolites* | 27.1 | 26.7 | 25.5 | 24.2 |
| *Cynarina lacrymalis* | 20.6 | 11.8 | 16.9 | 16.0 |
| *Duncanopsammia axifuga* | 10.8 | 8.1 | 12.5 | 14.2 |
| *Euphyllia glabrescens* | 17.4 | 17.8 | 18.4 | 22.7 |
| *Fimbriaphyllia ancora* | 9.0 | 11.3 | 8.7 | 11.9 |
| *Fimbriaphyllia paraancora* | 41.8 | 37.6 | 27.0 | 37.2 |
| *Homophyllia* cf. *australis* | 15.1 | 13.5 | 11.3 | 11.0 |
| *Homophyllia bowerbanki* | 11.8 | 37.7 | 10.0 | 11.9 |
| *Lobophyllia vitiensis* | 23.0 | 29.2 | 12.0 | 33.5 |
| *Micromussa amakusensis* | 37.0 | 27.4 | 36.7 | 30.9 |
| *Micromussa lordhowensis* | 23.2 | 41.8 | 39.6 | 27.9 |
| *Paragoniastrea australensis* | 13.9 | 10.2 | 7.7 | 9.9 |
| *Plerogyra sinuosa* | 9.9 | 22.6 | 17.9 | 18.4 |
| Pocilloporidae (F) | 20.9 | 31.9 | 45.2 | 48.6 |
| *Trachyphyllia geoffroyi* | 12.0 | 13.5 | 19.0 | 20.0 |

At larger scales (30x30 nm blocks) it is to be expected that an even larger proportion of overall or annual harvests will come from a single block (which often encompass multiple distinct reefs), especially if there are high levels of harvesting across a number of reefs or locations within the same general area. Accordingly, the maximum proportion of any given coral harvested from a single 30x30 nm block is much higher than for the maximum reported harvest levels from a single 6x6 nm block. Most notably, a very high proportion (38.4%) of the overall harvest (across all years for which data exists) for *Micromussa lordhowensis* comes from a single 30x30 nm block (Figure 4.11), and in recent years, up to 59.7% of corals have been harvested from this same area (Table 4.4). Relatively concentrated harvesting of other corals (including *Homophyllia* cf. *australis*) is also much more apparent when considering the distribution of reported harvests at the scale of 30x30 nm blocks (Figure 4.11), revealing that these corals are harvested mainly from specific regions, rather than specific reefs or locations.

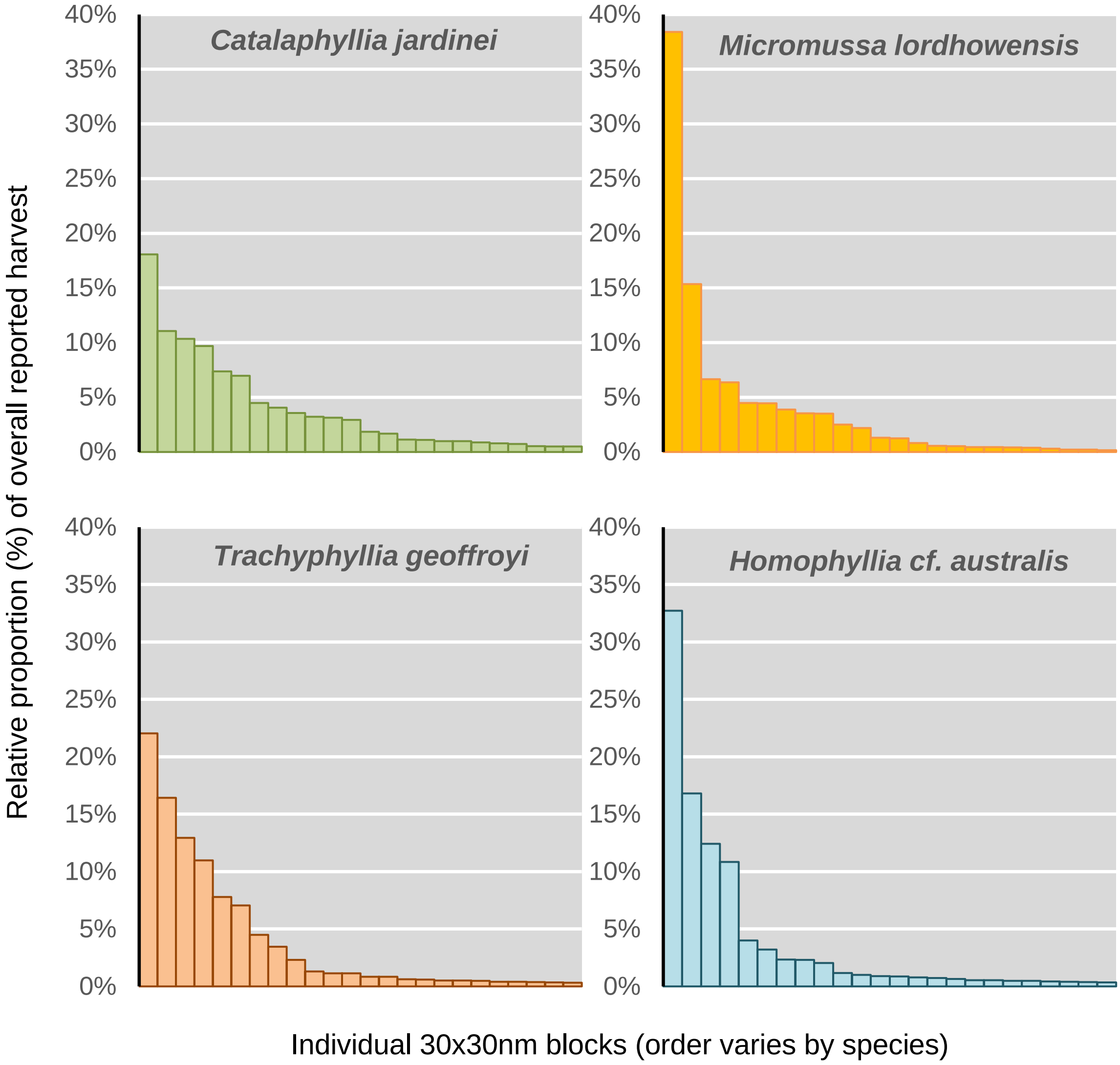



**Figure 4.11**. Distribution of total number of pieces harvested (from 2006-2007 through 2019-2020, where data is available) across distinct 30x30 nm blocks for four coral species . NB. Data for *Homophyllia cf. australis* included reported harvests of *L. vitiensis* due to taxonomic uncertainty and inconsistencies in reporting over time. Spatial information for harvesting was provided (DR3253iv) by Queensland Government Department of Agriculture and Fisheries, May 25th, 2021.

While it is important to assess the spatial distribution of coral harvests relative to the broad expanse of area of operation for the QCF, and prudent to distribute fishing effort to minimise localised or serial depletion of specific corals, there is no specific threshold (or necessary limit) on what proportion of harvests should be permitted from a single 6x6 nm or 30x30 nm block. For example, it is apparent that a very high proportion (66.2%) of Pocilloporidae are harvested from a single 30x30 nm block (Table 4.4), and harvests are highly concentrated even at the scale of the 6x6 nm grid (Table 4.3), even though these corals are very abundant in a wide range of regions, locations and habitats. In this instance, actual harvest levels are very low, and unlikely to pose a major risk to local coral populations or assemblages. The greatest utility for data on the distribution of reported harvests is to determine priority locations where stock assessments and monitoring should be undertaken for each of the different coral species.

**Table 4.4**. Maximum harvest levels (percentage based on number of pieces) recorded in a single 30x30 nm block in each of the last four catch reporting years. Values in red indicate instances where the maximum annual harvest from a single 30x30 nm block is >50%. Harvest level data based on data provided by Queensland Government Department of Agriculture and Fisheries, May 25th, 2021.

| Species/ Family | 2016-2017 | 2017-2018 | 2018-2019 | 2019-2020 |
|---|---|---|---|---|
| *Acanthophyllia deshayesiana* | 35.0 | 34.5 | 18.1 | 21.3 |
| Acroporidae (F) | 16.6 | 23.9 | 22.1 | 22.7 |
| *Blastomussa merleti* | 31.5 | 23.2 | 27.1 | 28.5 |
| *Blastomussa wellsi* | 20.3 | 14.9 | 19.2 | 20.3 |
| *Catalaphyllia jardinei* | 19.4 | 18.0 | 13.7 | 17.6 |
| *Cycloseris cyclolites* | 29.9 | 26.7 | 26.7 | 24.2 |
| *Cynarina lacrymalis* | 35.9 | 22.4 | 30.5 | 21.3 |
| *Duncanopsammia axifuga* | 20.6 | 21.2 | 24.1 | 27.1 |
| *Euphyllia glabrescens* | 24.7 | 34.5 | 24.9 | 32.9 |
| *Fimbriaphyllia ancora* | 25.1 | 19.5 | 15.5 | 26.0 |
| *Fimbriaphyllia paraancora* | 50.4 | 43.4 | 28.9 | 54.4 |
| *Homophyllia* cf. *australis* | 39.0 | 28.8 | 24.8 | 29.0 |
| *Homophyllia bowerbanki* | 23.8 | 40.4 | 26.1 | 31.8 |
| *Lobophyllia vitiensis* | 39.5 | 29.2 | 21.6 | 48.6 |
| *Micromussa amakusensis* | 50.3 | 29.4 | 36.7 | 40.7 |
| *Micromussa lordhowensis* | 51.3 | 58.7 | 59.7 | 44.0 |
| *Paragoniastrea australensis* | 22.5 | 21.2 | 18.3 | 19.5 |
| *Plerogyra sinuosa* | 18.0 | 35.7 | 26.1 | 34.6 |
| Pocilloporidae (F) | 32.2 | 40.2 | 66.2 | 62.0 |
| *Trachyphyllia geoffroyi* | 21.0 | 26.6 | 32.9 | 35.8 |

# 5. *Ecological Risk Assessments (ERAs)*

- *ERAs were completed for the QCF in 2008 and 2013*
- *ERA risk ratings and vulnerability assessments poorly reflect broader environmental concerns regarding hard coral species, especially considering that fishery-independent pressures have clearly escalated since the last ERA (in 2013)*

## 5.1 *ERA (2008)*

Ecological risk assessments (ERAs) are an important component of the risk-management approach used by the QCF for identifying species at elevated risk from harvesting (DEEDI, 2009; DAF, 2021a, 2021b). More specifically, these risk assessments should guide the subsequent management reviews and actions, whereby *the more vulnerable a species is to fishing, the greater the level of precaution required for management and the quality of information needed to justify any specific management approach* (Fletcher et al., 2003). ERA workshops (e.g., Roelofs, 2008) generally rely on extensive contributions from a range of experts and industry representatives, harnessing their collective knowledge and all available information to develop risk ratings for each of the harvested coral species; assessing risk at the level of genera or broader taxonomic groups will fail to capture the diversity of species within each group, which are likely to have very different risk factors and ratings (Roelofs, 2008). ERAs use a combination of likelihood and consequence scores, following Fletcher et al. (2002), to establish the risk posed by current and projected levels of harvesting while also considering other fishery-independent pressures (e.g., bleaching) facing each species. During the first ERA in 2008, a total of 61 hard corals (mostly at the level of genera) were assessed, and 10 species or genera were considered to be at elevated (albeit low) risk (Table 5.1); the species with the highest risk score (2) was *Catalaphyllia jardinei*, and no corals were considered to be at high or moderate risk. There was also limited pertinent information presented to clearly justify the different risk levels across different species, except for concerns raised by some European Union countries regarding harvests of the same species in Indonesia (Roelofs, 2008). The 2008 ERA was also preceded by a systematic vulnerability assessment (Roelofs and Silcock, 2008), which compiled information on the relative (scored on a 5-point scale) abundance, distribution and bleaching susceptibility of different coral species. The only hard coral considered to be moderately vulnerable was *Montipora* spp. (Roelofs and Silcock, 2008), but this information (along with industry advice on which species were most economically important), was simply used to prioritise species that were considered in the ERA.

The stated objectives of the 2008 ERA were to i) *Determine the level of risk to the ecological sustainability of coral species and 'living rock' harvested in the QCF*, and ii) *Develop management responses to species identified as greater than low risk*. While no species were identified as being *greater than low risk*, the 2008 ERA references the development of the QCF Performance Management System (PMS) to *provide a formal process for the review of catch data* (Roelofs, 2008). For each of the 10 species considered to be at greater than negligible risk (Table 5.1) performance measures were proposed to trigger further management review if either the annual harvest levels is >30% different from the average harvest levels for the preceding two years, or >80% of the annual harvest is recorded from a single 6x6 nm block (DEEDI, 2009). These performance measures were to be reported on annually in *Queensland Coral Fishery Annual Status Reports* (e.g., DEEDI, 2012), and actioned accordingly. However, performance measures were triggered on several occasions and for several different corals, but there was limited corresponding management action;

> **In 2010-2011**, reported harvest levels exceeded catch triggers for Acroporidae (DEEDI, 2012), but also for *Duncanopsammia axifuga*, where harvest levels (6,993 pieces) were 36.3% higher than average annual harvest levels (5,129 pieces) for the preceding two years. For Acroporidae, marked increases in harvest levels (82%) were attributed to changing market demand, though there was a commitment to *document the full range of species collected from the Acroporid family* (DEEDI, 2012). This remains an important requirement for effectively managing ever-increasing harvest levels of *Acropora* spp. (see section 7.1), but is yet to be undertaken. Moreover, n consideration was given to any other individual coral species because catch triggers were either not assessed, or reportedly not triggered, though it is unclear which data (weights versus no. of pieces) were used for these assessments.

**In 2013-2014**, performance measures were triggered for *Micromussa lordhowensis*, for which the relevant change in harvest levels was 78% (based on no. of pieces), and also for *Acropora* spp. and *Homophyllia (Scolymia)* spp. (DAF, 2014). Despite the large increase in reported harvest levels for *Micromussa lordhowensis*, there were *no prescribed management actions*. However, detailed vulnerability assessments were undertaken, coinciding with the 2013 ERA, and it was stated that the PMS would be updated ahead of the 2015 season, *with defined management responses to better deal with exceeding triggers* (DAF, 2014).

## 5.2 *ERA (2013)*

ERAs need to be updated periodically (Hobday et al., 2011), especially following changes in harvest levels or external pressures that might modify the vulnerability of harvested species. By the time the second ERA for the QCF was conducted in 2013 (Roelofs, 2018), 5 years after the preliminary assessment, there was heightened sensitivity regarding the vulnerability of corals, largely motivated by the publication of a seminal paper (De'ath et al., 2012) showing broadscale declines in coral cover on the GBR over the preceding decades. This greatly increased awareness of the impacts of coral bleaching and other major disturbances that had the potential to undermine the sustainability of coral harvesting. Moreover, harvest levels had more than doubled for the majority of species in the period between the 2008 and 2013 ERAs (Table 5.1).

The 2013 ERA workshop assessed 220 individual species, and found there were no high risk species, 4 species at moderate risk, and 76 species at low risk in the fishery (Table 5.1, see also Table 6.1). Species with the highest risk score (12 out of 30) were *Homophyllia* cf. *australis* and *Acanthophyllia deshayesiana*, for which there were reports of localised depletion in areas of concentrated fishing activity, and selective depletion of larger size polyps and/ or highly desirable colour morphs, which is attributed to fishery impacts (Roelofs, 2018). Selectivity of harvesting within many species (where harvesting is limited to relatively rare colour morphs) is often cited as a potential mechanism for ensuring the sustainability of harvesting (e.g., Roelofs, 2018). However, the extent of selectivity needs to be explicitly assessed, while also ensuring that selective removal of specific phenotypes does not undermine the viability and resilience of remaining individuals (e.g., Knittweis and Wolff, 2010).

**Table 5.1**. ERA risk levels for QCF harvested coral species/ genera, based on assessments conducted in 2008 (Roleofs, 2008) and 2013 (Roelofs, 2018). Also shown is the change in reported harvest levels (no. of pieces) immediately prior to each assessment (2006-2007 and 2011-2012, respectively). Given harvest levels were not explicitly recorded for many of the species groups, change is based on family-level recording (*), where relevant.

| Species | ERA 2008 | Proportional change in harvest level | ERA 2013 |
|---|---|---|---|
| *Acanthophyllia deshayesiana* | Negligible | - | Moderate |
| *Acropora* spp. | Low | 4.9* | Low |
| *Blastomussa merleti* | Low | 1.4 | Low |
| *Blastomussa wellsi* | Low | 2.4 | Low |
| *Catalaphyllia jardinei* | Low | 2.5 | Low |
| *Cycloseris cyclolites* | Negligible | 3.8* | Low |
| *Cynarina lacrymalis* | Negligible | 1.6 | Low |
| *Duncanopsammia axifuga* | Low | 2.6 | Low |
| *Euphyllia glabrescens* | Low | 2.1 | Low |
| *Fimbriaphyllia ancora* | - | 3.6* | Low |
| *Fimbriphyllia paraancora* | Negligible | 3.6* | Low |
| *Homophyllia* cf. *australis* | Negligible | 14.3* | Moderate |
| *Homophyllia bowerbanki* | Negligible | 14.3* | Moderate |
| *Leptoseris* spp. | - | - | Low |
| *Lobophyllia vitiensis* | Low | 14.3* | Low |
| *Micromussa amakusensis* | - | 14.3* | Low |
| *Micromussa lordhowensis* | Low | 14.3* | Low |
| *Montipora* spp. | Negligible | 4.9* | Low |
| *Moseleya latistellata* | - | - | Low |
| *Pachyseris* spp. | - | - | Low |
| *Paragoniastrea australensis* | - | - | Low |
| *Plerogyra* spp. | Low | - | Low |
| *Trachyphyllia geoffroyi* | Low | 2.1 | Moderate |
| *Turbinaria* spp. | Negligible | 0.3 | Low |

One of the key outcomes of the 2013 ERA was the uncertainty regarding the taxonomic identity of some important species (e.g., *Acanthophyllia deshayesiana* and *Homophyllia* cf. *australis*). It was also acknowledged that there was a lack of fishery-independent data on the distribution and abundance for many different species, which could lead to erroneous conclusions about vulnerability to harvesting for heavily targeted coral species; this was reflected in a long list of knowledge gaps and research priorities identified across coral species considered to be at low to moderate risk (Donnelly, 2013; Roelofs, 2018). However, the overarching ecological impacts of coral harvesting (at the scale of the entire area of operation) were considered to be very minor, especially given that >30% of the expansive area of the GBRMP is closed to coral harvesting (and all fishing), and that harvesting is very selective (e.g., taking only certain colour morphs) for many coral species. Rather, higher risk ratings for individual coral species were attributed to localised effects of harvesting in restricted areas of concentrated fishing. For example, risk ratings ascribed to *Trachyphyllia geoffroyi* ranged from 1 (low) to 9 (moderate), depending on the specific collection area (Roelofs, 2018).

The foremost response to the 2013 ERA came from industry-led undertakings to develop voluntary collection standards to mitigate the risk posed by harvesting (and compounding impacts of environmental change) on higher risk species, and mainly in restricted areas of high fishery catch and effort (Donnelly, 2013). For example, it was suggested that harvesting of *Acanthophyllia deshayesiana*, *Trachyphyllia geoffroyi and even Catalaphyllia jardinei* should be subject to species-specific size limits in areas of historically high catch and effort (Donnelly, 2013). While there is no available data on the size distribution of corals harvested, harvest levels of the these species from the relevant area (Arlington and Vlassoff Reefs) were reduced from 2013-2014 through to 2016-2017. However, harvest levels subsequently increased (especially in 2018-2019), and exceeded maximum annual harvest levels reported prior to 2013-2014.

# *6. Existing and proposed management arrangements*

## 6.1 *Policy for the Management of the QCF (2016-2021)*

- *The Policy for the Management of the Coral Fishery* (2016-2021) *introduced reporting of actual weights for all hard corals, but only at the level of overarching quota categories (e.g., all speciality corals combined)*
- *Without recording and reporting of harvested weight for all individual species and species groups, the only way to track harvest levels is based on the number of pieces*
- *Growth in harvest levels for individual species and species groups were supposed to be constrained using a Performance Management System (PMS), though no prescribed management actions occurred when performance thresholds were triggered*

The revised *Policy for the Management of the Coral Fishery* (2016-2021) came into effect on July 1st 2016 (DAF, 2016), aimed to foster growth in the fishery while also protecting against unsustainable harvest practices related to i) localised concentration of fishing effort, and ii) targeted take of highly vulnerable species. This policy (DAF, 2016) maintained many of the input and output controls that had been in place since 1997. There were however, changes in the reporting requirements, that were partly reflected in changes to logbook categories; the number of reporting categories increased from 5 species and 18 other categories of scleractinian coral (Supplementary Table 10.1) to 9 species and a total of 28 different reporting categories in 2009-2010 (Supplementary Table 10.2), which was further increased to 19 species and a total of 41 reporting categories in 2016-2017 (Supplementary Table 10.3). The most important change in 2016-2017 was a major shift in the reporting of weight aimed at addressing calls for *accurate and transparent reporting of the weight of collected CITES listed (hard) coral in the fishery*" noting that *the [previous] quota reporting system may have resulted in inaccuracies and under-reporting of quota* (DAF, 2016). Most critically, rather than estimating weight based on the relevant size categories of specialty coral, operators are required report the actual weight of all hard corals (including Acroporidae and Pocilloporidae) and report this in unload notices. Actual weights are however, only reported for higher level quota categories, while harvest levels for individual species (or species group) are only reported as the number of pieces.

Despite the increased number of reporting categories in 2016-2017, no species-specific harvest limits were proposed. Rather, marked changes in annual harvest levels (>30% above or below the average annual harvests for the two preceding years) of specific species or species groups triggered a specific management review and corresponding management action (where necessary), as per the PMS (DEEDI, 2009). Performance measures were triggered in 2016-2017, whereby the harvest levels for *Acropora* spp. were reported to have increased 62% (Roelofs and Albury, 2018), but no prescribed management actions were taken, as occurred in previous years (see Section 5.1).

Further management triggers were also proposed, if >80% of annual reported catches came from a single 6x6 nm block. The onus for monitoring these performance metrics was on fisheries managers, as it was acknowledged that there was limited capacity for external verification and monitoring of relevant catch data, due to commercial confidence surrounding the specific localities where coral species are harvested. This would also impede vulnerability assessments for CITES-listed species, though there appeared to be agreement that "public reporting of spatial information through the annual status reports is restricted to the six nautical mile scale to protect operator confidentiality" (page 11, DSEWPAC, 2012). Nonetheless, there remain sensitivities around disclosing harvest levels of individual species at specific 6x6 nm blocks, though these PMS catch triggers for concentrated levels of harvesting were set very high (80%) and have never been reached or exceeded.

## 6.2 *QCF Harvest Strategy (2021-2026)*

- *The current QCF Harvest Strategy (2021-2026) replaces the Performance Management System with a risk-based (tiered) approach to setting catch triggers*
- *For Tier 1 (highest risk) species, average annual harvests are to be constrained to 80% of the average annual harvest levels for the specified 3-year reference period (2016-2017 to 2018-2019).*
- *For Tier 2 (low, but significant risk) species, harvest levels are allowed to increase to 150% of reference harvest levels, yet reported harvest levels in 2019-2020 still exceeded proposed catch triggers*

The latest QCF Harvest Strategy (2021-2026) was released in August 2021 (DAF, 2021a), and implemented in September 2021. While the overarching harvest limit (TACC) remains at 200,000 units/kg, with a continued split between SC (30%; 60,000kg) and OC (70%; 140,000kg), the QCF Harvest Strategy (2021-2026) introduces catch triggers, which are intended to limit harvest levels of individual coral species to "within historic catch levels" (page 6, DAF, 2021a). QCF Harvest Strategy (2021-2026) explicitly recognises taxonomic (species-specific) differences in the risk of harvesting, and proposes a tiered approach to manage the risk of coral harvesting for individual coral species/ genera. Trigger levels use a multiplier (0.8 or 1.5), which varies depending on the specified risk level (or tier) of the species or species group, to limit future harvest levels relative to reference harvest levels (explained below). Also, "as the level of exploitation increases above historic levels, species will be elevated to higher levels of monitoring, assessment and management" (page 7, DAF, 2021a).

Reference harvest levels represent the average annual harvest of each coral species/ genera during a specified 3-year reference period, from 2016-2017 through to 2018-2019. The justification for choosing the relatively recent (2016-2017 through 2018-2019) reference period as a benchmark for assessing and limiting future increases in reported harvest levels, is that it represents the earliest implementation for many (26%) of the reporting categories now being used (Supplementary Table 10.3). This reference period is also purported to represent "a stable period of operation for the QCF" (page 7, DAF, 2021a), which may well be true in terms of the continuation of management arrangements. However, the reported harvest levels for the proposed reference period were already well outside reported catch levels from previous years, with rapid and sustained growth of many coral species over the preceding decade (e.g., Figure 4.6). Concerns about both rapid and sustained growth in harvest levels of individual species/ genera were also raised as far back as 2012 (DSEWPAC, 2012). Indeed, the PMS (initially established in 2009), was intended to prevent unconstrained and unregulated growth in harvest levels of individual coral species, explicitly allowing for a maximum of 30% change in harvest levels relative to the average of two previous years.

In the QCF Harvest Strategy (2021-2026), for coral species or species groups (genera) for which the risk of harvesting is considered to be unacceptably high (Tier 1) the proposed trigger level (or harvest limit) is 80% (averaged over 2-years) of the relevant reference harvest level (DAF, 2021a). For Tier 2 species, the proposed trigger level (or harvest limit) is 1.5 times of relevant reference levels, and management actions are only imposed (where necessary) to “ensure catch of a species does not increase more than 10% above the trigger” (page 9, DAF, 2021a). This effectively allows for a >50% increase in average annual harvest levels above reference harvest levels. However, the proposed reference period (2016-2017 through to 2018-2019) is fixed, such that long-term harvest levels will be sustained at or below this level. For all other species, no specific catch trigger is proposed, and no further management constraints are considered necessary at least until an ERA identifies additional species for which “fishing impacts are considered to generate an undesirable level of risk (moderate)” (page 7, DAF, 2021a).

Currently, only a single coral species (namely, *Homophyllia* cf. *australis*) is ascribed to Tier 1 (DAF, 2021a), making it unclear if or how information from the most recent ERA (Roelofs, 2018) is being used in the QCF Harvest Strategy (2021-2026). Notably, it is explicitly stated that “ERAs are also used to inform the acceptable level of risk from harvesting for coral species. If the ecological risk to a species is increased, then species are elevated to a higher tier” (page 6, DAF, 2021a). While *Homophyllia cf. australis* had the single highest risk rating in the last (2013) ERA (Roelofs, 2018), three other species (*Trachyphyllia geoffroyi*, *Acanthophyllia deshayesiana* and *Homophyllia bowerbanki*) were also ascribed moderate risk ratings, and should also be assigned to Tier 1 (Table 6.1). However, two of these species (*Acanthophyllia deshayesiana* and *Homophyllia bowerbanki*) are not even ascribed to Tier 2 in the QCF Harvest Strategy (2021-2026).

As a Tier 1 species, the average annual harvest of *Homophyllia* cf. *australis* should be limited to 17,752 pieces per year, which is approximately half of the reported harvest levels in 2019-2020 (Table 6.1). The relevant decision rule states that “If the two-year average harvest of any Tier 1 species is above 80% of the average historical reference period (2016-2018), management action must be in place for the following fishing season to restrict species catches (i.e. TACC, trip limits, spatial closures)" (page 7, DAF, 2021a). However, there is a lack of clarity or certainty about how restraints on harvest levels might be achieved. Does this mean that constraints on harvest levels will not be imposed for at least 2 years after the implementation of the QCF Harvest Strategy (2021-2026), at the end of the 2022-2023 reporting year, or is it possible to use retrospective data (from before the implementation) to establish "two-year average harvest"? How will harvest levels of *Homophyllia* cf. *australis*, and other species considered to be at moderate risk (*Trachyphyllia geoffroyi*, *Acanthophyllia deshayesiana* and *Homophyllia bowerbanki*), actually be constrained (especially if harvest levels are only ever reviewed after the end of each reporting year)?

**Table 6.1**. Operationalising the "tier-based" risk management approach as outlined in the QCF Harvest strategy (2021-2026). Tier levels as listed for each species/ genera in QCF Harvest strategy (2021-2026) are shown, with inferred tier levels (based on current ERA risk ratings) shown in brackets. Species where the recent harvest level exceeds the proposed catch triggers are indicated in red. Harvest level data based on data provided by Queensland Government Department of Agriculture and Fisheries, May 17th, 2021.

| Species | ERA 2013 | Harvest Strategy Tier | Reference harvest level | Catch triggers | 2019-2020 harvest level |
|---|---|---|---|---|---|
| *Homophyllia* cf. *australis* | Moderate | 1 (1) | 22,190 | 17,752 | 36,216 |
| *Trachyphyllia geoffroyi* | Moderate | 2 (1) | 14,609 | 11,687 | 29,159 |
| *Acanthophyllia deshayesiana* | Moderate | - (1) | 4,177 | 3,341 | 6,057 |
| *Homophyllia bowerbanki* | Moderate | - (1) | 2,156 | 1,725 | 2,639 |
| *Acropora* spp. | Low | 2 (2) | 105,977 | 158,965 | 138,874 |
| *Micromussa lordhowensis* | Low | 2 (2) | 33,169 | 49,754 | 34,509 |
| *Catalaphyllia jardinei* | Low | 2 (2) | 17,715 | 26,573 | 24,857 |
| *Fimbriaphyllia ancora* | Low | 2 (2) | 15,525 | 23,287 | 25,461 |
| *Euphyllia glabrescens* | Low | 2 (2) | 10,288 | 15,432 | 21,914 |
| *Duncanopsammia axifuga* | Low | 2 (2) | 9,661 | 14,491 | 12,204 |
| *Cycloseris cyclolites* | Low | - (2) | 8,684 | 13,027 | 16,236 |
| *Montipora* spp. | Low | - (2) | 6,106 | 9,159 | 12,520 |
| *Blastomussa wellsi* | Low | 2 (2) | 4,241 | 6,362 | 5,224 |
| *Paragoniastrea australensis* | Low | 2 (2) | 4,032 | 6,048 | 6,780 |
| *Cynarina lacrymalis* | Low | 2 (2) | 3,365 | 5,047 | 3,847 |
| *Plerogyra sinuosa* | Low | - (2) | 2,959 | 4,439 | 3,718 |
| *Fimbriphyllia paraancora* | Low | 2 (2) | 1,705 | 2,558 | 3,492 |
| *Micromussa amakusensis* | Low | - (2) | 1,238 | 1,858 | 981 |
| *Blastomussa merleti* | Low | - (2) | 1,218 | 1,827 | 1,147 |
| *Lobophyllia vitiensis* | Low | - (2) | 1,494 | 2,241 | 2,512 |

For Tier 2 species, presumed to represent those coral species for which there is an undesirable (but not unacceptable) risk posed by harvesting, the proposed catch triggers are 1.5 times the reference harvest levels, thereby allowing for significant future growth in harvest levels. Even so, recent harvest levels (2019-2020) for many of the coral species that are or should be (based on previous ERA assessments) ascribed to Tier 2, exceed the proposed catch triggers in 2019-2020 (Table 6.1). For these species, the relevant decision rules state “management action (e.g. trip or catch limits, size limits or spatial/temporal closures) must be in place for the following fishing season [to ensure catch of a species does not increase more than 10% above the trigger] until a detailed review is completed, including whether the species should be elevated to tier 1. If the review identifies that a species is of increasing importance, the species may be considered for further risk assessment, monitoring or management action” (page 9, DAF, 2021a). If current harvest levels are sustained or exceeded in 2021-2022, it is presumed that Queensland fisheries will need to be implementing appropriate actions (though they are yet to be clearly established) to constrain harvest levels of these species in 2022-2023. At the same time a review must be undertaken to “understand the reason for the increased harvest” and “assess the risks” (page 9, DAF, 2021a). It is unclear however, what information would be obtained (or is even available) to moderate concerns about the risks posed by higher harvest levels. It is also unclear, what reference or process will be used to establish “whether the species should be elevated to tier 1”, or if “the species is of increasing importance”?

Sustained or rapid increases in the reported harvest levels for individual coral species (see Section 7.1) mean that the risk posed by fishing has undeniably increased, and necessitates more careful consideration during NDF determinations. However, there very limited data or information available to assess whether increased harvest levels (let alone current or historical harvest levels) are negatively affecting individual coral species or stocks. This lack of stock assessments and monitoring also means it is very difficult to justify increased harvest levels for individual coral species, which should otherwise remain at suitably precautionary levels (Hobday et al., 2011; Smith et al., 2011). Future harvest levels and limits for these species should therefore, be constrained at or below the average annual harvest levels recorded during the proposed reference period (2016-2017 through 2018-2019), which itself represents a period of unprecedented growth in reported harvest levels (Figure 4.3).

The QCF Harvest Strategy (2021-2026) remains focussed on minimising the risk of localised depletion for individual species, proposing limit reference points where >50% of the average annual catch for a species in 2016-2018 (historical reference period) is taken from within a single 6x6 nm block (DAF, 2021a). Given the expansive area of operation for the QCF, and relatively diffuse catch and effort (see Section 4.5), reported harvest levels have not exceeded these new more conservative thresholds (down from 80% in the previous PMS; DEEDI, 2009) for any individual coral species/ genera in the last 4 reporting years, since 2016-2017 (Table 4.3). However, there is evidence of concentrated catch and effort at regional scales, whereby more than 50% of reported harvest levels come from a single 30x30 nm block (especially for *Micromussa lordhowensis* and *Fimbriaphyllia paraancora*), reflecting high levels of harvesting across a number of adjacent 6x6 nm blocks. It is unknown whether these relative and absolute levels of harvesting pose a risk of localised depletion, though it would be prudent to monitor harvested species and stocks within these areas.

# 7. Additional information required to support NDF determinations

- *Marked increases in harvest levels and limits for individual coral species necessitate increased levels of information to support positive NDF determinations*
- *Detailed information on the biology, ecology, and population status is also fundamental in setting provisional (suitably precautionary) or sustainable harvest limits for individual coral species*
- *Despite increased knowledge and understanding of the biology and ecology of major target species, there remain significant data and information gaps that preclude inferences about sustainable harvest limits*

While there is considerable (and intentional) flexibility in the information that may be used in making NDF determinations (as outlined in CITES Resolution Con. 16.7), positive NDF determinations are intended to provide assurances that the overall extent of harvesting (including known, inferred, projected, and estimated illegal harvests) will not substantially affect the survival or function of any affected species, either in specific areas or throughout their range (CITES, 2013). Moreover, the data and information required to support NDF determinations "should be proportionate to the vulnerability of the species concerned", where vulnerability is based on "the volume of legal and illegal trade" and "intrinsic and extrinsic factors that increase the risk of extinction" (page 2, CITES, 2013). Accordingly, increased levels of information (e.g., specific data on the local distribution and abundance of harvest species, and stock status and trends) is needed to to justify increased harvest levels or limits, as well as to counter increased extrinsic pressures (e.g., environmental change) that may affect species' vulnerability (Table 7.1).

The minimum requirements to support positive NDF determinations are taken quite liberally when the risk posed by harvesting is considered to be negligible. For example, if the harvest levels and spatial extent of harvesting are very small relative to the overall abundance or distribution of the species (Level 1; Table 7.1), this alone may justify a positive NDF determination even without any specific knowledge on the biology of the species or potential impacts of harvesting (e.g., DEH, 2006). Notably, the Commonwealth assessment of the QCF in 2006 concluded that QCF management arrangements were at that time, "appropriately precautionary" (page 18, DEH, 2006), reflecting that the limited availability of fishery-independent information to assess stock status and trends was acceptable given very low harvest levels. Critically, however, in these instances precautionary harvest levels should remain in place until relevant information becomes available to justify increased harvest levels and limits (e.g., DEWR, 2007; Hobday et al., 2011; Smith et al., 2011; Table 7.1).

**Table 7.1**. Alternative approaches for setting harvest limits, and required levels of information required to support differing approaches. Importantly, the relevant harvest limits would generally increase with increased levels of knowledge and understanding of target stocks and species, but similarly, increased levels of verifiable information are required to justify increasing harvest levels and limits for CITES-listed species. The levels of information required are incremental, rather than independent. For example, comprehensive catch and effort data is required for all levels at and above Level 1.

| Level | Information available | Harvest limits |
|---|---|---|
| 0 | No relevant knowledge of the species, and no recorded catch history | Provisional harvest limits |
| 1 | Comprehensive spatial and temporal catch and effort data | Precautionary harvest limits |
| 2 | Good knowledge of the biology and ecology (vulnerability) of targeted species, and rigorous ERA to consider the risk posed by sustained harvest levels | Sustained (fixed or staged, step-wise changes) harvest limits |
| 3 | Comprehensive information and data on the distribution, abundance, population structure and turnover of harvested species at the scale of the fishery | Biomass-based sustainable harvest limits |
| 4 | Relevant time-series (monitoring) data to establish population status and trends in relevant fished areas as well as suitable reference areas | Maximum (adaptive) sustainable harvest limits |

Information needed to support (or justify) increased harvest levels, and corresponding harvest limits (catch triggers) for individual coral species, depends on the magnitude and rate of change in harvest levels and limits. Importantly, relatively moderate and periodic increases in harvest limits may be justified on the basis of a rigorous ERA (Level 2; Table 7.1), which are necessarily informed by comprehensive catch data and knowledge of fundamental aspects of species' biology and ecology that influence their vulnerability. Any changes in proposed harvest limits must also be maintained for sufficient period to allow for any potentially negative impacts of revised harvest levels and limits to become apparent (e.g., up to a decade). Large or rapid changes in harvest levels necessitate much higher levels of information, which can really only be provided through dedicated research and/ or monitoring (Table 7.1) specific to each species or species group. Moreover, NDF determinations are expected to be undertaken only for verified species or approved genera (CITES, 2016) necessitating careful consideration of the taxonomic status of each species. There is therefore, considerable information that needs to be compiled and considered in making NDF determinations, especially where there are apparent or specific concerns raised about the risk posed by harvesting for individual species or groups. This information is also fundamental in setting appropriate harvest limits for individual coral species (see Section 8). Relevant information (where available) is summarised below for each of the 11 species/ genera, for which there have been sustained or recent increases in reported harvest levels (Table 7.2).

Increases in reported harvest levels are particularly apparent for 11 species/ genera (Table 7.1). For each of these species, the absolute magnitude of change (i.e., proportional change, regardless of time interval) in reported harvest levels (based on no. of pieces), prior, during and/ or post the 3-year reference period (2016-2017 through to 2018-2019) was >50% (or 1.5x), based on the maximum (long-term) change in harvest levels permitted for Tier 2 species in the current QCF Harvest Strategy (2021-2026). For *Acropora* spp., for example, recent (2019-2020) harvest levels are <150% of reference harvest levels, but reported harvest levels increased 180% (1.8x) within the reference period, from 82,279 pieces in 2016-2017 to 144,367 pieces in 2018-2019. In general, notable and significant increases in reported harvest levels have resulted from either sustained increases over a protracted period (e.g., *Homophyllia* cf. *australis* and *Micromussa lordhowensis*) or recent and rapid increases in harvest levels, mainly since 2016-2017 (e.g., *Trachyphyllia geoffroyi*, *Fimbriaphyllia* ancora, *Euphyllia glabrescens*, and *Cycloseris cyclolites*). These marked increases in harvest levels (see also Figure 4.6) pose a major challenge for current and future NDF determinations, especially given that there has not been commensurate increases in the level of information to justify increased harvest levels or limits (Table 7.1). At the same time, there have been heightened concerns about the threat posed by extrinsic (fishery-independent) pressures and threats (Pratchett et al., 2020b), which necessitate even higher levels of information to support positive NDF determinations.

**Table 7.2**. Recent (2019-2020) harvest levels and change (expressed as a proportion) for species of concern, where reported harvest levels have increased substantially (≥1.5) either prior (relative to 2009-2010 through 2011-2012), within (2018-2019 versus 2016-2017), or post (relative to 2019-2020) the specified reference period (2016-2017 through to 2018-2019). Also shown are the IUCN vulnerability rating (see also Carpenter et al., 2008) and ERA ratings for representative coral species (which are always conducted at the level of species).

| Species | Reported harvest (2019-2020) | Change relative to reference period | | | IUCN Red List (2008) | QCF ERA (2013) |
|---|---|---|---|---|---|---|
| | | Prior | Within | Post | | |
| 1. *Acropora* spp. | 138,874 | na | 1.8 | 1.3 | | |
| *Acropora anthocercis* | - | | | - | VU | - |
| *Acropora echinata* | - | | | - | VU | - |
| *Acropora microclados* | - | | | - | VU | - |
| *Acropora millepora* | - | | | - | NT | Low |
| *Acropora spathulata* | - | | | - | LC | |
| *Acropora tenuis* | - | | | - | NT | - |
| 2. *Homophyllia* cf. *australis* | 36,216 | 1.7 | 1.2 | 1.6 | LC | Moderate |
| 3. *Micromussa lordhowensis* | 34,509 | 2.4 | 1.3 | 1.0 | NT | Low |
| 4. *Trachyphyllia geoffroyi* | 29,159 | 2.3 | 3.1 | 2.0 | NT | Moderate |
| 5. *Fimbriaphyllia ancora* | 25,461 | na | 1.2 | 1.6 | VU | Low |
| 6. *Catalaphyllia jardinei* | 24,857 | 1.2 | 1.6 | 1.4 | VU | Low |
| 7. *Euphyllia glabrescens* | 21,914 | 2.0 | 1.2 | 2.1 | NT | Low |
| 8. *Cycloseris cyclolites* | 16,236 | na | 2.1 | 1.9 | LC | Low |
| 9. *Montipora* spp. | 12,520 | na | 1.5 | 2.1 | | - |
| *Montipora caliculata* | - | | | - | VU | Low |
| *Montipora danae* | - | | | - | LC | - |
| *Montipora nodosa* | - | | | - | NT | - |
| *Montipora verrucosa* | - | | | - | LC | - |
| 10. *Duncanopsammia axifuga* | 12,204 | 1.4 | 1.5 | 1.3 | NT | Low |
| 11. *Acanthophyllia deshayesiana* | 6,057 | 1.2 | 1.6 | 1.5 | NT | Moderate |

It is acknowledged that QCF harvest levels of hard corals (across all species) are still well within legislated and sustained catch limits (e.g., 60,000 kg for specialty coral species), and that management arrangements have been improved to address previous ecological concerns (e.g., localised depletion). However, NDF determinations apply to individual coral species, and increases in the reported harvest levels of several individual coral species (especially since 2018-2019), include several species that were previously identified as *CITES species of concern* (e.g., *Acropora* spp., *Trachyphyllia geoffroyi*, *Micromussa lordhowensis*, *Homophyllia* cf. *australis*, *Duncanopsammia axifuga*, *Euphyllia glabrescens*, and *Catalaphyllia jardinei*; DEEDI, 2012; DAF, 2014). There have also been concerted calls for dedicated research and monitoring of heavily harvested and highly vulnerable coral species in Queensland for >20 years (e.g., Harriot, 2001; Jones et al., 2017). However, there has been very limited relevant research (see Pratchett et al., 2020a), and there remains limited available data or information to infer or establish sustainable harvest limits of any or all harvested coral species. There has also been limited dedicated monitoring to assess stock status or trends (Jones et al., 2017), which might otherwise be used to infer that sustained harvest levels are within sustainability bounds.

## 7.1 *Acropora* spp.

**Family:** Acroporidae

**IUCN Red List Category:** Vulnerable to Least Concern (depending on specific species)

**QCF Risk Rating:** Negligible to Low (Table 6.1); *CITES species of concern* (e.g., DAF, 2014)

**Taxonomic References:** Cowman et al., 2020

***Biology and Ecology*** – *Acropora* spp. are the most diverse genera of hard corals, accounting for 30% of all reef-building (hermatypic) coral species (Madin et al., 2016). They exhibit a wide variety of growth forms based on variation in the size, shape and spacing of individual branches that extend medially through the growth of axial corallites. *Acropora* spp. are also relatively unique in having highly perforate skeletons, which partly accounts for their potentially rapid growth (Pratchett et al., 2015). *Acropora* corals are colonial and can grow to very large sizes (several metres across), but are also highly vulnerable to a wide range of disturbances (e.g., storms and cyclones, outbreaks of coral predators, as well as coral disease and bleaching), which often constrains the size and longevity of individual colonies (e.g., Wakeford et al., 2008; Pratchett et al., 2013).

*Acropora* corals are hermaphroditic, broadcast spawners (Baird et al., 2009) that generally release large numbers of gamete bundles (containing both eggs and sperm) during highly concentrated mass-spawning. Fertilized eggs develop into motile larvae that may be capable of settling with several days (Figueiredo et al., 2013), but can also remain in the plankton for several months before settling (Connolly and Baird, 2010), allowing for larval dispersal over large distances. Settlement rates are also typically very high in areas where *Acropora* spp. are abundant, but are sensitive to regional declines in the abundance of reproductive colonies (Gilmour et al., 2013; Hughes et al., 2019).

***Taxonomy*** – The molecular (genetic) basis of species-level taxonomy for *Acropora* spp. is largely unresolved, due to the limited systematic resolution that was possible using traditional genetic markers (Cowman et al., 2020). However, Cowman et al. (2020) have demonstrated the utility of genomic capture methods to distinguish putative species of *Acropora*, which paves the way for rigorous and robust delineation of species.

***Geographic range*** – Many *Acropora* species have been recorded throughout large areas of the Indo west-Pacific (e.g., *Acropora microclados*; Figure 7.1), but these distribution maps may need to be revised following resolved taxonomy.

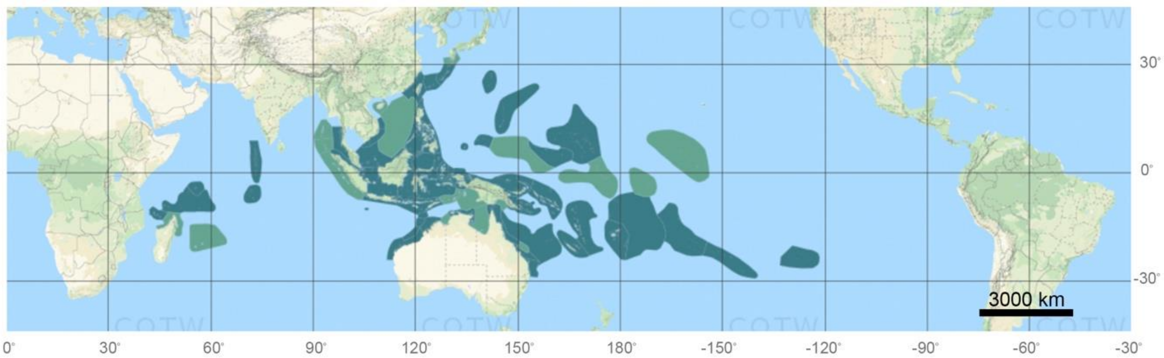



**Figure 7.1.** Global distribution range of *Acropora microclados*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021). NB. This information is likely to change with resolved taxonomy.

***Pressures and Threats*** – *Acropora* corals are particularly sensitive to changing environmental conditions and increasing disturbance regimes (e.g., Carpenter et al., 2008; Pratchett et al., 2020c). Accordingly, the abundance and cover of *Acropora* corals has declined dramatically in recent decades across many reef regions (e.g., Gardner et al., 2003; McWilliam et al., 2020; Pratchett et al., 2020c), and is often failing to recover in the face of increasing incidence of major disturbances (e.g., Madin et al. 2018) and escalating human pressures (Ortiz et al., 2021). *Acropora* corals are particularly susceptible to environmental change, and are among the first corals to bleach and die during severe heatwaves (Hughes et al., 2018). Overall abundance of *Acropora* corals on the GBR declined markedly due to recent mass-bleaching events (e.g., Pratchett et al., 2021), and though there has been subsequent recovery, these recovering coral assemblages will be particularly vulnerable to future marine heatwaves and mass-bleaching episodes (Pratchett et al., 2020c; see also AIMS 2021).

The cumulative pressures facing *Acropora* spp., and the vulnerability of these ecologically important reef-building corals (Wolff et al., 2018; Ortiz et al., 2018, 2021), is partly reflected in concerted efforts to restore *Acropora* spp. (and other fast-growing coral taxa) on the GBR (e.g., Howlett et al., 2021). The imperative for (and investment in) coral reef restoration is also expected to increase over time due to further increases in disturbances and pressures on coral reefs (Vercelloni et al., 2020). Critically, rapid recovery of coral assemblages (largely due to rapid growth of *Acropora* spp.) in the aftermath of previous disturbances (e.g., Linares et al., 2011; AIMS, 2021) increases vulnerability to future disturbances and increases volatility in the structure and function of coral reef ecosystems. Effects of harvesting *Acropora* spp., which are compounded by pre-existing disturbances and pressures, will therefore, need to be carefully managed.

***Harvesting*** – *Acropora* corals on the GBR are harvested both as fragments (largely taken from the outer edge of large colonies) and entire colonies, where suitably small and appropriately shaped. While fragmenting large colonies may sometimes result in unintended breakage of additional branches, the recovery potential of these colonies is very high, especially if the majority (>50%) of the original colony remains intact. By contrast, colonies that are removed in their entirety can only be replaced through settlement and subsequent growth of entirely new colonies, which is a slow process relative to the growth and recovery of remnant *Acropora* colonies (Gilmour et al., 2013).

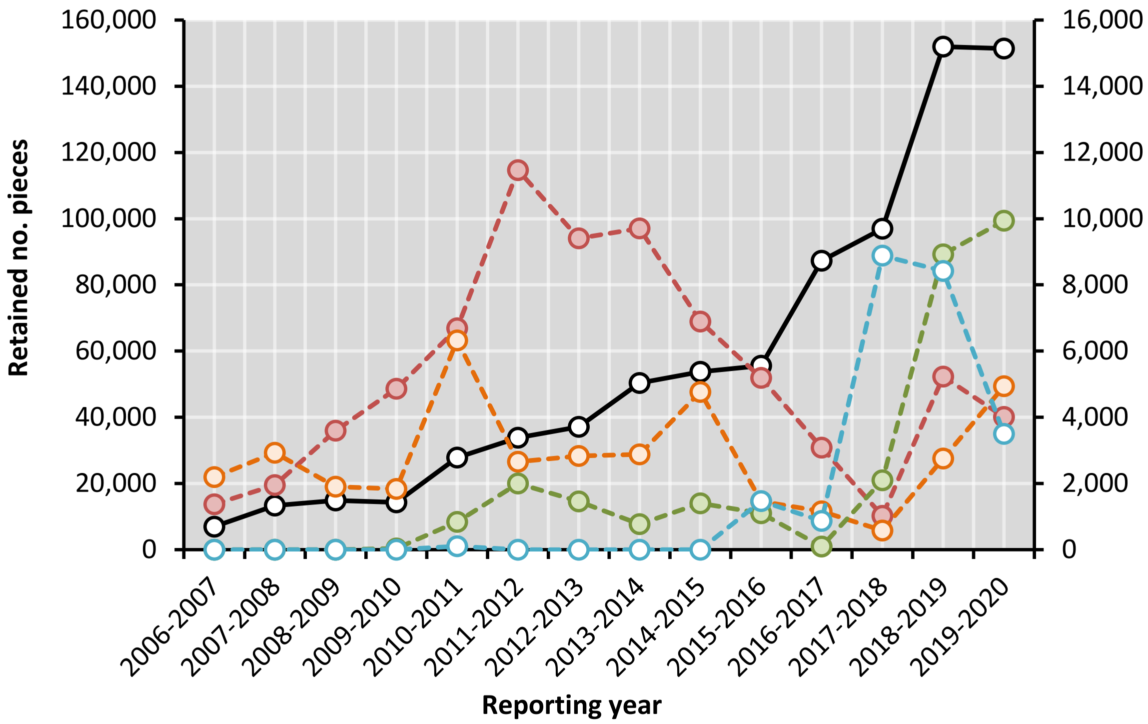



**Figure 7.2.** Interannual changes in reported harvest levels *Acroporidae* (mostly *Acropora* spp.) from 2006-2007 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from four individual 6x6nm blocks (dashed lines, and plotted on secondary axis), which account for most (collectively 20.8%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

Reported harvest levels for *Acropora* spp. increased >75% from 82,279 pieces in 2016-2017 to 144,367 pieces in 2018-2019 (Figure 4.6), building on sustained increases in reported harvesting of Acroporidae since 2006-2007 (Figure 7.2).

Acroporidae have been reported to be harvested from a very wide range of regions (104 distinct 30x30 nm blocks) on the GBR, representing 77.0% of areas (135 distinct 30x30 nm blocks) where coral harvesting has occurred since 2006-2007. Historically, much (up to 30% in 2011-2012, and 9.4% across the entire period) of the reported harvesting has occurred in a single 6x6nm block (Figure 7.2), but there have been marked increases in reported harvested from a number of additional blocks, especially since 2016-2017.

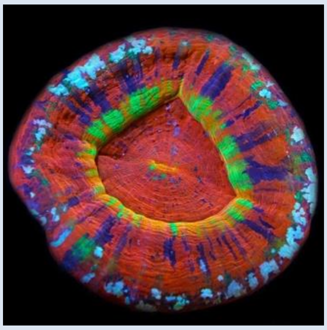
***Population status and trends*** – Extensive data on the population status and trends for *Acropora* spp. is available from the AIMS long-term monitoring program (e.g., Osborne et al., 2011; Johns et al., 2014), at least for relatively shallow reef fore-reef habitats at select monitoring reefs. These data show that there has been marked fluctuations in the abundance of *Acropora* spp., corresponding with spatial and temporal incidence of major disturbances (Osborne et al., 2011), and relatively rapid recovery in the aftermath of major disturbances (Johns et al., 2014). It is expected however, that *Acropora* spp. will become less abundant and less resilient with increasing incidence and severity of severe heatwaves, due to anthropogenic climate change (Hughes et al., 2018, 2019). The relevance of this data is only limited by incomplete knowledge and understanding of range of *Acropora* species that are harvested (and the proportions in which they are harvested), and their individual vulnerabilities and population trends.

Recent fishery-independent surveys in reef areas where *Acropora* spp. are harvested (Pratchett, 2021) recorded mean biomass estimates for *Acropora* spp. ranging from 34.4 kg per hectare in the central GBR to 62.8 kg per hectare in the northern GBR. Given the vast area of coral reef habitat within the GBR (>2 million hectares), these data would suggest that biomass-based sustainable harvest limits for *Acropora* spp. would greatly exceed current harvest levels and limits. Harvest limits will however, need to consider the proportionate harvest levels for individual species, and be adjusted (where necessary) if there are sustained declines in recorded cover of *Acropora* spp. across the GBR.

***Knowledge gaps and Research priorities*** – The main priority to assure the sustainability of ongoing harvests of *Acropora* corals is to clearly document which species are being targeted and assess the specific abundance of these species in major harvest areas. This may however, be partly constrained (at least in the short-term) until the taxonomy of *Acropora* spp. is suitably refined.

*Acropora* corals are also extremely amenable to repeated fragmentation and *ex situ* propagation, which could greatly reduce pressure on wild stocks and species. Unlike many of the other heavily harvested corals (where it is necessary to assess and develop procedures for captive breeding) there are few impediments to the rapid implementation and up-scaling of *ex situ* growth and propagation for *Acropora* corals. Moreover, asexual reproduction, through fragmentation, largely assures that original colour and growth form of coral colonies will be retained.

## 7.2 *Homophyllia* cf. *australis*



**Family:** Lobophyllidae

**IUCN Red List Category:** Least Concern
(last assessed in 2008)

**QCF Risk Rating:** Moderate (2013 ERA)
Tier 1 in QCF Harvest Strategy (2021-2026)

**Taxonomic References:** Arrigoni et al. (2014); Arrigoni et al. (2016)

***Biology and Ecology*** - *Homophyllia* cf. *australis* is a single polyp (monostomatous or solitary) species with polyps shaped like a disk or saucer. This species can be free-living or attached to the substrate by a broad or narrow stem. Very little is known regarding the biology and ecology of *Homophyllia* cf. *australis* and most information comes from recent research (Pratchett et al., 2020a). This species is a hermaphroditic broadcast spawner (Pratchett et al., 2020a). Extensive histological analyses (measurement of oocyte area) of *Homophyllia* cf. *australis* samples from Queensland have shown that this species may spawn before (up to 1-month prior) the peak spawning season for most broadcast spawning species (Pratchett et al., 2020a). *Homophyllia* cf. *australis* also appears to be capable of reproducing at relatively smaller sizes, where > 50% of colonies are reproductively mature at 64 mm diameter (Pratchett et al., 2020a).

**Taxonomy** - There is considerable uncertainty surrounding the taxonomy of *Homophyllia* cf. *australis*, questioning the relevance of reported distributions. Recent genetic analyses of monostomatous corals collected by Australian coral fisheries have revealed at least three distinct genetic lineages (or species); i) *Homophyllia* cf. *australis* which was restricted to samples from the GBR, Queensland, and only represented in collections from the southern GBR, ii) *Micromussa pacifica* which was also recorded only among the samples provided from the GBR, Queensland, and iii) an undescribed species which is strongly differentiated from both *Homophyllia* cf. *australis* and *Micromussa pacifica* and includes all samples that were provided from Western Australia and the Northern Territory (Pratchett et al., 2020a).

***Geographic range*** – Based on Veron et al. (2021) the reported distribution for *Homophyllia* cf. *australis*, or rather *Parascolymia australis* (which is considered to be the relevant nomenclature by Veron et al., 2021) cover a total of 43 ecoregions representing 28.7% of global ecoregions and 32.3% of ecoregions in the Indo-Pacific region (Figure 7.3), concentrated in the Indo-Pacific archipelago. However, this may represent the cumulative distribution for two or more distinct species.

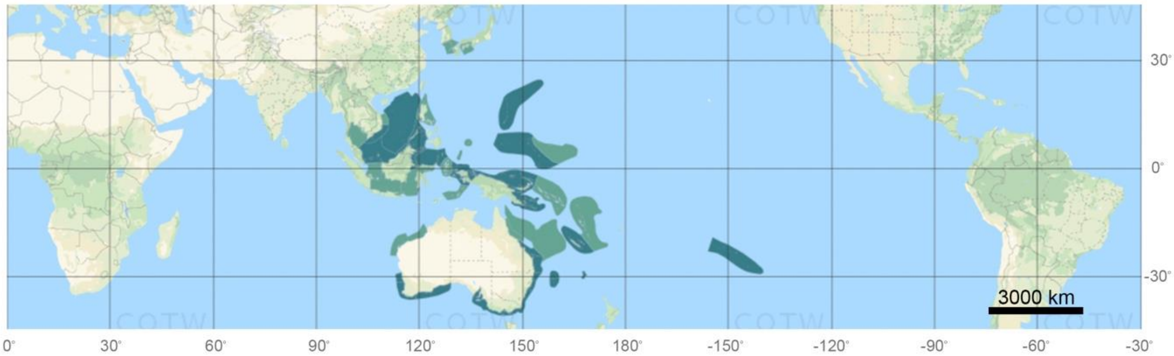



**Figure 7.3.** Global distribution range of *Parascolymia australis*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021). NB. This information is likely to change with resolved taxonomy.

***Pressures and Threats*** - Recent mass bleaching (Pratchett et al., 2021) certainly affected reefs within the distribution range of *Homophyllia* cf. *australis*, and experimental studies suggest that this species is sensitive to elevated temperatures (Pratchett et al., 2020b). However, harvesting is likely the foremost threat; *Homophyllia* cf. *australis* was the most heavily harvested single coral species (36,216 pieces or colonies) in 2019-2020, and there has been sustained high levels of harvesting for at least a decade. The localised depletion of *Homophyllia* cf. *australis* from particular areas, which are almost universally harvested as whole specimens, may also undermine capacity for reproduction and recovery. For example, regional declines in the abundance of other broadcast spawning corals has been shown to impair recruitment and population replenishment (Hughes et al., 2000), which may be further suppressed by regional-scale ocean warming and coral bleaching (Hughes et al., 2019).

***Harvesting*** - Reported harvests of *Homophyllia cf. australis* up until 2015-2016 were recorded as *Lobophyllia vitiensis* (Figure 4.6), but then split thereafter. The clear differentiation in harvest levels of *Homophyllia* cf. *australis* versus *Lobophyllia vitiensis* in 2016-2020, suggests that previous harvest records of *Lobophyllia* *vitiensis* (prior to 2016) were predominantly comprised of *Homophyllia* cf. *australis* (Figure 4.6), though it is not possible to definitively disaggregate these data. Harvest levels of both *Homophyllia* cf. *australis* and *Lobophyllia vitiensis* (data combined) been steadily increasing since 2006 and over 20,000 individual pieces have been collected annually since 2016. High harvest levels of entire corals in areas of concentrated fishing effort may pose significant risk of localised depletion, especially given fairly moderate densities recorded in recent surveys (Pratchett et al., 2020a).

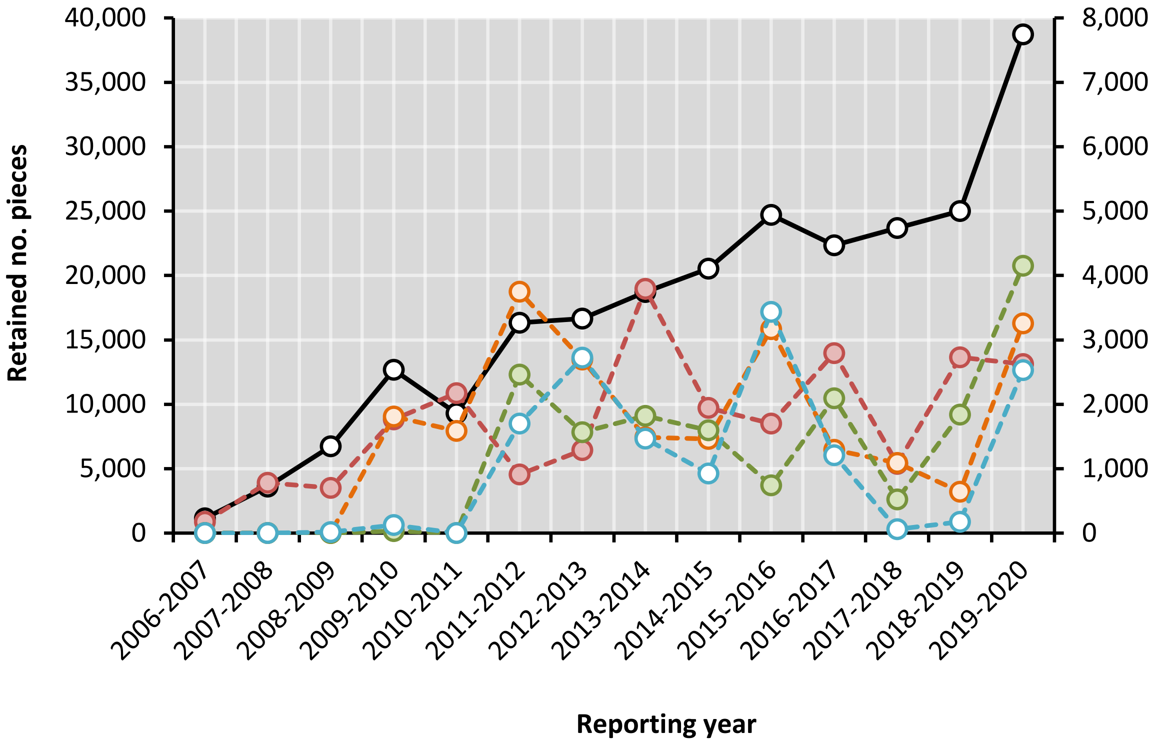



**Figure 7.4.** Interannual changes in reported harvest levels *Homophyllia* cf. *australis* and *Lobophyllia vitiensis* (data combined) from 2006-2007 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from four individual 6x6nm blocks (dashed lines, and plotted on secondary axis), which account for most (collectively 32.4%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

Harvesting of *Homophyllia* cf. *australis* (including *Lobophyllia vitiensis*) on the GBR has been reported from 97 (71.9%) distinct 30x30 nm blocks. However, the majority (81.2%; 196,920 out of 240,171) of *Homophyllia* cf. *australis* have been harvested from just 5 distinct 30x30 nm blocks, all in near shore areas of the southern GBR. It is possible that the relatively low number of corals collected outside of these areas are a distinct species, though this will require detailed sampling and genetic sequencing to resolve. Throughout the period from 2006-2007 through 2019-2020, *Homophyllia* cf. *australis* and *Lobophyllia vitiensis* have been mainly harvested from the same four 6x6nm blocks (Figure 7.2), which collectively account for 32.4% of all harvests. However, very high harvest levels were reported from an altogether different 6x6nm block in 2017-2018, and relatively low harvesting (albeit only temporarily) was reported from traditional areas that supported the majority of harvesting (Figure 7.2).

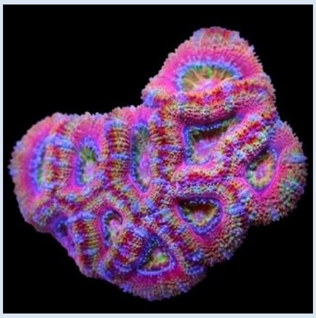
***Population status and trends*** – The population status and trends for *Homophyllia* cf. *australis* in Queensland waters are not known, and this uncertainty is compounded by questions regarding the taxonomy and relevant distribution of this species, which may be restricted to the southern GBR.

Recent fishery-independent surveys (Pratchett et al., 2020b) revealed low densities (5.4 individuals per $50m^2 \pm 0.7SE$) and biomass (0.3 kg per $50m^2 \pm 0.1SE$) of *Homophyllia* cf. *australis* in fished areas in the southern GBR, but it is unknown how these compare to the densities and biomass historically or in unfished areas. These data have limited utility justifying current harvest levels, nor establishing the biomass-based sustainable harvest limits for *Homophyllia* cf. *australis* without improved understanding of their distribution and abundance patterns.

***Knowledge gaps and Research priorities*** – The foremost research priority for *Homophyllia* cf. *australis* is to resolve its' taxonomic identity and affinities with other similar monostomatous corals from the family Lobophyllidae, and thereafter, resolve the distributional limits and area of extent for each species. Given the importance of this species for the QCF, and large increases in reported harvest levels (mostly from within a restricted area), *Homophyllia cf. australis* is also a prime candidate for direct monitoring of abundance and fishery impacts. Establishing the abundance of *Homophyllia* cf. *australis* within very limited areas where this species is predominantly harvested is also extremely tractable (e.g., Pratchett et al., 2020a), though complementary sampling should also be conducted at nearby relevant reference locations, where fishing is not permitted (subject to approval and permitting by GBRMPA).

Pressure on wild stocks of *Homophyllia cf. australis* may be reduced through captive breeding, though it is first necessary to establish the capacity to produce offspring of specific colours, thereby understanding the genetic versus environmental determinants of vibrant colours.

### 7.3 *Micromussa lordhowensis*



**Family:** Lobophyllidae

**IUCN Red List Category:** Near Threatened (last assessed in 2008)

**QCF Risk Rating:** Low (2013 ERA);
*CITES species of concern* (e.g., DAF, 2014)

**Taxonomic References:** Arrigoni et al. (2016)

***Biology and Ecology*** - *Micromussa lordhowensis* grows as massive colonies, with laterally compressed corallites of uneven height. Colonies have a thick fleshy mantle which is covered by fine papillae. *Micromussa lordhowensis* are often found in shallow, turbid reef environments. This species is a hermaphroditic broadcast spawner that releases large gamete bundles during spawning. Post-settlement survival is typically low, and growth rates of recruits are relatively slow (2 mm over 8 months) (Wilson and Harrison, 2005). However, *Micromussa lordhowensis* larvae can be competent for up to 78 days (Wilson and Harrison, 1998), hence there is potential for long-distance dispersal to reefs that may be more favourable for post-settlement survival and growth.

***Taxonomy*** – *Micromussa lordhowensis* was previously classified as *Acanthastrea lordhowensis*, but recent phylogenetic and morphological analyses have shown it is more appropriately placed within the genus *Micromussa* (Arrigoni et al., 2016). While *Micromussa lordhowensis* is recognised from several distinct locations around eastern Australia (including Lord Howe Island; Arrigoni et al., 2016), the broader geographical distribution and taxonomic identity of this species remains unclear.

***Geographic range*** – Confirmed and strongly predicted records of *Micromussa lordhowensis* cover a total of 65 ecoregions representing 43.3% of global ecoregions and 48.9% of ecoregions in the Indo-Pacific region (Veron et al., 2021), occurring throughout the Indo west-Pacific. They are generally uncommon, but can be relatively abundant in some areas. Despite being widely distributed (Figure 7.5), the majority of the *Micromussa lordhowensis* reported by the QCF come from the Mackay and southern Queensland regions.

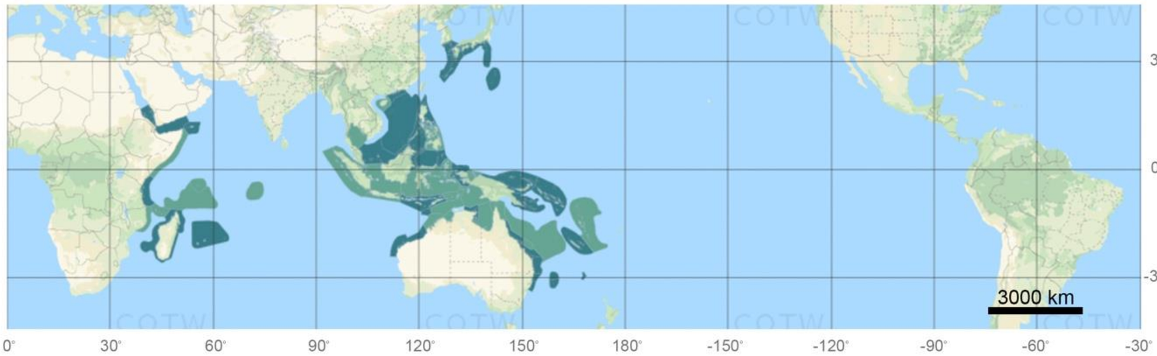



**Figure 7.5.** Global distribution range of *Micromussa lordhowensis*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** – Aside from harvest pressure, the most important known threats to *Micromussa lordhowensis* on the GBR are widespread and increasing effects of climate change and other increasing anthropogenic threats. Recurring mass bleaching events have affected reefs within the distribution range of *Micromussa lordhowensis* (e.g., Hughes et al., 2017, 2018; Pratchett et al., 2021). Moreover, experimental studies suggest that *Micromussa lordhowensis* is very sensitive to environmental changes (Pratchett et al., 2020b), with 100% mortality recorded when colonies from the southern GBR were exposed to elevated temperatures.

***Harvesting*** –*Micromussa lordhowensis* are one of the foremost target species in the QCF, and there have been significant and protracted increases in reported harvest levels from 16,249 pieces in 2009-2010 to 40,308 pieces in 2018-2019 (Figure 7.6). Despite sustained and increasing levels of harvesting, there is purported to be high selectivity for specific colour morphs (Roelofs, 2018); most colonies of *Micromussa lordhowensis* are uniform brown or green in colour, whereas harvesting is restricted to red, yellow or rainbow colour morphs. However, the proportional abundance of highly desirable colour morphs (especially in areas of concentrated harvesting) is yet to be established.

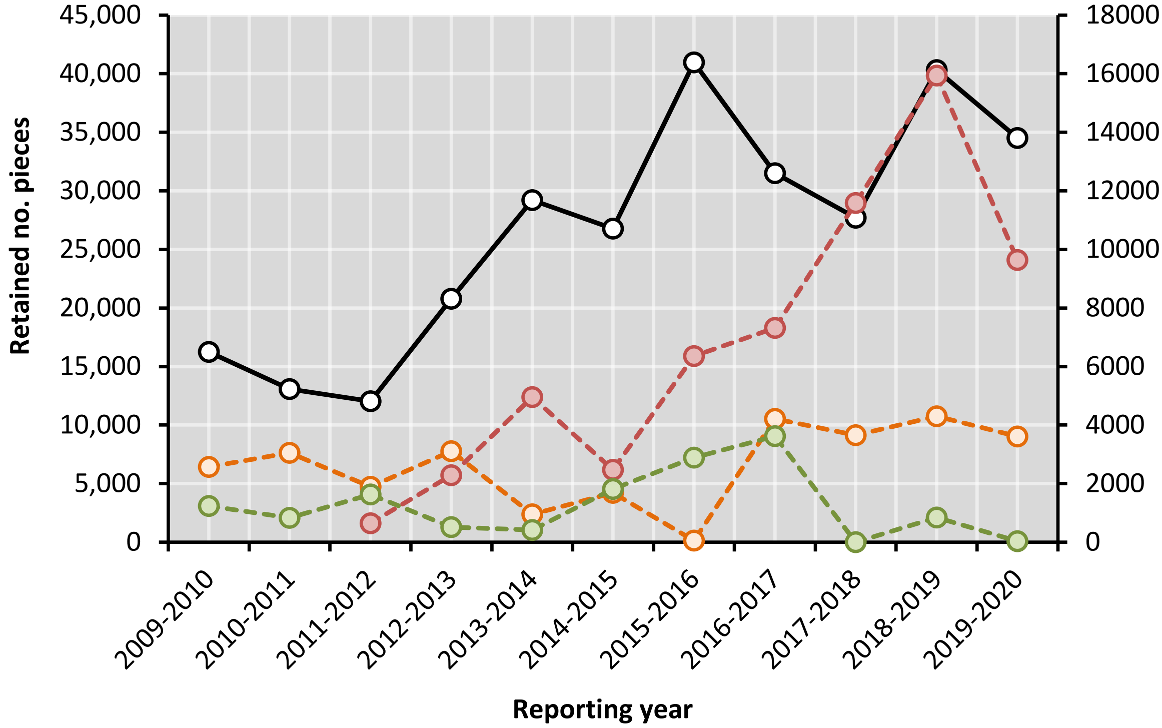



**Figure 7.6.** Interannual changes in reported harvest levels (no. of pieces) for *Micromussa lordhowensis* from 2009-2010 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from three individual 6x6nm blocks (dashed lines, and plotted on secondary axis), which account for most (collectively 35.5%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

Like other colonial corals, resilience to harvesting may be ensured by taking only a portion (<50%) of *Micromussa lordhowensis* colonies, thereby allowing for rapid recovery through re-growth, rather than taking entire colonies which can only be replaced if there is effective reproduction and settlement.

Harvesting of *Micromussa lordhowensis* on the GBR has been reported from 72 (53.3%) distinct 30x30 nm blocks. However, most (53.8%; 157,631 out of 293,192 pieces) of *Micromussa lordhowensis* have been harvested from 2 adjacent 30x30 nm blocks, in near-shore areas of the southern GBR. These areas may support usually high abundances of *Micromussa lordhowensis*, or disproportionate abundances of highly desirable colour morphs.

Reported harvest levels from individual 6x6nm blocks have fluctuated among years, with apparent increases in harvest levels reported for the single block that accounts for most (20.9%) of the reported harvests of *Micromussa lordhowensis*

(Figure 7.12). There has been an apparent decline in harvest levels reported from one block and low levels of harvesting reported from 2017-2018 (Figure 7.12). It is unknown if this is due to localised depletion, or changing fishing practices that were independent of changes in abundance of these corals.

***Population status and trends*** – The population status and trends for *Micromussa lordhowensis* in Queensland waters are not known, but their abundance may have declined in areas affected by severe heatwaves and coral bleaching. Most notably, this species appears to be particularly susceptible to elevated temperatures (Pratchett et al., 2020b), potentially explaining why it is most abundant on high latitude reefs (Arrigoni et al., 2016).

Recent fishery-independent surveys (Pratchett et al., 2020a) recorded low densities (2.3 colonies per $50m^2 \pm 0.4SE$) and biomass (0.6 kg per $50m^2 \pm 0.2SE$) of *Micromussa lordhowensis* even in the southern GBR. These data would suggest that *Micromussa lordhowensis* is generally uncommon (Pratchett et al., 2020a), but may be abundant in very specific habitats and areas. It is also unknown how the size and abundance of *Micromussa lordhowensis* in areas subjected to sustained harvest pressure compare to the densities and biomass historically, or in unfished areas. These data have limited utility justifying current harvest levels, nor establishing the biomass-based sustainable harvest limits for *Micromussa lordhowensis* without improved understanding of their distribution and abundance patterns.

***Knowledge gaps and Research priorities*** - Further research on *Micromussa lordhowensis* is warranted, mainly focussed on resolving potential taxonomic issues and the true geographical distribution and habitat associations. Explicit sampling also needs to be conducted in major harvest areas to provide more robust estimates of stock size, and also assess the proportion of colonies that are and are not susceptible to harvesting, based on colour and form.

Asexual propagation (fragging) of this species provides considerable opportunity to reduce wild harvest, and will likely preserve the colour of successive generations of fragments, though this does need to be explicitly tested.

## 7.4 *Trachyphyllia geoffroyi*

**Family:** Merulinidae

**IUCN Red List Category:** Near Threatened (last assessed in 2008)

**QCF Risk Rating:** Moderate (2013 ERA); *CITES species of concern* (e.g., DAF, 2014)

**Taxonomic References:** Huang et al. (2014)

***Biology and Ecology -*** *Trachyphyllia geoffroyi* colonies are flabello-meandroid, and often hourglass shaped. They are free-living and solitary, and often found in inter-reef environments, on soft sand or muddy substrates around continental islands. Juvenile corals initially settle on, and attach to, hard substrates (e.g., rocks or shells), but later break off as they get bigger and heavier, becoming free-living polyps with a cone-shaped bottom that helps them anchor in soft bottom environments (Fisk 1983). Histological analysis reveals that *Trachyphyllia geoffroyi* is a hermaphroditic broadcast spawner (Pratchett et al., 2020a). Preliminary studies of growth rates in the field (Pratchett et al., 2020a) suggested that these corals are very slow growing and long-lived, with negligible change in the size of corals recorded over 1-2 years.

***Taxonomy*** - Despite apparent differences in size, shape and colouration (e.g., from the northern versus southern GBR), recent genetic sequencing did not distinguish *Trachyphyllia geoffroyi* from Queensland and Western Australia, let alone from different regions of the GBR (Pratchett et al., 2020a).

***Geographic range*** - Confirmed and strongly predicted records of *Trachyphyllia geoffroyi* cover a total of 69 ecoregions representing 46% of global ecoregions and 51.9% of ecoregions in the Indo-Pacific region (Figure 7.7; Veron et al., 2021), occurring throughout the Indo west-Pacific. They are generally rare on reefs, but common around continental islands and in some inter-reef areas. *Trachyphyllia geoffroyi* is the only extant species in the genus *Trachyphyllia* (Huang et al., 2014).

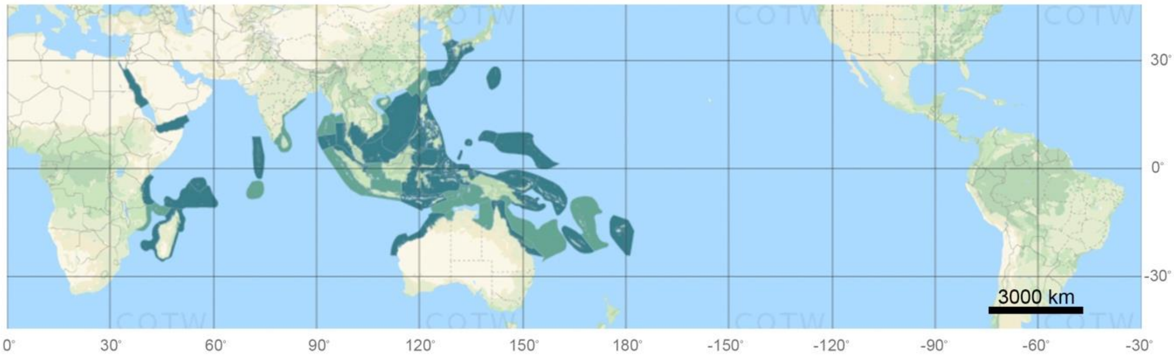



**Figure 7.7.** Global distribution range of *Trachyphyllia geoffroyi*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** - While *Trachyphyllia geoffroyi* readily bleaches when exposed to elevated temperatures, it rarely succumbs to temperature stress and is much more resilient to environmental change than any of the other coral species examined (Pratchett et al., 2020b). The risk posed by marine heatwaves for *Trachyphyllia geoffroyi* may be moderated by their tendency to occur in relatively deep, inter-reef habitats, where bleaching incidence has not been specifically assessed. Unattached colonies of *Trachyphyllia geoffroyi* may however, be vulnerable to displacement during severe storms or cyclones.

*Trachyphyllia geoffroyi* is heavily harvested by the QCF, and considered to be particularly prone to localised depletion in areas of sustained and concentrated fishing effort. *Trachyphyllia geoffroyi* can have very high abundance and biomass in specific habitats; however, most corals are harvested as relatively small and discrete colonies, from areas with fairly moderate abundance and biomass. Harvesting of entire colonies may reduce the density of coral broodstock in the wild and impair recruitment and population replenishment, though patterns of recruitment and population replenishment are not known for *Trachyphyllia geoffroyi*.

***Harvesting*** – Reported harvest levels for *Trachyphyllia geoffroyi* (based on the number of pieces retained annually) from the GBR consistently averaged around 7,500 pieces per year from 2006-2007 through 2017-2018, before increasing to 24,188 pieces in 2018-2019 and 29,159 pieces in 2019-2020. This is an increase of 70-75% in just the last few years (Figure 7.8). Although widely distributed and abundant in certain habitats (Roelofs, 2018), the slow growth currently reported for these corals (Pratchett et al., 2020a) may greatly increase their vulnerability to over-exploitation, and it is unknown to what extent localised fisheries depletion and effective reductions in mean coral size may undermine reproductive capacity and population viability.

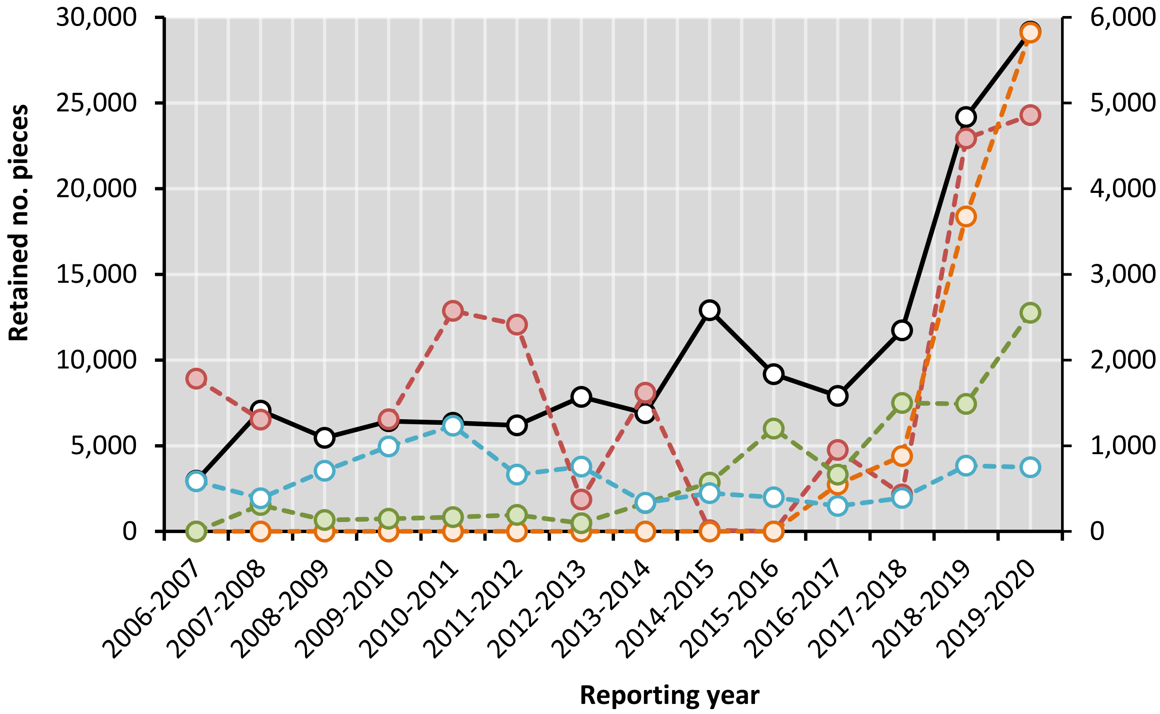



**Figure 7.8.** Interannual changes in reported harvest levels (no. of pieces) for *Trachyphyllia geoffroyi* from 2006-20070 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from four individual 6x6nm blocks (dashed lines), which account for most (collectively 35.5%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

Harvesting of *Trachyphyllia geoffroyi* on the GBR has been reported from a relatively limited, but increasing number of distinct 30x30 nm blocks (Figure 4.8). Harvesting is relatively evenly apportioned across a number of distinct blocks, and from several distinct regions (e.g., northern and southern GBR). Reported harvest levels from individual 6x6nm blocks have fluctuated among years, though apparent increases in overall harvest levels since 2017-2018 are attributable to increased harvested levels across all four distinct blocks that account for the majority (collectively 35.5%) of reported harvesting (Figure 7.8). Importantly, there is no evidence of sustained declines in reported harvest levels at key harvest locations do not show, as would be expected if purported localised depletion of *Trachyphyllia geoffroyi* (e.g., Roelofs, 2018) had lasting effects of harvest levels.

***Population status and trends*** – The population status and trends for *Trachyphyllia geoffroyi* in Queensland waters are not known, and given that they generally occur in inter-reef habitats, reported declines in abundance of corals in shallow reef habitats across the GBR (e.g., Mellin et al., 2019) is of limited relevance.

Recent fishery-independent surveys (Pratchett et al., 2020a) recorded moderate densities (13.8 individuals per $50m^2 \pm 2.1SE$), but low biomass (0.7 kg per $50m^2 \pm 0.1SE$) of *Trachyphyllia geoffroyi*. The estimated biomass of all colonies surveyed totalled 13.0 kg (Pratchett et al., 2020a), though *Trachyphyllia geoffroyi* was recorded in a number of disparate locations across the GBR. These data have no utility justifying current harvest levels, nor establishing the biomass-based sustainable harvest limits for *Trachyphyllia geoffroyi*. It is also unknown how the size and abundance of *Trachyphyllia geoffroyi* in areas subjected to sustained harvest pressure compare to the densities and biomass historically, or in unfished areas.

***Knowledge gaps and Research priorities* –** Further research on population dynamics and turnover for *Trachyphyllia geoffroyi* is critically needed to understand the capacity of this species to recover from localised disturbances (including localised fisheries depletion). Most importantly, we need to understand replenishment processes, including reproduction, larval development, settlement rates and habitat requirements, as well as growth and survival of juveniles. This information will not only inform fisheries management, but help determine the viability of captive breeding and rearing.

## 7.5 *Fimbriaphyllia ancora*

**Family:** Euphyllidae

**IUCN Red List Category:** Vulnerable
(last assessed in 2008)

**QCF Risk Rating:** Low (2013 ERA)

**Taxonomic References:** Luzon et al. (2017)

***Biology and Ecology*** - *Fimbriaphyllia ancora* forms large flabello-meandroid colonies with polyps that have tubular tentacles with no side branches but with anchor- or bean-shaped tips. The polyps extend during the day and only partially at night, but the skeleton is obscured unless the tentacles are contracted. When feeding, the tentacles usually elongate. Large colonies are usually found in shallow environments exposed to moderate wave action. *Fimbriaphyllia ancora* are gonochoric, producing only male or female gametes within each colony. During spawning, gametes are released in synchrony for external fertilisation (Twan et al., 2003).

***Taxonomy*** – Recent molecular analysis has verified that the genus *Euphyllia* should be split into two genera: *Euphyllia* and *Fimbriaphyllia*; with *Fimbriaphyllia ancora* classified under the latter (Luzon et al., 2017). The dichotomy between these two genera is supported by divergence in polyp shape and length, sexuality, and reproductive mode.

***Geographic range*** – Confirmed and strongly predicted records of *Fimbriaphyllia ancora* cover a total of 68 ecoregions representing 45.3% of global ecoregions and 51.1% of ecoregions in the Indo-Pacific region (Figure 7.9; Veron et al., 2021), occurring throughout the Indo west-Pacific. They are seldom common, but may be a dominant species on protected horizontal substrates and on rocky outcrops in high latitude locations.

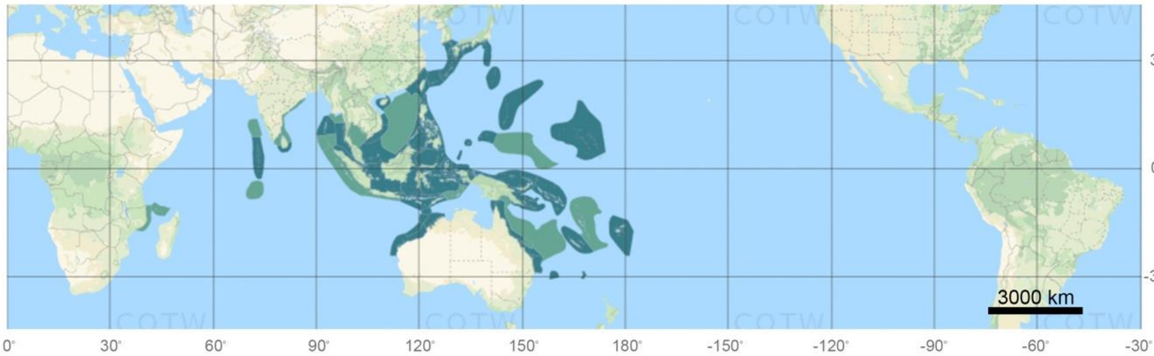



**Figure 7.9.** Global distribution range of *Fimbriaphyllia ancora*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** - Aside from harvest pressure, the most important known threat to *Fimbriaphyllia ancora* on the GBR are widespread and increasing effects of climate change and other increasing anthropogenic threats. Recurring mass bleaching events have certainly affected reefs within the distribution range of *Fimbriaphyllia ancora* (e.g., Hughes et al., 2017, 2018; Pratchett et al., 2021). However, the specific thermal sensitivity and bleaching susceptibility of *Fimbriaphyllia ancora* is unknown.

***Harvesting*** - Harvests of *Fimbriaphyllia ancora* and other *Euphyllia* spp. (except for *Euphyllia glabrescens*), were not distinguished (reported as *Euphyllia* spp.) prior to 2016-2017 (Figure 7.10). High harvest levels for *Fimbriaphyllia ancora* from 2016-2017 onwards, suggests that *Fimbriaphyllia ancora* made up a considerable proportion of previous harvest levels of *Euphyllia* spp. There was a consistent increase in harvest levels of *Euphyllia* spp. between 2006 and 2016. Harvest levels averaged at ~14,000 pieces between 2016 and 2018 (start of species-level reporting for *Fimbriaphyllia ancora*), but has since increased at a rate of 25-30% per year (18,275 pieces in 2018-2019; 25,461 pieces in 2019-2020). The risk posed by harvesting may be partly moderated by selectivity for specific colour morphs (Roelofs, 2018); most colonies of *Fimbriaphyllia ancora* are brown, whereas harvesting is restricted to green, pink and peach colour morphs. However, the proportional abundance of highly desirable colour morphs (especially in areas of concentrated harvesting) are yet to be established. The risk posed by harvesting may be further moderated by taking only fragments from larger colonies, rather than taking entire colonies or all colonies from dense but isolated assemblages.

Harvesting of *Fimbriaphyllia ancora* on the GBR has been reported from 82 (60.7%) distinct 30x30 nm blocks, with relatively high harvest levels reported from several distinct regions. Throughout the period from 2006-2007 through 2019-2020 there has been an apparent decline in reported harvests of *Fimbriaphyllia ancora* and *undifferentiated Euphyllia* spp. (data combined) at two of the 6x6nm blocks where harvesting predominantly occurred (Figure 7.10), and corresponding in increases in harvests altogether different 6x6nm blocks. It is unknown if this is due to localised depletion, but may be partly attributable to temporal changes in reporting practices, where catches of *Fimbriaphyllia ancora* where only differentiated from other *Euphyllia* spp. from 2016-2017.

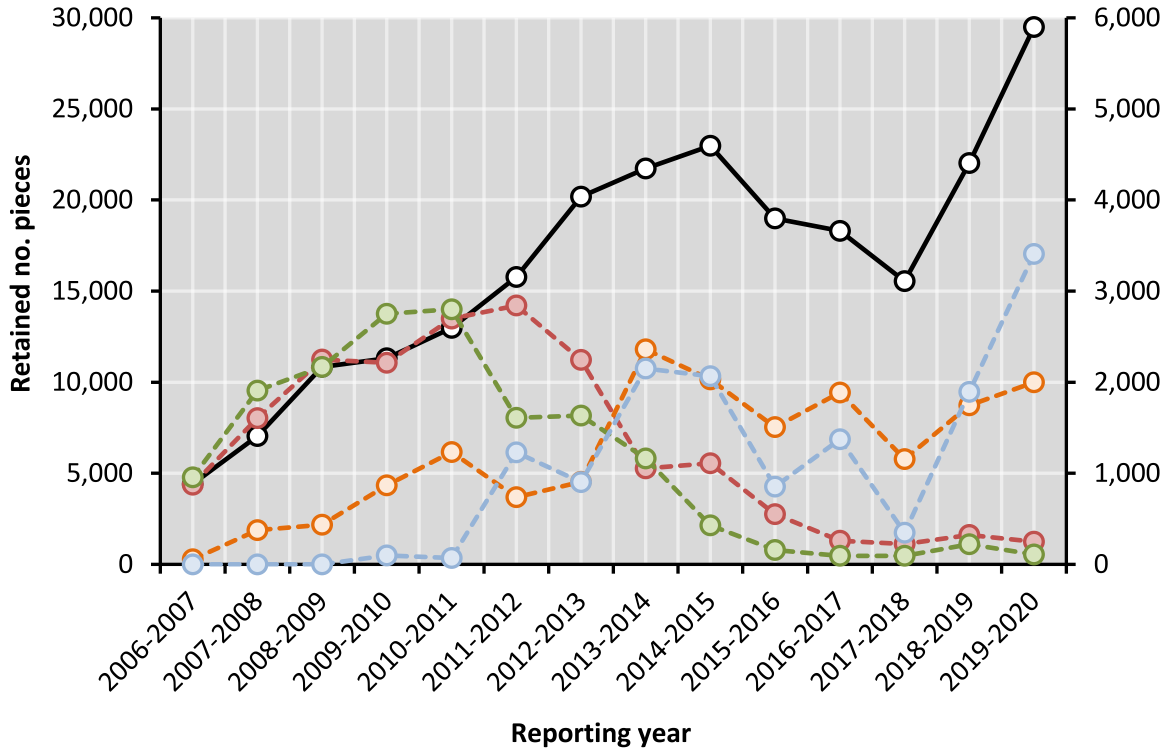


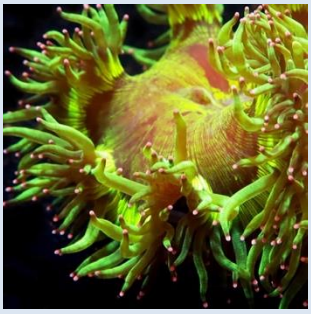

**Figure 7.10.** Interannual changes in reported harvest levels *Fimbriaphyllia ancora* and undifferentiated *Euphyllia* spp. (data combined) from 2006-2007 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from four individual 6x6nm blocks (dashed lines, and plotted on secondary axis), which account for most (collectively 28.6%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

***Population status and trends*** – The population status and trends for *Fimbriaphyllia ancora* in Queensland waters are not known, but their abundance may have declined in areas affected by severe heatwaves and coral bleaching.

Recent fishery-independent surveys (Pratchett et al., 2020a) recorded low densities (1.3 colonies per 50m$^2$ ± 0.2SE) and biomass (1.0 kg per 50m$^2$ ± 0.5SE) of *Fimbriaphyllia ancora*, though this was based on very limited samples. These data have limited utility in justifying current harvest levels, nor establishing the biomass-based sustainable harvest limits for *Fimbriaphyllia ancora* without improved understanding of their distribution and abundance patterns. It is also unknown how the size and abundance of *Fimbriaphyllia ancora* in areas subjected to sustained harvest pressure compare to the densities and biomass historically, or in unfished areas.

***Knowledge gaps and Research priorities*** –Improved information on the spatial distribution and abundance of *Fimbriaphyllia ancora*, relative to the spatial distribution of harvesting, will be essential in understanding the risk posed by harvesting. *Fimbriaphyllia ancora* is amenable to both sexual (spawning) and asexual propagation (fragging), which may reduce reliance on wild harvest and reduce pressure on wild stocks.

## 7.6 *Catalaphyllia jardinei*



**Family:** Merulinidae

**IUCN Red List Category:** Vulnerable (last assessed in 2008)

**QCF Risk Rating:** Low (2013 ERA); *CITES species of concern* (e.g., DAF, 2014)

**Taxonomic References:** Veron et al. (2021)

***Biology and Ecology*** - *Catalaphyllia jardinei* are usually free-living, and mostly occur as small discrete polyps, but can form very large flabello-meandroid colonies, especially in the southern GBR. Colonies/ polyps have long tubular tentacles extending from large fleshy oral discs that make them look like anemones during the day. The colour of tentacle tips and striped pattern on the oral disc are distinctive for this species. *Catalaphyllia jardinei* are often found in inter-reef areas with their cone-shaped base embedded in the soft substrate. Juvenile corals initially settle on, and attach to, hard substrates (e.g., rocks or shells), but later break off as they get bigger and heavier, becoming free-living when mature (Fisk 1983). Contrary to previous studies reporting the *Catalaphyllia jardinei* is gonochoric (Willis et al., 1985), more recent histological analyses revealed that this species is a hermaphroditic broadcast spawner that reaches sexual maturity at an estimated diameter of 99 mm (Pratchett et al., 2020a).

***Taxonomy*** – *Catalaphyllia jardinei* is a very distinctive coral and currently the only recognised species in the genus *Catalaphyllia* (Hoeksema and Cairns, 2021). Recent molecular analysis did not distinguish distinct morphs of *Catalaphyllia jardinei*, sampled across widely separated locations within Australia (Pratchett et al., 2020a).

***Geographic range*** – Confirmed and strongly predicted records of *Catalaphyllia jardinei* cover a total of 43 ecoregions representing 28.7% of global ecoregions and 32.3% of ecoregions in the Indo-Pacific region (Figure 7.11; Veron et al., 2021). They are widely distributed and can be very abundant in certain habitats, with large colonies in southern GBR.

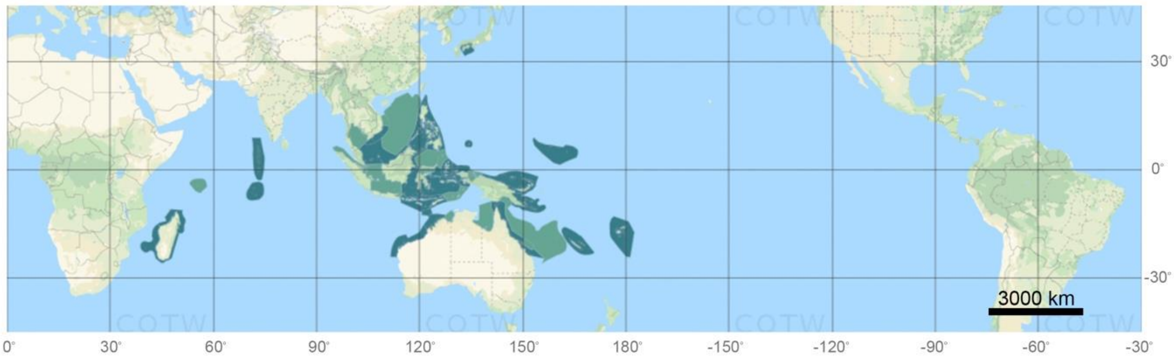



**Figure 7.11.** Global distribution range of *Catalaphyllia jardinei*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** - Aside from harvest pressure, the most important known threat to *Catalaphyllia jardinei* on the GBR are widespread and increasing effects of climate change and other increasing anthropogenic threats. The risk posed by marine heatwaves for *Catalaphyllia jardinei* may be moderated by their tendency to occur in in relatively deep, inter-reef habitats, where bleaching incidence has not been specifically assessed. However, experimental studies suggest that *Catalaphyllia jardinei* is sensitive to elevated temperatures (Pratchett et al., 2020b). Unattached colonies of *Catalaphyllia jardinei* may also be vulnerable to displacement during severe storms or cyclones.

***Harvesting*** - Harvest levels for *Catalaphyllia jardinei* (based on the number of pieces retained annually) consistently averaged around 15,000 pieces per year between 2006-2007 through 2017-2018, before increasing to 24,358 pieces in 2018-2019 and 24,857 pieces in 2019-2020 (Figure 7.12). Although they can have very high abundance in specific habitats, sustained harvesting in the same location over many years may lead to localised depletion (e.g., WA Department of Fisheries, 2008). Harvesting of entire colonies may reduce the density of coral broodstock in the wild and impair recruitment and population replenishment (*sensu* Hughes et al., 2000), though patterns of recruitment and population replenishment are not known for *Catalaphyllia jardinei*. Resilience to harvesting will also be enhanced by harvesting fragments from larger colonies, where possible, rather than removing entire large colonies.

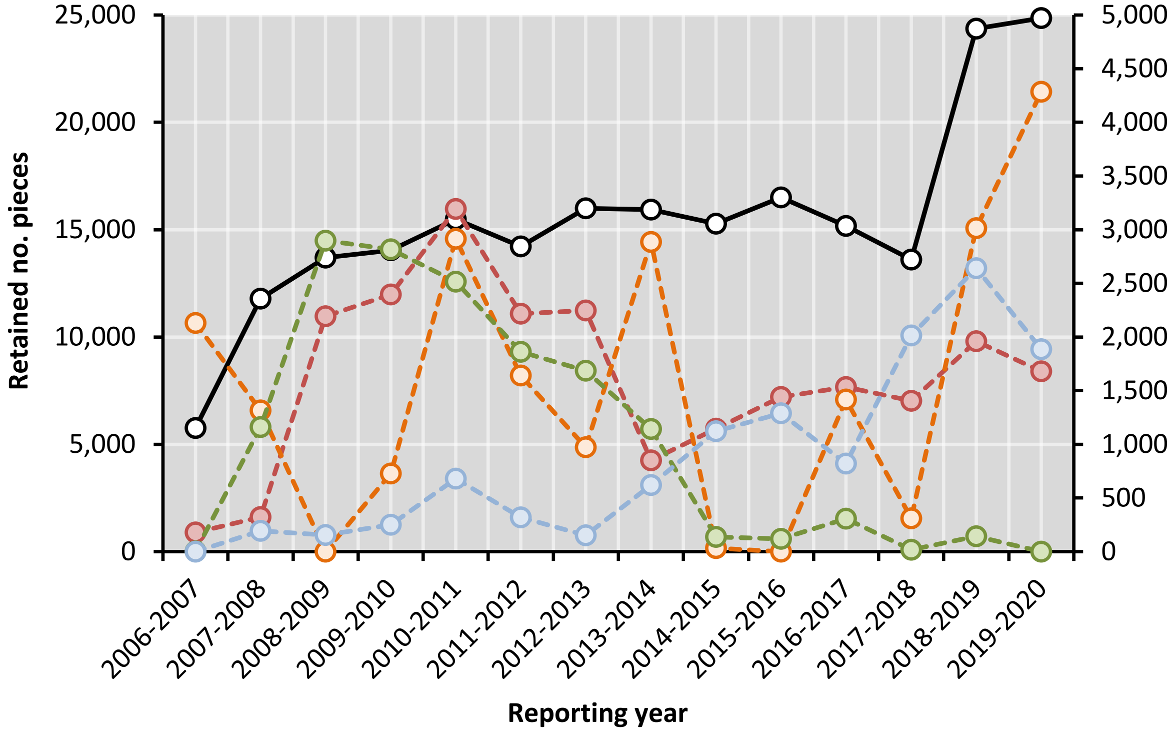



**Figure 7.12.** Interannual changes in reported harvest levels (no. of pieces) for *Catalaphyllia jardinei* from 2006-2007 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from individual 6x6nm blocks (dashed lines, and plotted against secondary axis) which account for most (collectively 32.9%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

Harvesting of *Catalaphyllia jardinei* on the GBR has been reported from 73 (54.1%) distinct 30x30 nm blocks, with moderate harvest levels reported from several distinct regions. Reported harvest levels from individual 6x6nm blocks have fluctuated among years, with no apparent trend in harvest level reported for the two blocks that account for most (10.5% and 10.0%, respectively) of the reported harvests of *Catalaphyllia jardinei* (Figure 7.12). However, there has been an apparent decline in harvest levels reported from one block and low levels of harvesting reported from 2014-2015, with corresponding increases in reported harvest levels form another distinct block (Figure 7.12). It is unknown if this is due to localised depletion, or independent changes in fishing operations.

***Population status and trends*** – The population status and trends for *Catalaphyllia jardinei* in Queensland waters are not known, and given that they generally occur in inter-reef habitats, reported declines in abundance of corals in shallow reef habitats across the GBR (e.g., Mellin et al., 2019) is of questionable relevance.

Recent fishery-independent surveys (Pratchett et al., 2020a) recorded high, but variable densities (52.3 individuals per $50m^2 \pm 26.4SE$) and biomass (324.9 kg per $50m^2 \pm 151.7$ SE) for *Catalaphyllia jardinei*. Most notably, the estimated biomass of all colonies surveyed totalled 5,208 kg (Pratchett et al., 2020a) and *Catalaphyllia jardinei* was recorded in a number of disparate locations across the GBR. These data suggest that current harvest levels for *Catalaphyllia jardinei* (Figure 4.7) pose very limited risk to widespread populations within the GBR, though more work is needed to understand growth, recruitment and population turnover, and definitively establish biomass-based sustainable harvest limits.

***Knowledge gaps and Research priorities*** – Further research on population dynamics and turnover for *Catalaphyllia jardinei* is critically needed to understand the capacity of this species to recover from localised disturbances (including localised fisheries depletion). Most importantly, we need to understand replenishment processes, including reproduction, larval development, settlement rates and habitat requirements, as well as growth and survival of juveniles. This information will not only inform fisheries management, but help determine the viability of captive breeding and rearing.

## 7.7 *Euphyllia glabrescens*

**Family:** Euphylliidae

**IUCN Red List Category:** Near Threatened (last assessed in 2008)

**QCF Risk Rating:** Low (2013 ERA);
*CITES species of concern* (e.g., DAF, 2014)

**Taxonomic References:** Luzon et al. (2017)

***Biology and Ecology*** - *Euphyllia glabrescens* forms large phaceloid colonies with corallite walls forming on the outer edges with the polyps having the ability to completely retract into the skeleton. They have long, tubular tentacles with knob-like tips that extend during the day and only partially at night. They are estimated to grow (radial extension) at a rate of 9 mm per year (Pratchett et al., 2020a). Unlike closely related species in the genus *Euphyllia* (*Fimbriaphyllia*), which are mostly broadcast spawners (Baird et al., 2009), *Euphyllia glabrescens* are hermaphroditic brooders (Fan et al., 2006; Pratchett et al., 2020a). Release of planula larvae have been reported to be associated with lunar cycles and diel patterns (Fan et al., 2006). With the appropriate conditions, survival is usually high following fragmentation. There have been reports of tentacular autotomy following mechanical agitation, followed by polyp regeneration (Toh and Ng, 2016).

***Taxonomy*** – Recent molecular analysis has verified that the genus *Euphyllia* should be split into two genera: *Euphyllia* and *Fimbriaphyllia*; with *Euphyllia glabrescens* remaining in the former (Luzon et al., 2017). The dichotomy between these two genera is supported by divergence in polyp shape and length, sexuality, and reproductive mode.

***Geographic range*** – Confirmed and strongly predicted records of *Euphyllia glabrescens* cover a total of 87 ecoregions representing 58% of global ecoregions and 65.4% of ecoregions in the Indo-Pacific region (Veron et al., 2021). They are generally uncommon, but may be abundant where they occur (Figure 7.13), although the distribution of preferred colour morphs may be more limited.

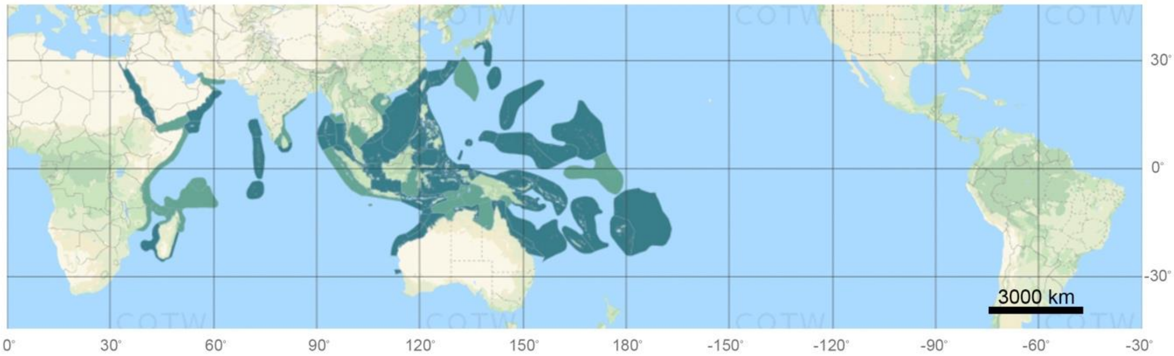



**Figure 7.13.** Global distribution range of *Euphyllia glabrescens*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** - Recurrent mass bleaching events (Hughes et al., 2017, 2018) have affected reefs within the distribution range of *Euphyllia glabrescens.* Moreover, *Euphyllia glabrescens* has been shown to be particularly susceptible to experimentally-imposed temperature stress (Pratchett et al., 2020b).

*Euphyllia glabrescens* is one of the most sought-after corals by the aquarium trade, and concerns have been raised about the sustainability of wild collection. Although they are widespread and occur in a range of different habitats, their specific reproductive mode (brooding larvae) could indicate that new colonies will really only establish within the immediate vicinity of reproductive adults, such that localised depletion may have lasting effects on population replenishment. *Euphyllia glabrescens* also often occur as very large colonies or aggregations (often of the same colour morph), making them particularly vulnerable to localised and serial depletion.

***Harvesting*** - Reported harvest levels for *Euphyllia glabrescens* increased steadily from 2,642 pieces in 2016-2017 up to 11,967 pieces in 2018-2019, but increased markedly to 21,914 pieces in 2019-2020 (Figure 7.14). Harvesting is largely focussed on very specific and vibrant colours and the best available knowledge suggests that all colour morphs are the same species. If so, this will greatly moderate the ecological risk posed by harvesting on the species as a whole. The risk posed by harvesting may be further moderated by only harvesting small fragments from larger colonies, rather than taking entire colonies or all colonies of desirable colours from dense but isolated assemblages.

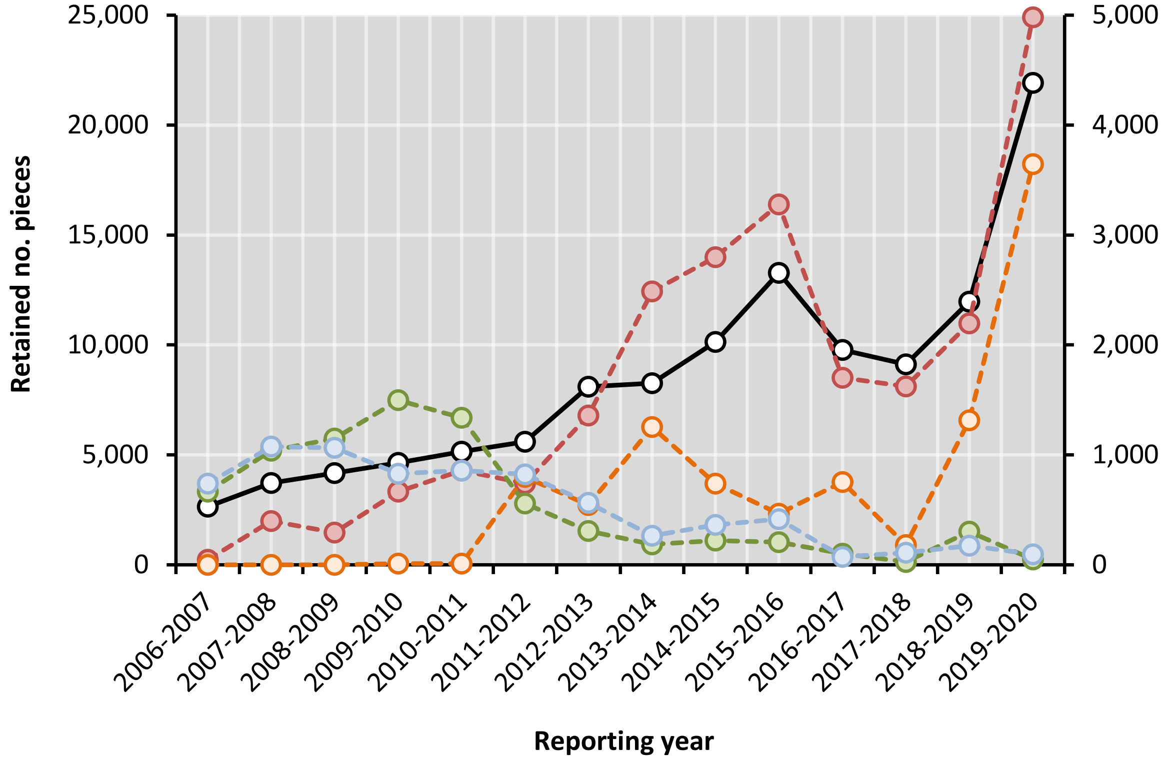



**Figure 7.14** Interannual changes in reported harvest levels (no. of pieces) for *Euphyllia glabrescens* from 2006-2007 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from individual 6x6nm blocks (dashed lines, and plotted against secondary axis) which account for most (collectively 40.7%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

Harvesting of *Euphyllia glabrescens* on the GBR has been reported from 90 (66.7%) distinct 30x30 nm blocks, with relatively high harvest levels reported from several distinct regions. Throughout the period from 2006-2007 through 2019-2020 reported harvests of *Euphyllia glabrescens* (data combined) have been increased (in line with overall harvests) at two of the predominant 6x6nm blocks where harvesting predominantly occurred (Figure 7.14). Meanwhile, reported harvests have declined throughout this period at two other 6x6nm blocks. It is unknown if this is due to localised depletion, or changing fishing practices that were independent of changes in abundance of these corals.

***Population status and trends*** – The population status and trends for *Euphyllia glabrescens* in Queensland waters are not known, but their abundance may have declined in areas affected by severe heatwaves and coral bleaching.

Recent fishery-independent surveys (Pratchett et al., 2020a) recorded low densities (3.1 colonies per $50m^2 \pm 0.8SE$) and biomass (1.9 kg per $50m^2 \pm 0.8SE$) of *Euphyllia glabrescens*, though this was based on very limited samples. These data have limited utility in justifying current harvest levels, nor establishing the biomass-based sustainable harvest limits for *Euphyllia glabrescens* without improved understanding of their distribution and abundance patterns. It is also unknown how the size and abundance of *Euphyllia glabrescens* in areas subjected to sustained harvest pressure compare to the densities and biomass historically, or in unfished areas.

***Knowledge gaps and Research priorities*** – The research priority for this species is to explore whether highly desirable colours have a genetic basis, which will be readily achieved using selective breeding experiments. Given that this species is rarely common, concentrated harvesting in areas where aggregations and highly desirable colour morphs of *Euphyllia glabrescens* are found may lead to localised depletion.

As a brooder, *Euphyllia glabrescens* makes a good candidate for sexual propagation (Nietzer et al., 2018), although further studies are needed to enhance settlement rates, as well as post-settlement growth and survival.

## 7.8 *Cycloseris cyclolites*

**Family:** Fungiidae

**IUCN Red List Category:** Least Concern (last assessed in 2008)

**QCF Risk Rating:** Low (2013 ERA)

**Taxonomic References:** Gittenberger et al. (2011); Veron et al. (2021)

***Biology and Ecology*** – *Cycloseris cyclolites* has a disc-shaped skeleton, where the centre is often raised and the underside is concave (Pratchett and Kelley, 2020). Colonies are free-living and commonly found in soft inter-reef and lower reef slope substrates (Fisk, 1983). They are capable of righting themselves if turned over or extricating themselves if buried under sediment, by controlling constriction and relaxation of distended tissue on the oral side and edges (Goreau and Yonge, 1968). Species under the family Fungiidae are gonochoristic and mostly spawn gametes (Baird et al., 2009), although they are also capable of reproducing asexually by fragmentation (Gilmour, 2002; Hoeksema and Waheed, 2011). Large aggregations of *Cycloseris cyclolites* and other mushroom corals, likely caused by repetitive asexual reproduction, have been reported along the eastern coast of Australia (Hoeksema, 2015).

***Taxonomy*** – *Cycloseris* was previously synonymised with *Diaseris* and classified as a subgenus of *Fungia* (Hoeksema 1989). However, more recent molecular (genetic) analysis of mushroom corals reinstated the genus *Cycloseris* (Gittenberger et al., 2011). *Cycloseris cyclolites* is a relatively distinct species first described in the early 1800s (Hoeksema and Cairns, 2021).

***Geographic range*** - Confirmed and strongly predicted records of *Cycloseris cyclolites* cover a total of 84 ecoregions representing 56.0% of global ecoregions and 63.2% of ecoregions (Figure 7.15; Veron et al., 2021), occurring throughout the Indo west-Pacific.

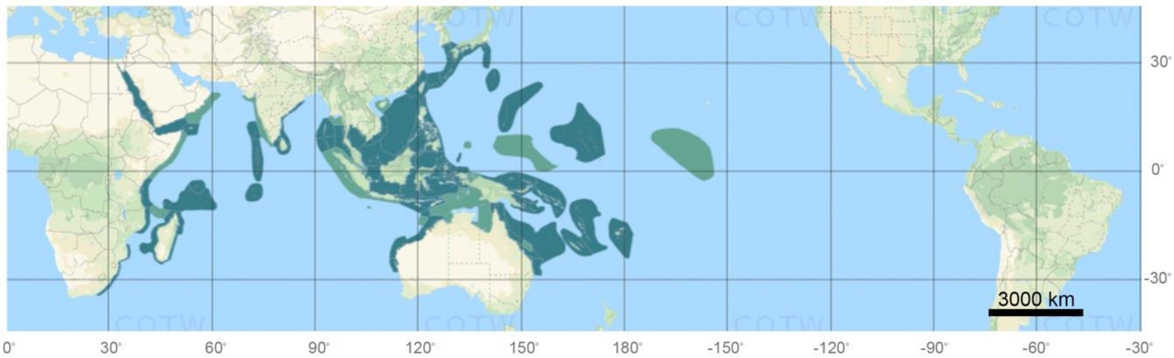



**Figure 7.15.** Global distribution range of *Cycloseris cyclolites*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** - The risk posed by marine heatwaves for *Cycloseris cyclolites* may be moderated by their tendency to occur in in relatively deep, inter-reef habitats, and bleaching incidence has not been assessed in these areas. The thermal sensitivities or bleaching susceptibility of *Cycloseris cyclolites* are also yet to be experimentally assessed. *Cycloseris cyclolites* populations may be vulnerable to cyclones and sedimentation (*sensu* Gilmour, 2004).

***Harvesting*** - *Cycloseris cyclolites* are harvested as individual, free-living polyps, in areas of inter-reef areas dominated by sandy substrates. They are rarely targeted explicitly, but often harvested opportunistically in inter-reef habitats, whilst targeting *Catalaphyllia jardinei* (Roloefs, 2018). Since specific reporting of *Cycloseris cyclolites* (as distinct from other Fungiidae) in 2016-2017, there has been a threefold increase in reported harvest levels, from 6,284 polyps in 2016-2017 up to 16,236 in 2019-2020 (Figure 7.16).

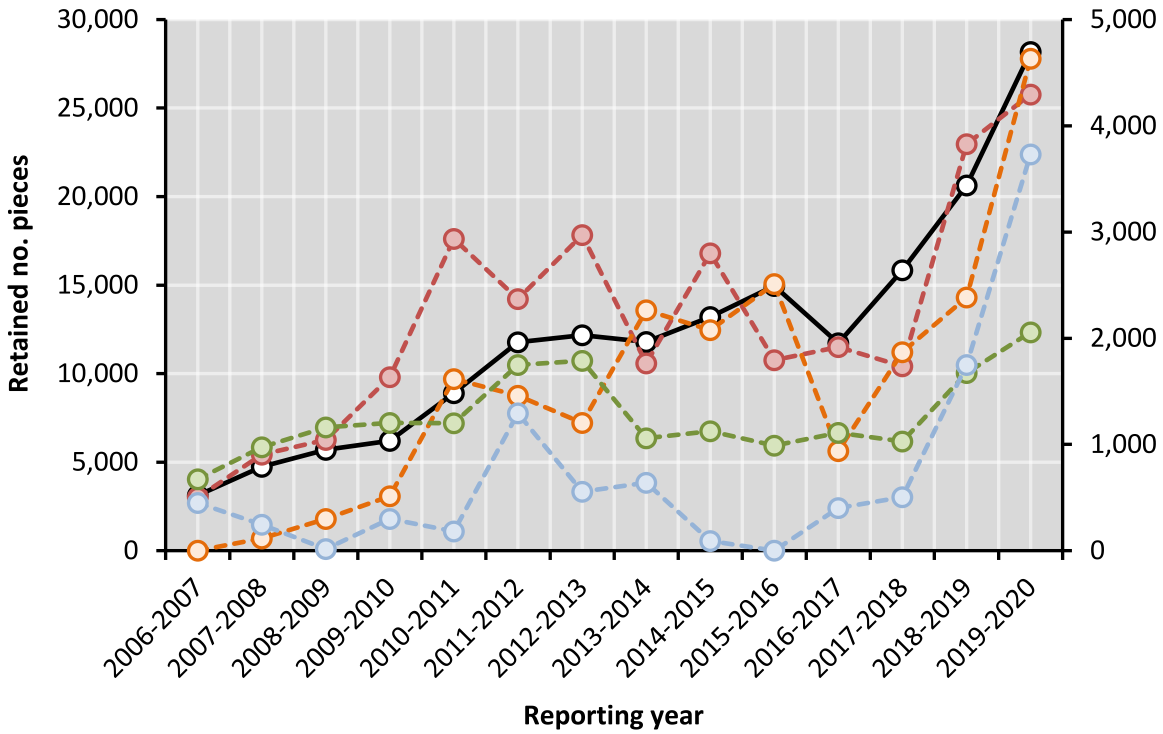


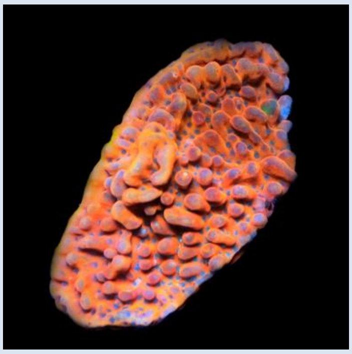

**Figure 7.16** Interannual changes in reported harvest levels *Cycloseris cyclolites* and undifferentiated Fungiidae (data combined) from 2006-2007 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from four individual 6x6nm blocks (dashed lines, and plotted on secondary axis), which account for most (collectively 47.5%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

Harvesting of *Cycloseris cyclolites* on the GBR has been reported from 50 (37.0%) distinct 30x30 nm blocks, with relatively high harvest levels reported from several distinct regions. Reported harvest levels from individual 6x6nm blocks have fluctuated among years, but increased markedly since 2017-2018 across all four distinct blocks that account for the majority (collectively 47.5%) of reported harvesting (Figure 7.16).

***Population status and trends*** – The population status and trends for *Cycloseris cyclolites* in Queensland waters are not known, and given that they generally occur in inter-reef habitats, reported declines in abundance of corals in shallow reef habitats across the GBR (e.g., Mellin et al., 2019) is of questionable relevance. There is yet to be any fishery-independent surveys conducted to assess the distribution or abundance of *Cycloseris cyclolites*. However, given these corals occur in similar areas and habitats as other targeted coral species (e.g., Catalaphyllia jardinei), existing video transects may be analysed to provide provisional data on distribution and abundance.

***Knowledge gaps and Research priorities*** – Extensive fishery-independent surveys are warranted for *Cycloseris cyclolites*, to verify its distribution and abundance on the GBR. Previous studies have concentrated on muddy or sandy substrate on deep reef slopes in the northern GBR (Goreau and Yonge, 1968; Fisk, 1983). It will also be important to understand the reproductive biology of *Cycloseris cyclolites* to better understand potential recovery and resilience to localised depletion. Growth rates following fragmentation should also be explored as a strategy for asexual propagation to reduce wild harvest.

### 7.9 *Montipora* spp.



**Family:** Acroporidae

**IUCN Red List Category:** Vulnerable to Least Concern depending on specific species (last assessed in 2008)

**QCF Risk Rating:** Low (2013 ERA)

**Taxonomic References:** Fukami et al. (2000); Veron et al. (2021)

***Biology and Ecology*** –*Montipora* is the second most speciose genus of hard corals (second only to *Acropora*), but also one of the least studied due to difficulties associated with species identification. Colonies commonly form laminar plates or encrusting sheets, but can also be foliaceous, submassive, or branching. *Montipora* spp. are often found in sheltered mid- or lower reef slope habitats (Done 1982), and are rarely dominant, but often common across a broad range of habitats. *Montipora* corals are hermaphroditic, broadcast spawners (Baird et al.,

2009) that generally release large numbers of gamete bundles (containing both eggs and sperm) during synchronised mass-spawning events. *Montipora* colonies produce eggs containing zooxanthellae (Heyward and Collins, 1985), whereas in the other genera, symbiotic algae are incorporated after the metamorphosis of larvae to polyps.

***Taxonomy*** – *Montipora* spp. are one of the three major phylogenetic lineages (together with *Acropora* spp. and *Astreopora* spp.) in the family *Acroporidae* (Fukami et al., 2000; Wallace et al., 2007). Distinguishing individual species of *Montipora* spp. is challenging, and current taxonomy is likely to be subject to a major overhaul (as per *Acropora*).

***Geographic range*** – *Montipora* spp. are widely distributed and are common on reefs and lagoons in the Pacific Ocean (throughout the GBR), Indian Ocean, and the Red Sea (Veron et al., 2021). Confirmed and strongly predicted records of *Montipora caliculata* cover a total of 82 ecoregions representing 54.7% of global ecoregions and 61.7% of ecoregions in the Indo-Pacific region (Figure 7.17).

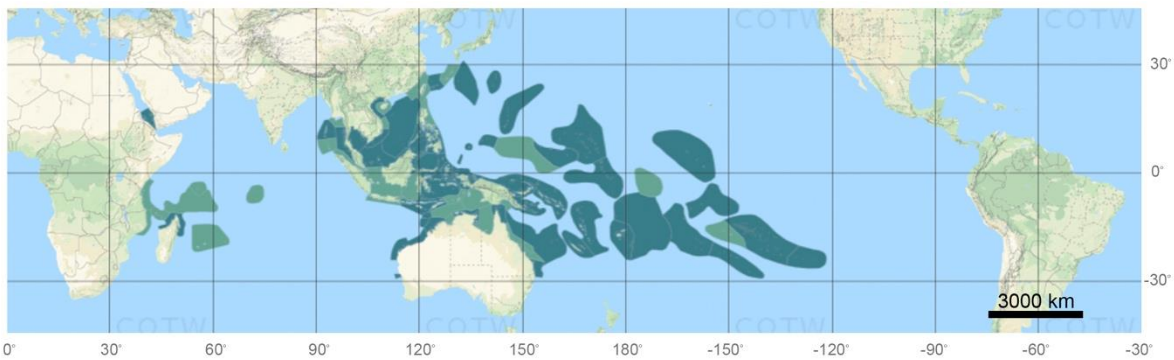



**Figure 7.17.** Global distribution range of *Montipora caliculata*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** - Like other Acroporidae, *Montipora* spp. are susceptible to anthropogenic pollution, sedimentation, climate-induced bleaching, and coral predators (Pratchett and Hoogenboom, 2019). *Montipora* spp. are generally more resistant to bleaching compared to *Acropora* spp. (Marshall and Baird, 2000; Kennedy et al., 2017), but the increasing frequency of marine heatwaves and corresponding mass bleaching events is expected to have detrimental effects on the abundance and population viability of *Montipora* spp. (Hughes et al., 2018, 2019). *Montipora* spp. are relatively fast growing and can recover quite quickly (with years), though large-scale disturbances and widespread depletion may lead to regional declines in reproduction and recruitment (Hughes et al., 2019), thereby undermining the capacity for recovery.

***Harvesting*** - *Montipora* spp. on the GBR are often harvested as fragments removed from the outer edge of large colonies or sometimes as whole colonies. Given their relatively fast growth rates, the recovery potential of these colonies can be high, especially if the majority (>50%) of the original colony remains intact. By contrast, colonies that are removed in their entirety can only be replaced through settlement and subsequent growth of entirely new colonies, which is a much slower process (Gilmour et al., 2013).

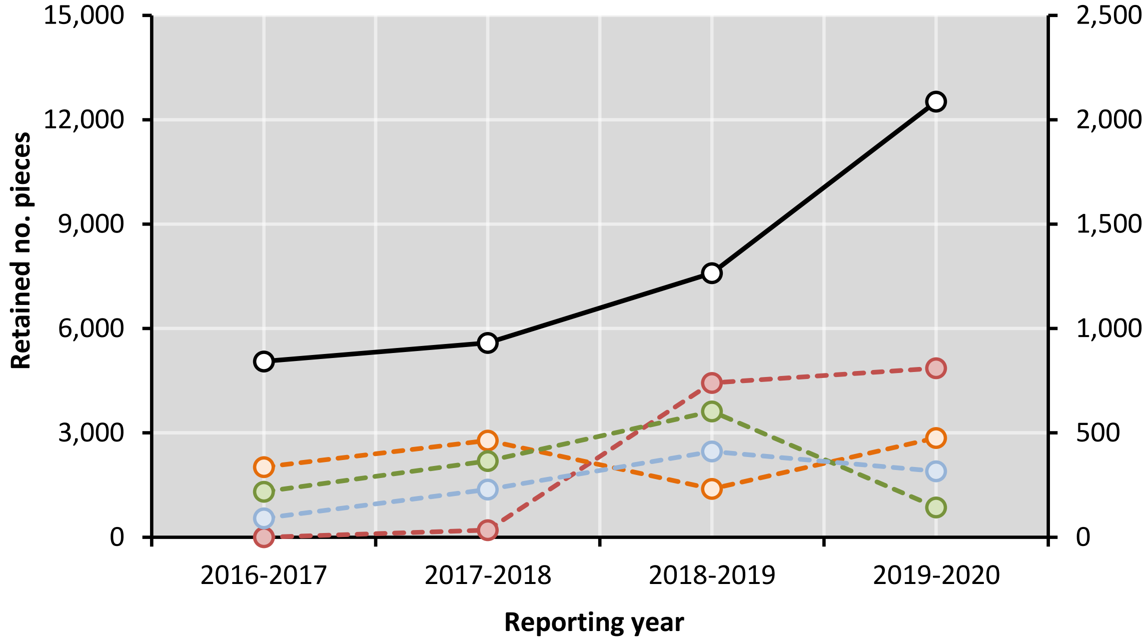



**Figure 7.18.** Interannual changes in reported harvest levels (no. of pieces) for *Montipora* spp. from 2016-2017 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from individual 6x6nm blocks (dashed lines, and plotted against secondary axis) which account for most (collectively 17.8%) of reported harvesting. Harvests of *Montipora* spp. prior to 2016-2017 were recorded as Acroporidae (see Figure 7.2). Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

Since harvest reports of *Montipora* spp. were disaggregated from Acroporidae in 2016-2017, there has been a slight increase in reported harvest levels (Figure 7.18). It is undeniable, however, that harvesting is unevenly apportioned among the wide variety of species of *Montipora* that occur on the GBR, and more work is required to characterise the range of species that are targeted, and their relative abundance at key harvest locations.

*Harvesting of Montipora* spp. has been reported from 79 (58.5%) distinct 30x30 nm blocks. However, it is very likely that different *Montipora* species occur and are harvested in different locations and habitats. Reported harvest levels from individual 6x6nm blocks have fluctuated among years, but have generally increased across all four distinct blocks that account for the majority (albeit only 17.8%) of reported harvesting (Figure 7.18).

***Population status and trends*** – Specific population trends for *Montipora* spp. are not known, but it is very likely that their abundance on the GBR has declined (and fluctuated) in approximate accordance with changes in the abundance of *Acropora* spp. (e.g., Osborne et al., 2011; Johns et al., 2014). Critically, it is expected that *Montipora* spp. will become less abundant and less resilient with increasing incidence and severity of severe heatwaves, due to anthropogenic climate change (Hughes et al 2018, 2019).

***Knowledge gaps and Research priorities*** – The main priority to assure the sustainability of ongoing harvests of *Montipora* corals is to clearly document which species are being targeted, and assess the specific abundance of these species in in major harvest areas. This may however, be partly constrained (at least in the short-term) until taxonomy is suitably refined.

## 7.10 *Duncanopsammia axifuga*

**Family:** Dendrophylliidae

**IUCN Red List Category:** Near Threatened
(last assessed in 2008)

**QCF Risk Rating:** Low (2013 ERA); *CITES species of concern* (e.g., DAF, 2014)

**Taxonomic References:** Veron et al. (2021)

***Biology and Ecology*** - *Duncanopsammia axifuga* has a tubular branching morphology, and occurs in relatively deep (~20 m) inter-reefal habitats, but also, in shallow, turbid intertidal habitats (Pratchett et al., 2020a). Colonies tend to form small creeping colonies or low profile clumps. They are estimated to grow (radial extension) at a rate of 12 mm per year (Pratchett et al., 2020a). This species is a stable gonochoric broadcast spawner (Willis et al., 1985; Pratchett et al., 2020a). Size at reproductive maturity (>50% reproductively mature) is estimated to be 83 mm diameter (Pratchett et al., 2020a).

***Taxonomy*** - *Duncanopsammia axifuga* is a fairly distinctive coral that was described in the 1800s (Hoeksema and Cairns, 2021), though it does exhibit different growth habits in different regions and environments. Preliminary genetic sequencing has confirmed the monospecific status of *Duncanopsammia axifuga* across distinct and widely separated locations in northern Australia (Pratchett et al., 2020a).

***Geographic range*** - There are confirmed and strongly predicted records of *Duncanopsammia axifuga* encompassing 15 ecoregions, representing 10% of global ecoregions and 11.3% of ecoregions in the Indo-Pacific region (Veron et al., 2021), largely constrained to northern Australia (Figure 7.19).

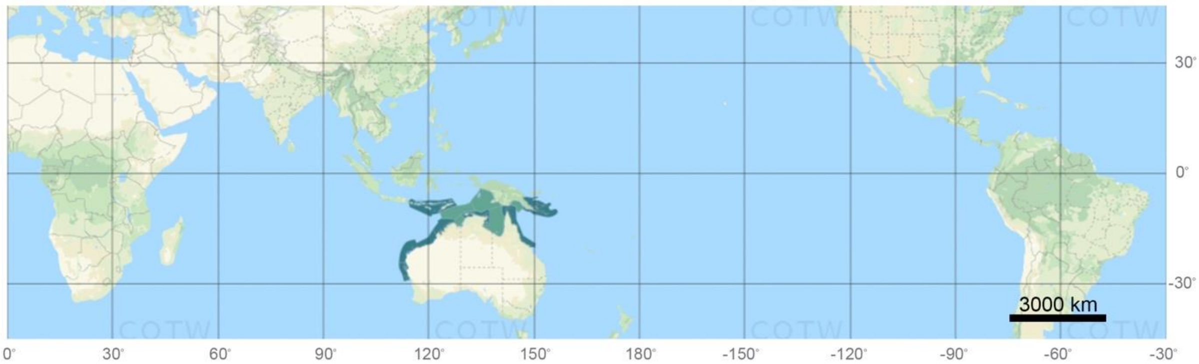



**Figure 7.19.** Global distribution range of *Duncanopsammia axifuga*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** - While *Duncanopsammia axifuga* bleaches when exposed to elevated temperatures and/ or high light intensity (Pratchett et al., 2020b), it is able to withstand (survive) considerable environmental stress. This resilience may reflect the tendency for *Duncanopsammia axifuga* to occur in a broad range of habitats, including highly turbid intertidal areas in Western Australia (Pratchett et al., 2020a).

*Duncanopsammia axifuga* is heavily targeted by the aquarium trade and there have been persistent concerns about the risk of overexploitation for *Duncanopsammia axifuga*, given it is often reported to be rare (e.g., Johns et al., 2014) and presumed to be rare (e.g., Atkinson et al., 2008). However, recent sampling in specific areas of concentrated fishing activity for *Duncanopsammia axifuga* from Western Australia confirms that this species can be very abundant in certain habitats (Pratchett et al., 2020a).

***Harvesting*** - There has been a threefold increase in the amount (number retained) of *Duncanopsammia axifuga* harvested from Queensland waters from 2006-2007 to 2019-2020, with particularly pronounced increases in harvest levels since 2016-2017 (Figure 7.20). The risk posed by harvesting is however, likely to be very low because colonies in Queensland waters tend to be sparsely branching and very fragile, such that the high number of pieces may actually reflect only very small numbers of colonies. Fragments (individual branches or clumps of branches) are also harvested mainly from the outer edge of larger colonies, which are likely to re-grow relatively quickly.

Harvesting of *Duncanopsammia axifuga* on the GBR has been reported from 70 (51.9%) distinct 30x30 nm blocks, with relatively high harvest levels reported from several distinct regions. Reported harvest levels from four distinct 6x6nm blocks that account for the majority (collectively 34.5%) of reported harvesting have fluctuated among years (Figure 7.8), but have generally declines since 2013-2014. This shows recent increases in overall harvest levels are attributable to increased harvesting in different 6x6nm blocks from where this species has been predominantly harvested, especially up until 2013-2014. Given there has not been a corresponding increase in reported harvest levels at specific 6x6nm blocks, this likely reflects moderate levels of harvesting across a broad range of different locations.

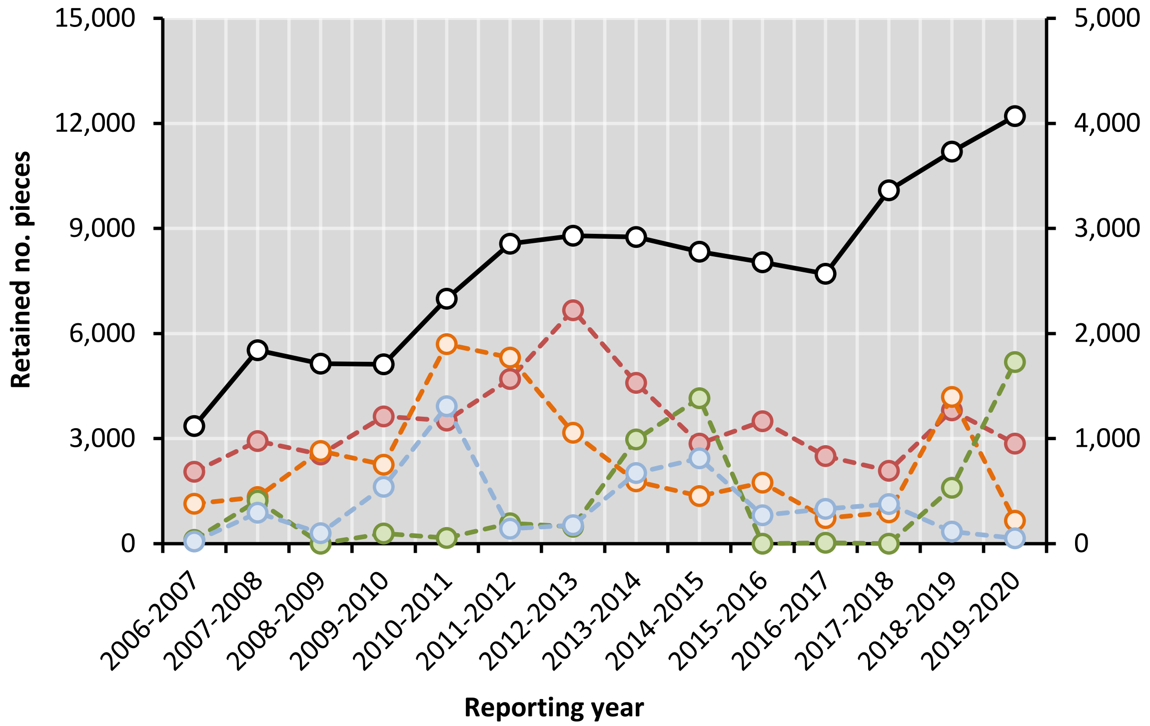



**Figure 7.20.** Interannual changes in reported harvest levels (no. of pieces) for *Duncanopsammia axifuga* from 2006-2007 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from individual 6x6nm blocks (dashed lines, and plotted against secondary axis) which account for most (collectively 34.5%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

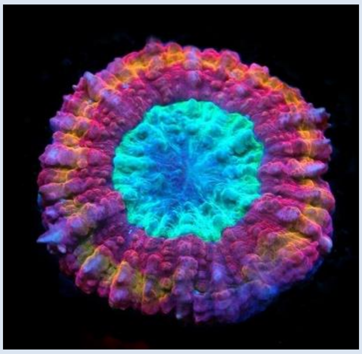
***Population status and trends*** – The population status and trends for *Duncanopsammia axifuga* in Queensland waters are not known, and given that they generally occur in inter-reef habitats, reported declines in abundance of corals in shallow reef habitats across the GBR (e.g., Mellin et al., 2019) is of questionable relevance.

Recent fishery-independent surveys (Pratchett et al., 2020a) recorded low densities (1.5 individuals per $50m^2$ ± 0.5SE) and very low biomass (0.2 kg per $50m^2$ ± 0.2SE) of *Duncanopsammia axifuga*. The estimated biomass of all colonies surveyed in Queensland totalled <1 kg (Pratchett et al., 2020a), though very high biomass of *Duncanopsammia axifuga* was recorded on some transects in WA. These data have limited utility justifying current harvest levels, nor establishing the biomass-based sustainable harvest limits for *Duncanopsammia axifuga* without improved understanding of their distribution and abundance patterns. It is also unknown how the size and abundance of *Duncanopsammia axifuga* in areas subjected to sustained harvest pressure compares to the densities and biomass historically, or in unfished areas.

***Knowledge gaps and Research priorities*** – Further research on patterns of distribution and abundance are warranted for *Duncanopsammia axifuga* on the GBR, to further verify that this species is widespread and potentially abundant in some areas or habitats. Importantly, previous field-based monitoring on the GBR (e.g., Pratchett et al., 2020a) did not encompass any areas or habitats where this species was abundant.

*Duncanopsammia axifuga* is extremely amenable to repeated fragmentation and *ex situ* propagation, which would greatly reduce pressure on wild stocks.

### 7.11 *Acanthophyllia deshayesiana*



**Family:** Lobophylliidae

**IUCN Red List Category:** Near Threatened (last assessed in 2008 as *Cynarina lacrymalis*)

**QCF Risk Rating:** Moderate (2013 ERA)

**Taxonomic References:** Darus et al. (2016); Veron et al. (2021)

***Biology and Ecology*** – *Acanthophyllia deshayesiana* has a conical, horn-like skeleton and is often free-living and buried in inter-reefal soft sediment (Pratchett & Kelley 2020). *Acanthophyllia deshayesiana* inhabit protected reef environments, and are often found attached to rocks under overhangs, or at times can be found on soft substrates with gentle currents. There is currently no published information on the reproductive biology of *Acanthophyllia deshayesiana*; although it can be assumed that they are gonochoristic spawners based on the sexuality and reproductive mode of closely related species (Baird et al., 2009).

***Taxonomy*** - Previously synonymised with *Cynarina lacrymalis* (Best & Hoeksema 1987) due to similarities in morphology and morphometric characters, *Acanthophyllia deshayesiana* is now considered a distinct genus and species based on descriptive characters (Darus et al., 2016). Skeletal structures are close to *Cynarina lacrymalis* except that the paliform crown is absent or nearly so and primary septa are larger in *Acanthophyllia deshayesiana* (Veron et al., 2021).

***Geographic range*** - Confirmed and strongly predicted records of *Acanthophyllia deshayesiana* cover a total of 13 ecoregions representing 8.7% of global ecoregions and 9.8% of ecoregions in the Indo-Pacific region (Figure 7.21; Veron et al., 2021), restricted to the Indo-Pacific archipelago (or Coral Triangle) and GBR.

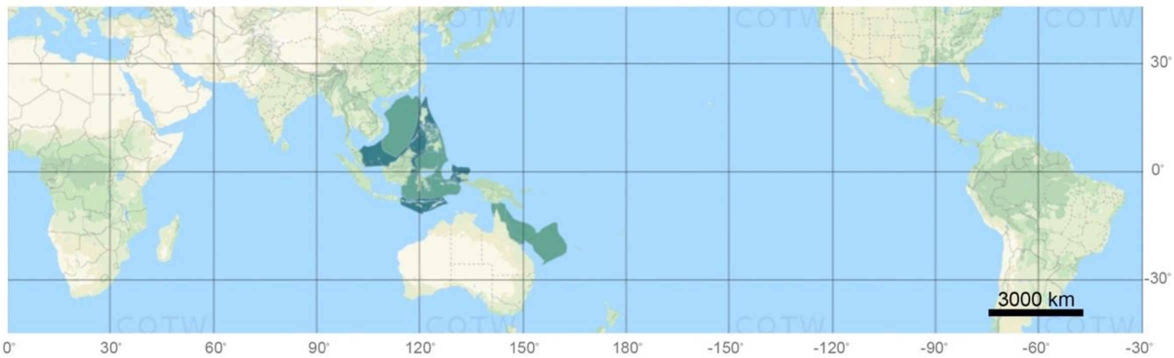



**Figure 7.21.** Global distribution range of *Acanthophyllia deshayesiana*. Dark green areas are confirmed records, light green areas are strongly predicted records (from Veron et al., 2021).

***Pressures and Threats*** - The risk posed by marine heatwaves for *Acanthophyllia deshayesiana* may be moderated by their tendency to occur in in relatively deep, inter-reef habitats, and bleaching incidence has not been assessed in these areas. The thermal sensitivities or bleaching susceptibility of *Acanthophyllia deshayesiana* are also yet to be experimentally assessed.

***Harvesting*** - Monostomatous (or single polyp) species, such as *Acanthophyllia deshayesiana* are almost universally harvested as whole specimens, which may reduce the density of coral broodstock in the wild. Regional declines in the abundance of other broadcast spawning corals has been shown to impair recruitment and population replenishment (*sensu* Hughes et al., 2000). The capacity for this species to recover from localised disturbances (including localised fisheries depletion and bleaching) is also unknown (Pratchett et al., 2020a).

Since species-level recording for *Acanthophyllia deshayesiana* started in 2016-2017, there has been a threefold increase in the reported harvest levels (number of pieces), from 2,086 colonies in 2016-2017 to over 6,057 colonies in 2019-2020 (Figure 7.22).

Harvesting of *Acanthophyllia deshayesiana* on the GBR has been reported from 38 (28.1%) distinct 30x30 nm blocks, with relatively high harvest levels reported from several distinct blocks, mainly in the northern GBR. Reported harvest levels from individual 6x6nm blocks have fluctuated among years, but have generally increased across all four distinct blocks that account for the majority (47.3%) of reported harvesting (Figure 7.18).

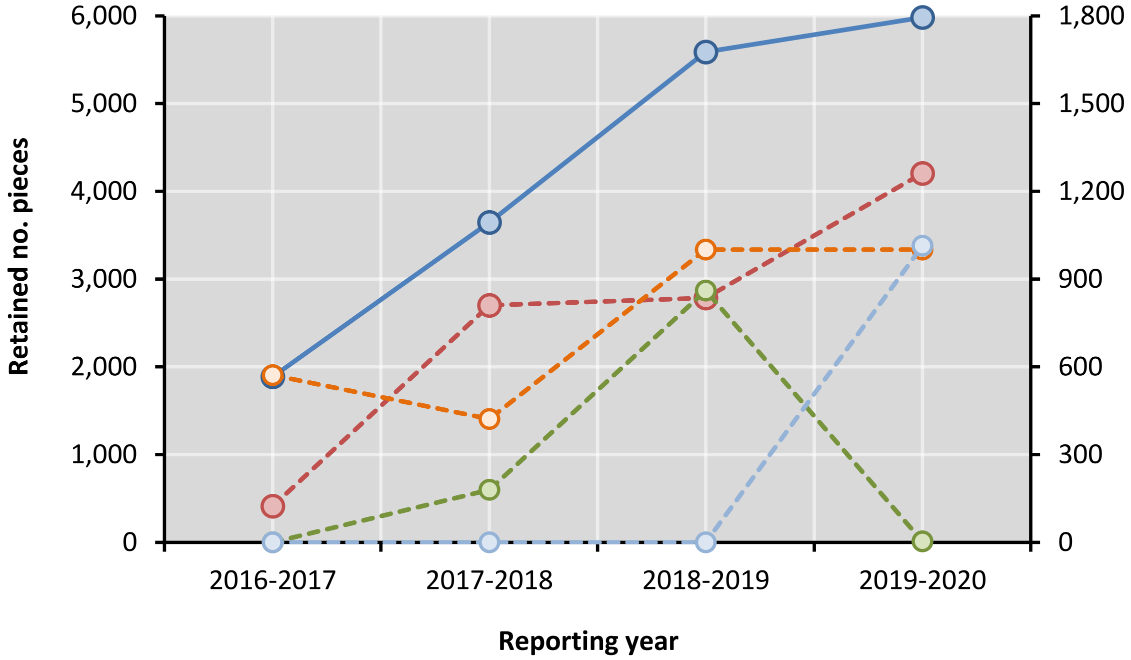



**Figure 7.22.** Interannual changes in reported harvest levels (no. of pieces) for *Acanthophyllia deshayesiana* from 2016-2017 through 2019-2020, showing overall harvest levels (solid line) and also reported harvests from individual 6x6nm blocks (dashed lines, and plotted against secondary axis) which account for most (collectively 47.3%) of reported harvesting. Harvest level data (DR3253iv) provided by Queensland Government Department of Agriculture and Fisheries, on May 25th, 2021.

***Population status and trends*** – The population status and trends for *Acanthophyllia deshayesiana* in Queensland waters are not known, and given that they generally occur in inter-reef habitats, reported declines in abundance of corals in shallow reef habitats across the GBR (e.g., Mellin et al., 2019) is of questionable relevance.

Recent fishery-independent surveys (Pratchett et al., 2020a) recorded moderate densities (6.6 individuals per $50m^2 \pm 0.7SE$) and biomass (0.3 kg per $50m^2 \pm 0.1$ SE) for *Acanthophyllia deshayesiana* in areas where it occurred. It is however, unknown how the size and abundance of *Acanthophyllia deshayesiana* in areas subjected to sustained harvest pressure compare to the densities and biomass historically, or in unfished areas. These data have limited utility in justifying even the relatively low harvest levels currently reported, nor establishing the biomass-based sustainable harvest limits for *Acanthophyllia deshayesiana* without improved understanding of their distribution and abundance patterns.

***Knowledge gaps and Research priorities*** – Further research on *Acanthophyllia deshayesiana* is warranted, particularly on taxonomy, reproductive biology and growth, population size and distribution, ecology and habitat status, threats and resilience to disturbances. Specifically, further sampling and genetic studies will be needed to validate the taxonomy of this species and to verify that it is widespread and potentially abundant in some areas of the GBR. Pressure on wild stocks of *Acanthophyllia deshayesiana* may be reduced through captive breeding, though it is first necessary to establish the capacity to produce offspring of specific colours, thereby understanding the genetic versus environmental determinants of vibrant colours.

# 8. Proposed Harvest Limits

- *Despite some improvements in knowledge of the biology of select coral species that are important target species in the QCF, there is insufficient information to justify large or rapid increases in harvest levels apparent for some species*
- *While it is premature to even consider sustainable harvest limits for the QCF, specific harvest limits need to be established for all individual coral species based on either precautionary or sustained harvest levels*
- *Further increases in harvest levels of any and all coral species should be suitably constrained, at least until there is sufficient information to support or justify increased harvest levels and limits*

There are many considerations, and different approaches that could be used, in setting appropriate harvest limits for individual coral species and genera (e.g., Kvamsdal et al., 2016). The reality is, however, that there is very limited data and information available to establish sustainable harvest limits for individual coral taxa harvested by QCF. Given very limited quantitative and verifiable information on the local distribution, abundance, stock structure and turnover of targeted coral species, as well as very limited sampling or monitoring to establish potential effects of harvesting, proposed harvest limits need to remain well within precautionary limits (e.g., Smith et al., 2011). While it is admittedly subjective what constitutes a precautionary harvest limit, the fundamental expectation is that harvest limits should be maintained at initial low levels, and only increased very slightly and only after prolonged periods of monitoring of fisheries catch and effort data during sustained management arrangements. If however, there is relevant information to support a fundamentally different approach to setting harvest levels and limits (Table 7.1) then there is no need to constrain increases in harvest levels. Rather, harvest limits should be set according to sustainability principals and allowed to fluctuate so long harvest levels remain at or below specified limits.

Even though overall harvest levels of hard corals for the QCF are still well within legislated and sustained catch limits (e.g., 60,000 kg for specialty coral species), there is a recognised need to constrain both the growth rates and the overall magnitude of increases in harvest levels for individual coral species (e.g., DEEDI, 2009; DAF, 2021a). Most notably, the QCF Harvest Strategy (2021-2026) suggests that future average annual harvest levels should be limited to 0.8 times reference harvest levels for any and all species where current harvesting is considered to pose an unacceptable level of risk. Given marked increases in reported harvest levels for several coral species that have also already been highlighted as CITES *species of concern*, such constraints (as applied to Tier 1 species) should be applied to multiple species, including *Acropora* spp., *Micromussa lordhowensis*, *Homophyllia* cf. *australis*, *Trachyphyllia geoffroyi*, and *Acanthophyllia deshayesiana* (Table 8.1). This approach will redress very recent and pronounced increases in harvest levels observed for some taxa (e.g., *Trachyphyllia geoffroyi*), but still does not entirely account for long-term sustained increases in harvest levels apparent for some other species, especially *Homophyllia* cf. *australis* and *Micromussa lordhowensis*.

For *Acropora* spp., a definite harvest limit needs to be established and is long overdue. There have been very large increases in harvest levels over many years, and despite triggering management thresholds (e.g., DEEDI, 2012), no constraints on harvest levels have ever been imposed. Given that *Acropora* spp. are reported under the OC quota category in the QCF, there is potential for up to 140,000 kg of *Acropora* spp. to be harvested annually from the GBR.

For *Acropora* spp., as for other colonial coral species, quota limits based on the number of pieces (colonies or fragments) are inappropriate given the considerable variation in the size of *Acropora* colonies or fragments that may be harvested. It is more appropriate to propose weight-based harvest limits (Table 8.1). Using extensive data for *Acropora* spp. harvested by the QCF (Pratchett, 2021), a weight conversion factor of 0.23 was applied to catch records (based on number of pieces) resulting in a proposed harvest limit of 19,500kg. All weight conversion factors should be verified and suitably modified (if necessary) based on extensive data that will become available once simultaneous reporting of both number of pieces and their combined weight is mandated. However, the proposed harvest limit (19,500kg) is based on best available information, and applies the Tier 1 (0.8) multiplier. Given much of the concern regarding coral loss and reef degradation is centred around *Acropora* spp. (see Section 1.4), there is strong justification for recognising *Acropora* spp. as Tier 1 species (for which current harvest levels and limits pose an unacceptable risk). It is acknowledged, however, that there is very high biomass of *Acropora* spp. on many GBR reefs (e.g., Pratchett, 2021; see also Section 7.1). However, it not appropriate to establish biomass-based sustainable harvest limits for entire genera, because it does not account for differences in abundance and vulnerability among the wide range of species that may be harvested.

Reduced harvest limits (below reference harvest levels) are also proposed for *Micromussa lordhowensis*, even though this species was not considered in the moderate risk category during the last (2013) ERA (Roelofs, 2018). This is because there have been significant and protracted increases in reported harvest levels since 2009-2010, when species-specific harvest levels were first reported for *Micromussa lordhowensis*. Substantial increases in harvest levels (>70%) for *Micromussa lordhowensis* also triggered performance measures in 2014, though required management actions were deferred on the basis that the PMS needed to be reviewed (DEEDI, 2012). Independent concerns regarding the vulnerability of *Micromussa lordhowensis* to overexploitation by the QCF have also been raised previously (Jones, 2011), and recent surveys failed to establish high abundance of this species (Pratchett et al., 2020a) purported to occur in certain areas or habitats (Roelofs, 2018).

In addition to the aforementioned species (*Acropora* spp., *Micromussa lordhowensis*, *Homophyllia* cf. *australis*, *Trachyphyllia geoffroyi*, and *Acanthophyllia deshayesiana*), there are at least 6 other species/ genera for which there have been large (mostly very recent) increases in reported harvest levels (Table 7.2). These species (e.g., *Catalaphyllia jardinei, Fimbriaphyllia ancora*, *Euphyllia glabrescens*, *Duncanopsammia axifuga*, *Cycloseris cyclolites*, and *Montipora* spp.) are however, of low concern relative to the aforementioned group of species, and so it is probably unnecessary to impose harvest limits that are actually lower (e.g., 0.8x) than the reference harvest levels. Nonetheless, there is insufficient information to justify the large increases in harvest levels that have already occurred, let alone allow for further increases in average annual harvest levels. At a minimum, harvest limits should be equal to the reference harvest levels, thereby ensuring future annual harvests do not exceed the average of the reported harvest levels for the 3-year reference period, from 2016-2017 through 2018-2019.

**Table 8.1**. Proposed QCF harvest limits for CITES-listed hard coral species to account for recent increases in reported harvest levels, and constrain further increases relative to average harvest levels for a 3-year reference period (2016-2017 through 2018-2019). For species of moderate concern it is suggested that harvest limits should be set at 0.8 times of reference harvest levels For species of low concern, it is suggested that harvest limits should not exceed the reference harvest levels. These harvest limits are intended to represent maximum harvest levels in each subsequent harvest year, at least until there is relevant information or appropriate justification (including revised and rigorous estimates of weight conversions) for modifying harvest levels and limits.

| Concern | Taxa | Reference harvest level | Multiplier | Harvest limit (no. pieces) | Weight Conversion | Harvest limit (kg) |
|---|---|---|---|---|---|---|
| Moderate | *Acropora* spp. | 105,977 | 0.8 | 84,782 | 0.23 | 19,500 |
| Moderate | *Micromussa lordhowensis* | 33,169 | 0.8 | 26,535 | 0.14* | 3,715 |
| Moderate | *Homophyllia* cf. *australis* | 22,190 | 0.8 | 17,752 | 0.06* | 1,065 |
| Moderate | *Trachyphyllia geoffroyi* | 14,609 | 0.8 | 11,687 | 0.06* | 701 |
| Moderate | *Acanthophyllia deshayesiana* | 4,177 | 0.8 | 3,341 | 0.11* | 368 |
| Low | *Catalaphyllia jardinei* | 17,715 | 1.0 | 17,715 | 0.10* | 1,772 |
| Low | *Fimbriaphyllia ancora* | 15,525 | 1.0 | 15,525 | 0.12* | 1,863 |
| Low | *Euphyllia glabrescens* | 10,288 | 1.0 | 10,288 | 0.09* | 926 |
| Low | *Duncanopsammia axifuga* | 9,661 | 1.0 | 9,661 | 0.10 | 966 |
| Low | *Cycloseris cyclolites* | 8,684 | 1.0 | 8,684 | 0.06 | 521 |
| Low | *Montipora* spp. | 6,106 | 1.0 | 6,106 | 0.18 | 1,099 |

* Weight conversions and proposed harvest limits take account of permitted trimming and offcuts for relevant coral species

To prevent further (even more widespread) increases in harvest levels for individual coral species, which should be constrained irrespective of the perceived risk posed by harvesting (Table 7.1), proportionate harvest limits should be applied to all coral species for which there is relevant catch history information. Based on the alternative strategies for limiting growth in harvest levels put forward in QCF Harvest Strategy (2021-2026), the most appropriate approach would be to impose Tier 2 harvest limits (150% of reference harvest levels). However, a minimum provisional harvest limit should also be considered, which would be used as provisional limit for all species (or genera) not yet harvested. Given the distribution of estimated weight for individual coral species (and genera) harvested in 2019-2020, there is an obvious break at 600kg and virtually all species (or genera) for which the estimated weight of recent harvests are >600kg (all except *Paragoniastrea australensis*) have already been identified as warranting prescribed harvest limits (Figure 8.1). If the 600kg minimum provisional harvest limit is applied, proposed harvest limits for *Acanthophyllia deshayesiana* and *Cycloseris cyclolites* (currently, 368 and 521kg, respectively) should also be increased.

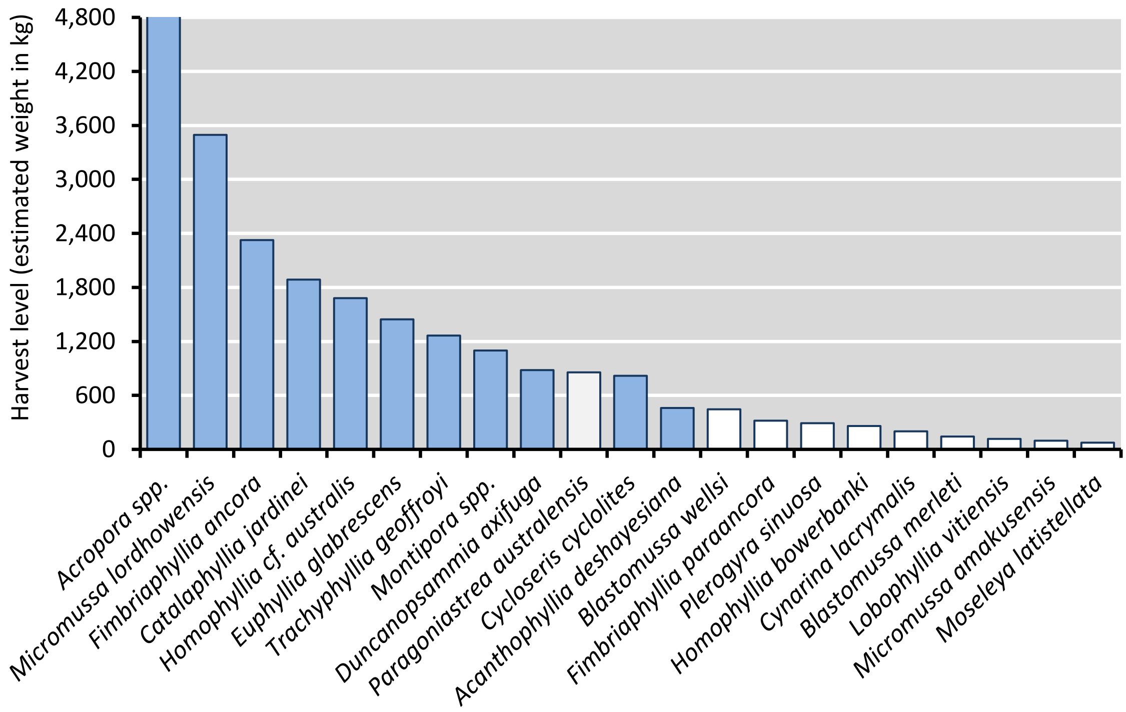



**Figure 8.1**. Distribution of estimated weights (in 2019-2020) for individual coral species. The vertical axis has been truncated (obscuring the total weight for *Acropora* spp; 23,374kg) to emphasise species that are above (in blue) and below (in white) the 600kg provisional harvest limit.

The recommendations presented herein (Table 8.1) differ from proposed harvest limits (catch triggers) in the QCF Harvest Strategy (2021-2026), which allows for increased harvest levels of all coral species, except *Homophyllia* cf. *australis*. Critically, harvest limits need to be imposed as soon as practical to constrain escalating harvest levels of several major target species (Table 8.1; see also Section 4.4), requiring that harvest limits are set at or below reference harvest levels. In some instances the Tier 1 harvest limit (0.8x reference harvest levels) proposed QCF Harvest Strategy (2021-2026) is overly restrictive, but the current Tier 2 harvest limit (1.5x reference harvest levels) is also inappropriate. Therefore, consideration needs to be given to introducing another intermediate Tier in QCF Harvest Strategy (2021-2026), where harvest limits are set at a maximum of 1.0x reference harvest levels, which is a much more appropriate strategy for all individual coral species for which there is an undesirable risk posed by harvesting (i.e., Tier 2 species). These limits require marked reductions in harvest levels, especially compared to reported harvest levels in 2019-2020 (which are likely to have further increased in 2020-2021), but it is a fundamental requirement of precautionary harvest limits that growth is constrained (e.g., DEEDI, 2009), and required information to justify increased harvest levels is not available, especially not at the rate or extent that has occurred in recent years.

The only way to reduce constraints imposed by proposed harvest limits (Table 8.1) is to improve the biological and ecological knowledge (more specifically, quantitative and comprehensive data on the distribution and abundance, especially biomass, of individual species) underpinning prescribed harvest limits for individual species. The specific knowledge gaps, and corresponding research priorities, that create uncertainty regarding the risk posed by harvesting, and currently prevent the establishment of sustainability-based harvest limits, vary among the different species (or genera) of concern (Table 8.2). For *Acropora* spp. (and less so for *Montipora* spp.) there is considerable existing information on the distribution, abundance and habitat affinities, as well as contemporary knowledge on stock structure and condition (e.g., AIMS, 2021, Dietzel et al., 2021). The utility of extensive monitoring for assessing harvestable biomass of *Acropora* spp. is also greatly aided by recent analyses allowing for biomass conversions (Pratchett, 2021), though necessary conversions and calculations of reef-wide biomass will still require considerable work. The major issue, however, is that for these groups of highly diverse species, there is limited information available on catch composition, which is needed to better understand risks posed by harvesting for individual species. Once catch composition is established, it may also be necessary to obtain additional information on the distribution and abundance (especially biomass) of major target species (Table 8.1), especially if these species are rarely encountered or considered by established monitoring programs. For other major harvest species, especially *Homophyllia* cf. *australis*, the main research priority is to resolve taxonomic uncertainties (Table 8.2; see also section 7.2). However, the foremost research priority for establishing sustainability-based harvest limits for individual species or genera is to obtain increased information on the distribution, abundance (especially biomass), and habitat affinities, across the GBR, following Pratchett et al. (2020a). The extent of research required (and cost) to address this important knowledge gap will vary among species, but also, estimated of harvestable biomass need to be accompanied by increased understanding of population structure and turnover (i.e., reproduction and recruitment, as well as growth and survival of established colonies) even for relatively well studied taxa (see Guzner et al., 2007; Edmunds and Riegl, 2020) to establish biomass-based sustainable harvest limits (Table 7.1). Moreover, ongoing monitoring of in key harvest locations (and comparable reference locations) will need to be established before considering maximum (adaptive) sustainable harvest limits.

Much of the research required to establish sustainability-based harvest limits, and reduce uncertainty regarding the risk posed by harvesting, for individual species and genera (Table 8.2), is fairly routine and tractable. The need for research, and specific research requirements, is also largely unchanged in the last few decades. Indeed, many of the questions posed herein are not new, and have been posed previously with direct reference to the QCF (e.g., Harriot, 2001; Donnelly, 2013). Importantly, however, increased research investment and specific targeted research to address fundamental research priorities for individual species or genera (as per Table 8.2) is the only way to remove constraints imposed by prescribed harvest limits, which must otherwise by imposed for major harvest species.

**Table 8.2**. Summary of knowledge gaps and research priorities relevant to each of the individual species (or genera) of concern, emphasising information that is needed to establish sustainability-based harvest limits, and reduce uncertainty regarding the risk posed by harvesting.

| Key knowledge gaps and research priorities | *Acropora* spp. | *Homophyllia* cf. *australis* | *Micromussa lordhowensis* | *Trachyphyllia geoffroyi* | *Acanthophyllia deshayesiana* | *Catalaphyllia jardinei* | *Fimbriaphyllia ancora* | *Euphyllia glabrescens* | *Duncanopsammia axifuga* | *Cycloseris cyclolites* | *Montipora* spp. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Understanding of catch composition and information on the distribution and abundance (especially biomass) of major target species. | ** | | | | | | | | | | ** |
| Additional taxonomic research (including genetic sampling) to unequivocally establish species identity and boundaries | * | ** | ** | | ** | | | | | | * |
| Quantitative and comprehensive data on the distribution, abundance (especially biomass), and habitat affinities, on the GBR | | * | * | ** | * | ** | ** | ** | ** | ** | |
| Improved knowledge of population dynamics, especially reproduction and recruitment, as well as growth and survival of established colonies | * | * | * | * | * | * | * | * | * | * | * |
| Dedicated sampling to quantify selectivity of harvesting (e.g., according to colour) and compare abundance (availability) of harvested and non-harvested phenotypes | | * | * | | | | * | * | | | |
| Established monitoring in key harvest locations (and comparable reference locations) to clearly document effects of fishing | | * | * | * | | | * | * | | | |
| Improved knowledge of external (fishery-independent) threats to stocks and populations, which may undermine sustainability of harvesting | | | | | | | * | | | | |

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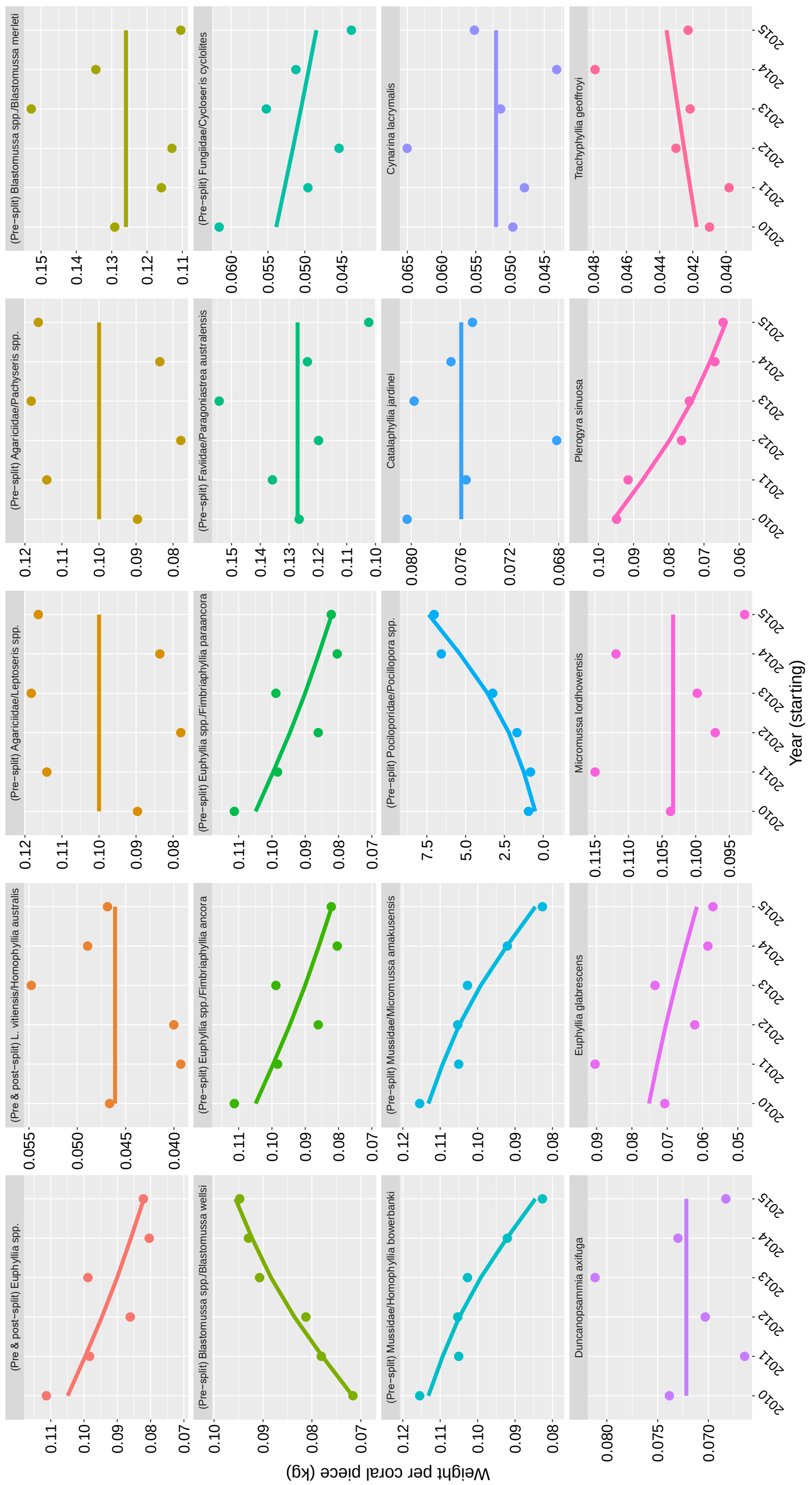


**Supplementary Figure 10.1**. Temporal changes in weight per pieces, based on the ratio of retained to retained number of pieces during the period from 2010-2011 through 2015-2016. This information was then used to calculate the retained weight of corals from July 1st 2016 onwards, given there is no longer reporting of weight within individual reporting categories. Harvest level data based on data provided by Queensland Government Department of Agriculture and Fisheries, May 17th, 2021.

**Supplementary Table 10.1**. QCF logbook reporting requirements (including all reporting categories for scleractinian corals), version CS03, which was in effect from 2006-2007 through 2008-2009. Coral categories included species (e.g., *Catalaphyllia jardinei*), genera (e.g., *Galaxea*) and families (indicated by "F").

| Product Type | Information Recorded | Taxonomic Groups |
|---|---|---|
| Ornamental | Weight (kg) based on volume | Acroporidae (F) |
| | | Pocilloporidae (F) |
| Live | No. pieces per size (weight) category, with estimated weight (kg) for pieces >1.0kg | *Catalaphyllia jardinei* |
| | | *Blastomussa* spp. |
| | | *Duncanopsammia axifuga* |
| | | *Euphyllia glabrascens* |
| | | *Caulastrea* |
| | | Other Faviidae (F) |
| | | Fungiidae (F) |
| | | *Goniopora/ Alveopora* |
| | | *Trachyphyllia geoffroyi* |
| | | 2. *Cynarina lacrymalis* |
| | | 3. Dendrophyllia/Tubastraea |
| | | 4. *Galaxea* |
| | | 6. *Lobophyllia/Symphyllia/Acanthastrea* |
| | | 8. Pectinidae (F) |
| | | 10. *Porites* |
| | | 12. *Scolymia* |
| | | 13. Stylasteridae (F) |
| | | 15. *Turbinaria* |
| | | 16. Other Euphyllidae (F) |
| | | 17. Pocilloporidae (F |
| | | 18. Acroporidae (F) |
| | | 19. Agariciidae (F) |
| | | 20. Merulinidae (F) |

**Supplementary Table 10.2**. QCF logbook reporting requirements (including all reporting categories for scleractinian corals), version CS04, which was in effect from 2009-2010 through 2016-2017. Coral categories included species (e.g., *Catalaphyllia jardinei*), genera (e.g., *Plerogyra*) and families (indicated by "F").

| Product Type | Information Recorded | Taxonomic Groups |
|---|---|---|
| Ornamental | Weight (kg) based on volume | Acroporidae (F) |
| | | Pocilloporidae (F) |
| Specialty | No. pieces per size (weight) category, with estimated weight (kg) for pieces >1.0kg | *Catalaphyllia jardinei* |
| | | *Blastomussa merletti* |
| | | *Blastomussa wellsi* |
| | | *Duncanopsammia axifuga* |
| | | *Euphyllia glabrascens* |
| | | Faviidae (F) |
| | | Fungiidae (F) |
| | | *Scolymia vitensis* |
| | | *Plerogyra* |
| | | *Trachyphyllia geoffroyi* |
| | | *Acanthastrea lordhownesis* |
| | | Fungiidae (F) |
| Other species | Total no. pieces | 1. Acroporidae(F) |
| | | 2. Agariciidae(F) |
| | | 7. *Cynarina lacrymalis* |
| | | 8. Dendrophylliidae(F) |
| | | 9. Other Euphyllidae (F) |
| | | 10. *Galaxea* |
| | | 11. *Goniopora* / *Alveopora* |
| | | 14. Merulinidae (F) |
| | | 16. Oculinidae (F) |
| | | 17. Other hard corals |
| | | 20. Pectinidae (F) |
| | | 22. Pocilloporidae (F) |
| | | 23. *Scolymia* |
| | | 24. Other Mussidae (F) |
| | | 25. Stylasteridae (F) |
| | | 27. *Turbinaria* |

**Supplementary Table 10.3**. QCF logbook reporting requirements (including all reporting categories for scleractinian corals), version CS05, which came into effect on July 1st 2016. Coral categories include species (e.g., *Acanthastrea amakusensis*), genera (e.g., *Acropora*) and families (indicated by "F").

| Product Type | Information Recorded | Taxonomic Groups |
|---|---|---|
| Hard corals | No. pieces | 1. *Acanthastrea amakusensis* |
| | | 2. *Acanthastrea bowerbanki* |
| | | *3. Acanthatrea (*Micromussa*) lordhwensis* |
| | | 4. *Acanthophyllia deshayesiana* |
| | | 5. *Acropora* |
| | | 6. *Alveopora* |
| | | 8. *Blastomussa merleti* |
| | | 9. *Blastomussa wellsi* |
| | | 10. Caryophyllidae (F) |
| | | 11. *Catalaphyllia jardinei* |
| | | 12. *Cynarina lacrymalis* |
| | | 13. Other Dendrophylliidae (F) |
| | | 14. *Duncanopsammia axifuga* |
| | | 15. *Euphyllia ancora* |
| | | 16. *Euphyllia glabrascens* |
| | | 17. *Euphyllia paraancora* |
| | | 18. Other Faviidae (F) |
| | | 19. *Fungia* (*Cycloseris*) *cyclolites* |
| | | 20. Other Fungiidae (F) |
| | | 21. *Galaxea* |
| | | 22. *Goniastrea australensis* |
| | | 23. *Goniopora* |
| | | 26. *Leptoseris* |
| | | 27. Merulinidae (F) |
| | | 29. *Montipora* |
| | | 30. *Moseleya latistellata* |
| | | 31. Other Mussidae (F) |
| | | 32. Oculinidae (F) |
| | | 33. Other hard coral |
| | | 34. *Pachysers* |
| | | 35. Pectinidae (F) |
| | | 36. *Plerogyra sinuosa* |
| | | 37. *Pocillopora* |
| | | 38. Other Poritidae (F) |
| | | 39. *Scolymia* (*Homophyllia*) *cf. australis* |
| | | 40. *Scolymia* (*Lobophyllia*) *vitensis* |
| | | 41. *Seriatopora* |
| | | 42. Sylasteridae (F) |
| | | 43. *Stylopohora* |
| | | 44. *Trachyphyllia geoffroyi* |
| | | 46. *Turbinaria* |