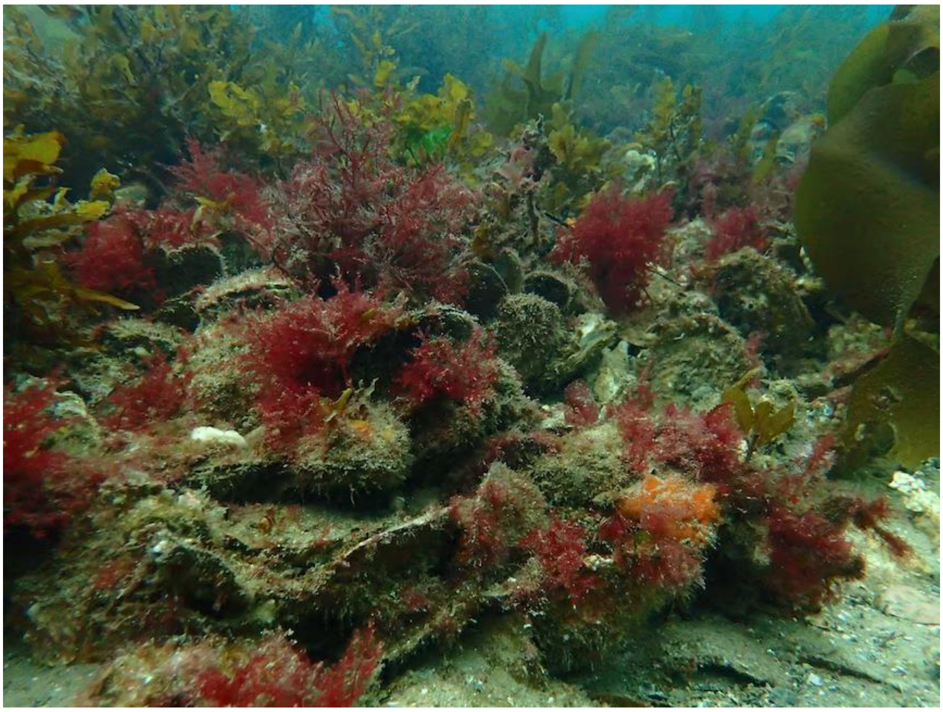
Australian Government
Department of Climate Change, Energy, the Environment and Water

Draft Conservation Advice for *Ostrea angasi oyster reefs of southern Australia*

This draft document is being released for consultation on the description, listing eligibility and conservation actions of the ecological community.

The purpose of this consultation document is to elicit additional information to better understand the definition and status of the ecological community and help inform conservation actions. The draft assessment below should therefore be considered **tentative** at this stage, as it may change as a result of responses to this consultation process.

This document combines the Conservation Advice and listing assessment for the threatened ecological community. It provides a foundation for conservation action and further planning.



Ostrea angasi oyster reef © Chris Gillies, The Nature Conservancy

Proposed Conservation Status

The *Ostrea angasi* oyster reefs of southern Australia is proposed to be listed in the Critically Endangered category of the threatened ecological communities list under the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) (EPBC Act).

Draft Conservation Advice for *Ostrea angasi* oyster reefs of southern Australia

About this document

This document describes the ecological community and where it can be found (section 1); outlines information to assist in identifying the ecological community and important occurrences of it (section 2); and describes its cultural significance (section 3).

In line with the requirements of section 266B of the EPBC Act, it sets out the grounds on which the ecological community is eligible to be listed as threatened (section 6); outlines the main factors that cause it to be eligible for listing (section 4); and provides information about what could appropriately be done to stop its decline and/or support its recovery (section 5).

CONTENTS

Glossary

Term	Definition
Remnant reef	A remnant reef refers to the area of reef that still exists after a larger reef extent has been degraded or destroyed.
Existing	An existing reef encompasses remnant reefs and contemporary reefs that may have formed since historical degradation but does not include contemporary restoration sites unless otherwise stated.
Infauna	Infauna refers to aquatic animals that live in the substrate of a body of water and that are especially common in soft sediments.
Intertidal	Intertidal refers to the area above water level at low tide and underwater at high tide.
Subtidal	Subtidal refers to the area below the low tide mark.
Spat	Once oyster larvae permanently attach to a surface, they are referred to as spat.
Recruitment	Recruitment refers to the process of incorporating new oysters into a population.
Cultch	Cultch refers to the mass of old dead shells and other material on which an oyster bed or reef is formed.
Oyster reef and bed	For the purposes of this document, 'oyster bed' and 'oyster reef' are both used to describe native flat oyster reef ecological community occurrences.
Minimum Convex Polygon	A minimum convex polygon is the smallest polygon in which no internal angle exceeds 180 degrees.
Dredge fishing	Dredge fishing refers to a method in which rigid fishing gear is towed from a boat along the seabed to harvest bottom-dwelling bivalves and other biota.
Living site	A living site is a place where First Nations Australians undertook social activities, such as meetings, ceremonies, eating and sharing of food. During the course of these activities, they discarded items, such as shell and bone, botanical remains, ash and charcoal. Over time, the shells and bones built up into large mounds. Living sites are often referred to as 'middens'.
Emersion	Emersion refers to the process of emerging from water after being submerged in the ocean.
Immersion	Immersion refers to the state of being submerged underwater in the ocean.
Reef Builder program and associated partners restoration sites	Reef Builder was an AU$20 million partnership between the Australian Government and The Nature Conservancy (TNC) that delivered an extensive program of work between January 2021 and December 2023 to rebuild shellfish reefs at 13 projects across Western Australia, South Australia, Victoria, Tasmania, New South Wales, and Queensland to accelerate the recovery of our lost shellfish reef ecosystems. Reef Builder projects were delivered in collaboration with a broad range of partners including State Government Agencies, local Councils, other Non-Government Organisations and community groups which brought considerable in-kind funding to the program and delivered a wide range of co-benefits for local coastal communities.
Example First Nations names for oyster	dainya (Dharawal poples), barnabil (Wadawurrung peoples), pirra (Nukunu peoples), taralangkana (palawa kani)
IMCRA Bioregions	IMCRA Bioregions refers to the Integrated Marine and Coastal Bioregionalisation of Australia Version 4.0, which is the product of the combination of the Interim Marine and Coastal Regionalisation of Australia (IMCRA v3.3), which provided a marine regionalisation of inshore waters, with the National Marine Bioregionalisation (NMB) for off-shelf waters. In combining the two national scale marine regionalisations, IMCRA v4.0 covers Australia's waters from the coast to the edge of the Exclusive Economic Zone excluding Antarctica and Heard and Macdonald Islands. The definition of IMCRA v3.3 bioregions is based on broadscale patterns, evident within a combination of biological and physical data.

1 Ecological community name and description

1.1 Name

The name of the ecological community is the '*Ostrea angasi* oyster reefs of southern Australia' (hereafter referred to as the 'ecological community', 'native flat oyster reef ecological community' or 'native flat oyster reef/s'). The name of the ecological community refers to the dominant oyster species that forms the biogenic reef structure of the ecological community and its historical geographical extent. The entity originally placed on the Finalised Priority Assessment List ('Temperate coastal oyster beds and reefs') has been split into two distinct ecological communities based on the two primary oyster reef forming species. This Conservation Advice covers the *Ostrea angasi* (native flat oyster) (Sowerby, 1871) dominated sub-type. This distinction is based on evidence that the two ecological community sub-types within the original nomination comprise different dominant structural forms and predominately range across different geographic areas. As such, they also differ from each other in some aspects of their associated community assemblages, key threats, and ecosystem function.

1.2 Description of the ecological community and the area it inhabits

The EPBC Act defines an ecological community as an assemblage of native species that inhabit a particular area in nature. This section describes the species assemblage and area in nature that comprises the *Ostrea angasi* oyster reefs of southern Australia.

The ecological community described in this Conservation Advice is characterised by the three-dimensional biogenic reef and bed structures formed by the accumulation of living and dead shell material of the primary oyster species *O. angasi* (native flat oyster), and the living organisms that rely on and utilise the bivalve-produced habitat. When formed as a reef or bed, oysters function as ecosystem engineers and provide a range of ecological functions and services such as shelter and refuge for mobile species; structurally complex habitat for benthic and epifaunal species; biological filtration and nutrient cycling; sediment stabilisation and coastal protection; and shelter that promotes the growth of other estuarine/marine habitat (Grabowski & Peterson 2007; Gillies et al. 2015; Gillies et al. 2017; Crawford et al. 2019).

The native flat oyster reef ecological community occurs in both marine and estuarine waters and based on the International Union for Conservation of Nature (IUCN) global ecosystem typology, is part of the marine shelf biome and semi-confined transitional waters biome (Bishop et al. 2020; Keith et al. 2020). The northern and southern delineation points of the ecological community encompass the historical distribution, which extends along the southern Australian coastline from around Port Stephens in New South Wales (NSW) through to around Swan River in southern Western Australia (WA), including Tasmania (Tas) (Gillies et al. 2018; Cook et al. 2021). Native flat oyster remnant reefs have been identified in NSW, South Australia (SA) and Tas, with active or planned restoration sites being developed within the historical extent of occurrence of the ecological community (Colella et al. 2017; Gillies et al. 2020; TNC 2022).

This section primarily describes the typical range of natural states of remnant reefs of the ecological community. As a result of past disturbance, not all extant occurrences of the ecological community are in a completely natural, undisturbed state. There are also restoration sites of native flat oyster reefs that may function as the ecological community if they meet the key diagnostic characteristics, patch definition and condition thresholds outlined in section 2.1, section 2.2 and section 2.3. Section 2.3 provides information to identify which patches of native flat oyster reefs retain sufficient conservation value to be considered a Matter of National Environmental Significance under the EPBC Act. Additional information to assist in identifying patches of the ecological community is provided throughout section 2.

1.2.1 Area in nature inhabited by the ecological community

The historical distribution of the native flat oyster reef ecological community encompasses twenty-three marine meso-scale bioregions from the Hunter region in NSW to southern WA, including Tas (IMCRA v4.0; Commonwealth of Australia 2006[1]). Native flat oyster reefs were likely present in over 120 historical locations (see Table 7 in the listing assessment and the historical location list in Appendix E). Currently, there is now only one known remnant reef of the ecological community in Tas within the Freycinet bioregion, one in SA within the Eyre bioregion, and four remnant reefs likely to contain the ecological community in NSW within the Batemans Shelf and Twofold Shelf bioregions (Figure 1). There are also current and planned restoration sites being developed within the historical extent of occurrence of the ecological community that may function as the ecological community once established, if they meet the key diagnostic characteristics and conditions thresholds outlined in section 2.1 and section 2.3 (Colella et al. 2017; Reeves et al. 2019; Gillies et al. 2020; TNC 2022). There are currently 13 native flat oyster reef restoration sites of substantial size developed through the Reef Builder Program and associated partnerships, that are considered likely to meet the key diagnostic characteristics, patch definition and condition thresholds for the ecological community (TNC 2022, 2024a; NSW DPIRD Fisheries 2024 unpublished data; TNC 2024 unpublished data). There may be other native flat oyster reef restoration projects that are of similar size or smaller-scale projects, but the monitoring data for these sites was either not available or not provided at the time of listing.

The ecological community typically forms in the intertidal and subtidal zone down to a depth of 20 m. Reefs comprised of native flat oysters have also been suggested to of occurred down to 30 m (Gillies et al. 2018, 2020). Currently, one known occurrence of the ecological community is located completely within the subtidal zone in Tas, one within the intertidal zone in SA (McAfee 2024. pers comm 1 July), and four occurrences in NSW are found within the lower intertidal zone, in shallow water of less than 2 m deep (Keating 2024. pers comm 27 September). Surveys of the ecological community in Georges Bay, St Helens, Tas, indicate that the native flat oyster reef patches typically occur just beyond the deeper edges of seagrass beds and on a slope or flat substrate of silty sand (Crawford & Cahill 2008; Crawford et al. 2019). While observations of the ecological community in Coffin Bay, SA, show the reef primarily comprising the native flat oyster and *Pinna bicolor* (razorfish), interspersed with seagrass (McAfee 2024. pers comm 1 July).

---

[1] IMCRA v.4.0: Integrated Marine and Coastal Bioregionalisation of Australia Version 4.0 is the product of the combination of the Interim Marine and Coastal Regionalisation of Australia (IMCRA v3.3), which provided a marine regionalisation of inshore waters, with the National Marine Bioregionalisation (NMB) for off-shelf waters. In combining the two national scale marine regionalisations, IMCRA v4.0 covers Australia's waters from the coast to the edge of the Exclusive Economic Zone excluding Antarctica and Heard and Macdonald Islands. The definition of IMCRA v3.3 bioregions is based on broadscale patterns, evident within a combination of biological and physical data.

Native flat oysters can settle on hard substrates, such as rocky outcrops, and can break away as adults, surviving as solitary individuals and creating areas of mixed beds and reef comprising both loose and cemented oysters (Gillies et al. 2017). Historical accounts describe native flat oyster reefs occurring in a wide variety of locations, including flat and sloping benthic areas devoid of seagrass and on intertidal sand and mud flats (Alleway & Connell 2015; Ford & Hamer 2016).

Functionally, the ecological community relies on hard substrata for the native flat oyster to develop the biogenic structure and associated physical conditions that are then colonised and utilised by other species. Structurally, the ecological community is made up of a dead shell matrix (cultch) and live oysters that together form low-profile beds/aggregations or higher-profile reefs (Gillies et al. 2017, 2020; NSW DPI 2020). Cultch adds to the habitat structure and to the continuity of the ecological community over time as it provides space for new oyster recruits and other organisms to colonise (Kasoar et al. 2015). Oyster recruitment and new growth is essential for the persistence of the ecological community (Gillies et al. 2020).

Figure 1. Indicative distribution of existing sites (black circle) and restoration sites of (red square) *Ostrea angasi* oyster reefs of southern Australia that are likely or known to occur and historical locations (blue square). Restoration sites of native flat oyster reefs are from the Reef Builder Program and associated partnerships. Historical locations comprise scenario 1 and scenario 2 assumptions and caveats from Table 6 and Table 7 in the listing assessment.

Source: Localities, 1:250,000 © Commonwealth of Australia, Geoscience Australia, 2004. Interim Marine and Coastal Regionalisation (IMCRA) for Australia, © Commonwealth of Australia, Geoscience Australia, 1997. Coastline and State Borders, 1:100,000 © Commonwealth of Australia (Geoscience Australia), 1990. Native Flat oyster reefs, compiled from several sources: Gillies et al. 2018 & 2020, NSW DPIRD - Fisheries oyster reef mapping project, through expert elicitation and other key literature sources.

Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein. The map has been collated from a range of sources, with data at various resolutions. Data used are assumed to be correct as received from the data suppliers.

This map has been compiled from datasets with a range of scales and quality from various sources. Data used are assumed to be correct. Historical locations comprise historical locations identified in Gillies et al. (2018, 2020) that likely contained commercially harvested native flat oyster reefs that are ≥ 1 ha (see Table 6) and also includes all other lines of evidence noted from those studies and any additional historical locations identified from expert consultation and additional literature sources that indicate native flat oyster reefs may have been present (see Table 6). Sites that appeared to overlap across different lines of evidence were removed, with commercially harvested locations used as the primary baseline location in areas where this line of evidence was present, but uncertainty for the historical location list is still present due to the limitations of using location point data from multiple evidence sources (see Appendix E for list of historical locations). The ecological community distributions included in this map are only indicative and not meant for local assessment. Planning decisions at a local scale should seek some form of ground truthing to confirm the existence of the ecological community at locations of interest. Such assessments should refer to the text of the Listing and Conservation Advice for the ecological community.

Consultation Questions on the name and area inhabited.

- Do you agree with the proposed name for the ecological community? Is there an appropriate First Nations name that could be used in addition to, or instead of the name described?
- Do you agree with the proposed geographic distribution and description of the area in nature for the ecological community? Are there any suggested changes to better describe the area in nature inhabited by the ecological community?
- Are you aware of any additional remnant reefs that are likely to meet the key diagnostic characteristics, patch definition and conditions thresholds for the ecological community that are not noted? Please provide supporting evidence.
- Are there other native flat oyster reef restoration sites that may meet the key diagnostic characteristics, patch definition and condition thresholds to be considered the ecological community? Please provide the relevant information to support this.

1.2.2 Description of the assemblage

The native flat oyster reef ecological community is characterised by a core component of fauna and flora, plus transient or opportunistic taxa that may reside in the ecological community for periods of time or utilise the oyster reefs for specific purposes (e.g. refuge and feeding). The overall composition and abundance of taxa associated with the ecological community may vary between locations depending on the geographical location, hydrological conditions, physical environment and surrounding interconnected ecosystems.

Native flat oyster reefs and beds can have densities of greater than 50 native flat oysters/m^2 (Gillies et al. 2017). The biogenic structure of the ecological community provides hard surfaces for sessile organisms to colonise and highly rugose habitat that support a wide range of taxonomic groups, including sessile and mobile macroinvertebrates (e.g. arthropods, polychaetes, molluscs, echinoderms), macroalgae, and fish (Gillies et al. 2017; Crawford et al. 2019; NSW DPIRD 2024 unpublished data, Appendix A). Other shellfish species also add to the habitat structure of the ecological community (Gillies et al. 2015). For example, *Venerupis largillierti* (Venus clam) often occurs within and around the native flat oyster reef ecological community in Georges Bay, St Helens, Tas (Jones & Gardner 2016). Native flat oyster reefs can also form mixed shellfish reefs with *Mytilus galloprovincialis* (blue mussel), *V. largillierti*, *Pinna bicolor* and other species (Gillies et al. 2015; Dom McAfee 2024. pers comm 1 July).

Common species observed within the ecological community in Tas and on degraded native flat oyster reefs in Port Phillip Bay, Vic, include several species of red, green and brown algae (e.g. *Undaria pinnatifida, Sargassum sp.* and *Ulva sp.*), suspension feeders (e.g. *M. galloprovincialis, Mimachlamys asperrima, Veneridae* bivalves, and various species of barnacles, zooanthids, sponges, ascidians, and hydroids), mobile grazers (e.g. *Heliocidaris erythrogramma*), generalists (e.g. *Guinusia chabrus, Mitra glabra, Palaemon serenus, Pagurixus handrecki*), predators (e.g. *Hapalochlaena maculosa, Coscinasterias muricata, Anthothoe albocincta,* and nudibranchs), and fishes (e.g. *Meuschenia freycineti* and *Pseudolabrus rubicundus*) (Gillies et al. 2017). The ecological community in Georges Bay, St Helens, Tas, has been found to have as much as three times the diversity and abundance of fauna than in nearby soft sediments (Crawford et al. 2019).

A more comprehensive list of flora and fauna species that occur, or are likely to occur in the ecological community, are in Appendix A.

Consultation Questions on the species assemblage

- Are any fauna or flora species incorrectly recorded in this section or in Appendix A? Please provide details.
- Is there additional information on flora or fauna you would like to see included, particularly commonly encountered? Please suggest further information/ sources, particularly those from recent surveys and studies on remnant reefs.

1.2.3 Relevant biology and ecology

Oyster reef ecosystems provide a wide range of ecological functions, ecosystem services and key interactions including the provision of complex habitat; nutrient cycling and water filtration; sediment and shoreline stabilisation; and fisheries enhancement (Grabowski & Peterson 2007; Gillies et al. 2015; Crawford et al. 2019; McAfee et al. 2020a).

1.2.3.1 Habitat provision

Oyster reefs form through successive generations of bivalves settling and growing onto existing oyster substrate (Gillies et al. 2020). The primary reef-building oyster species (both living oysters and non-living shell cultch) provides a hard substrate onto which oyster larvae and other sessile organisms attach (Ysebaert et al. 2019). The oyster reef grows vertically and over time, becomes structurally complex habitat that provides refuge for mobile invertebrates and fish species; modifies predator-prey interactions within a seascape; acts as a nursery for many organisms; and traps sediments which provide further habitat for infaunal communities (Cole et al. 2007; Shervette & Gelwick 2008; Grabowski et al. 2012; Ysebaert et al. 2019; McLeod et al. 2020). Observations on remnant patches of the native flat oyster reef ecological community in Georges Bay, St Helens, Tas, indicate representative inhabitants from most major functional groups, with some similar observations in NSW remnant reef sites (Gillies et al. 2017; Crawford et al. 2019; NSW DPIRD 2024 unpublished data). Abundance of echinoderms, arthropods, molluscs and fish were higher, and the abundance of annelids were similar, on the remnant native flat oyster reefs compared to soft sediment habitat (Crawford et al. 2019).

1.2.3.2 Fisheries enhancement

Oyster reefs support many species of economically important fishes (Cole et al. 2021), and can enhance fisheries productivity by providing shelter, nursery grounds and access to abundant food (McAfee et al. 2020a). To date, there have been few reported biological or fish surveys on remnant native flat oyster reefs to determine their fisheries enhancement value. However, during visual surveys over remnant native flat oyster reefs in Georges Bay in Tas, Crawford et al. (2019) observed the commercially important *Heliocidaris erythrogramma* (shortspined sea urchin) in high numbers and *Notolabrus tetricus* (blue-throated wrasse) in low numbers. In addition, targeted fish surveys using Baited Remote Underwater Video Cameras (BRUVs) at Rogues Point native flat oyster reef restoration site in SA observed numerous fish species that may be recreationally or commercial important, such as *Arripis georgianus* (Australian herring), *Pseudocaranx wrighti* (skipjack trevally) and *Portunus armatus* (blue swimmer crab) (Colella et al. 2017; PIRSA 2024). BRUV surveys at Wagonga from 2021-2024 also found a variety of important commercial and recreational species including *Chrysophrys auratus* (Australasian snapper), *Pseudocaranx georgianus* (silver trevally) and *Acanthopagrus australis* (yellowfin bream) (NSW DPIRD 2024 unpublished data). While BRUV surveys at the Margaret Reef native flat oyster reef restoration site in Port Phillip Bay, Vic, found high numbers of the recreationally and commercially important Australasian snapper foraging around the reefs (Bray 2020; TNC 2022; VFA 2022).

Similarly, Connolly et al. (2024) observed an average enhancement in fish production across two subtidal native flat oyster reef restoration sites in Vic, with fish biomass enhancement from a single year's cohort measured at 5820 kg ha^{-1} in Dromana and 12,740 kg ha^{-1} in Margaret, after enough time has lapsed for all species to have matured, with 98% of this biomass attributed to species with commercial or recreational harvest. The Australasian snapper made up over 90% of biomass in these two sites, despite other fish producing higher densities of juveniles (Connolly et al. 2024), which could be due to Port Philip Bay being a nursery for snapper and surveys occurring during possible spawning periods (VFA 2024a & b). The Glenelg native flat oyster reef restoration site in SA in the same study reported only two species, with a total of 1.4 kg ha^{-1} in enhancement consisting almost entirely of Southern Squid (*Sepioteuthis australis*) (Connolly et al. 2024). McAfee et al. (2024) also observed that *Asparagopsis taxiformis* (red seaweed), a plant of commercial and environmental interest for cattle feed, was more productive in a native flat oyster reef restoration site in SA.

1.2.3.3 Nutrient cycling and water filtration

Oyster reef communities influence nutrient cycling primarily through removal of particulates from the water column and deposition to the benthos, and through nutrient processing and assimilation into oyster shell and flesh (Newell & Mann 2012). Oysters filter organic matter from the water column, contributing to the biochemical cycling of nutrients from the water column to the benthos (Kellogg et al. 2013). Organic matter is either used directly for growth or deposited in the reef matrix or on surrounding sediment surfaces (bio-deposition) (Kellogg et al. 2013). Moreover, microbial communities in the oyster guts and shell help process these nutrients through denitrification, a process essential to the remediation of eutrophic ecosystems (Kellogg et al. 2014). Remnant clumps of native flat oysters in Tas have been observed to filter particulate matter at rates of up to approximately 98,000 particles m^2 h^1, with denitrification rates of up to approximately 3,380 μmol N_2-N m^2 h^1 (Strain et al. 2024).

Although studies on nutrient cycling of the native flat oyster have not been investigated, oyster ecosystems can modify nutrient cycling in surrounding habitat. Bivalve bio-deposition couples pelagic and benthic nutrient cycles by shunting nutrient rich particulates from the water column to the benthos and making these particles available to sediment invertebrates (as food) and microbial communities, which can trigger nutrient degradation processes, such as denitrification (Kellog et al. 2014). These nutrients can then be used by marine vegetation, such as seagrass, to promote growth (Peterson & Heck Jr 2001a, 2001b). Nutrients released by oysters to the water column, such as ammonia, are also used by seagrass to promote above-ground growth (Sandoval-Gil et al. 2016). Higher abundance of seagrass and infauna can in turn improve sediment quality through sediment aeration (Alsaffar et al. 2020). Furthermore, the increased structural complexity provided by a bivalve community can increase the density of epiphytic grazers that can reduce epiphytic growth on seagrass adjacent to oyster reefs (Peterson & Heck Jr 2001a).

1.2.3.4 Sediment stabilisation and coastal protection

Although studies investigating sediment stabilisation and coastal protection are not specific to the native flat oyster, oyster reef communities in general can play a critical role in trapping and stabilising sediments and attenuating wave energy (Scyphers et al. 2011; Grabowski et al. 2012). Living intertidal oyster reefs are increasingly managed as a nature-based solution for foreshore erosion while also providing habitat (Grabowski & Peterson 2007; Scyphers et al. 2011; Morris et al. 2021). Several empirical and modelled studies from the United States demonstrate that oyster reef communities can enhance the extent of adjacent seagrass and saltmarsh ecosystems by reducing wave energy, promoting sediment stabilisation (thereby enhancing light penetration and facilitating seagrass growth at deeper depths), and preventing coastal erosion (enhancing saltmarsh recruitment) (Newell & Koch 2004; Wall et al. 2008; Scyphers et al. 2011; Sharma et al. 2016). While native flat oyster spat relies on hard substrate for reef formation, other species such as *Pinna bicolor* can colonise soft sediment and then act as settlement material for spat, allowing reefs to form on and stabilise soft sediments (Martin et al. 2025).

Wave attenuation capacity by oyster reefs is complex and varies based on environmental characteristics and the physical characteristics of the oyster reef structure. Wave attenuation services generally decrease with increasing water depth and decreasing elevation above the surface or reduced vertical reef accretion (Wilberg et al. 2019; Howie & Bishop 2021; Salatin et al. 2022). As the ecological community commonly forms as low-profile beds (0.05 m-0.15 m) and can form within the subtidal habitat zone down to a depth of 20 m (Gillies et al. 2017; Gillies et al. 2020), the extent of the coastal protection services provided by some patches of the ecological community may be limited. The use of oyster reef communities in restoration for coastal protection has been suggested in areas that receive moderate wave action or where oyster reefs have shallow crests (Scyphers et al. 2011; La Peyre et al. 2014; Morris et al. 2021). Shallow subtidal oyster reefs formed on coral have been described as contributing to wave dissipation in Glenelg (Adelaide Times 1857). Native flat oyster reefs have been included in reef restoration sites with preventing erosion as an objective, although these were in combination with larger areas of intertidal Sydney rock oyster reefs and saltmarsh that are better positioned to prevent erosion (TNC 2024a, NSW DPIRD Fisheries 2024). Further investigation is required to determine the value of native flat oyster reefs in providing coastal protection services across the potential range of patch configurations developed by the ecological community.

Consultation Questions on the relevant biology and ecology

- How can the current information on the relevant biology and ecology be improved using latest data?

- Are there any other relevant functional biology and ecology processes or other elements you think are important to include in this document? If so, please explain your reasons and provide any supporting evidence.

2 Identifying areas of the ecological community

Section 1.2 describes this ecological community and the particular area in nature it inhabits. This section provides additional information to assist with the identification of the ecological community and important occurrences of it.

The native flat oyster reef ecological community may intergrade with other habitat types and ecological communities (see section 2.2.6 and section 2.2.7). Key diagnostic characteristics outline the features that identify an assemblage of species as being the *Ostrea angasi* oyster reefs of southern Australia and distinguish it from other ecological communities, noting that additional information to assist with identification is provided in the other sections of this document, particularly the description (section 1.2) and Appendix A.

2.1 Key diagnostic characteristics

The key diagnostic characteristics are designed to inform the identification of the ecological community. Assemblages of native species that do not meet the key diagnostics are not part of the nationally listed ecological community. To be considered the listed ecological community, an occurrence also needs to meet the patch definition (section 2.2) and condition thresholds (section 2.3).

The ecological community is defined as the assemblage of native species inhabiting a particular area in nature as described in section 1.2 and referenced information therein, that meet the following key diagnostic characteristics:

- *Ostrea angasi* is the primary oyster reef forming species (i.e. percent cover or adult densities is greater than any other shellfish reef-forming species);
- Occurs in southern Australian marine and estuarine waters in NSW (south of Port Stephens), Vic, SA, southern WA (south of Swan River), and Tas.
    - Within the national IMCRA meso-scale bioregions of Leeuwin-Naturaliste, WA South Coast, Eucla, Murat, Eyre, Spencer Gulf, North Spencer Gulf, St Vincent Gulf, Coorong, Otway, Central Victoria, Victorian Embayments, Boags, Freycinet, Bruny, Davey, Franklin, Flinders, Twofold Shelf, Batemans Shelf, Hawkesbury Shelf and Manning Shelf (IMCRA v4.0; Commonwealth of Australia 2006[1], Figure 1);
- Occupies the lower intertidal to subtidal habitat zone down to a depth of 20 m below sea level;

- Forms the primary physical structure, made up of dead shell and live oyster cemented or bedded together in soft sediments[2] or on structures purposely built for oyster reef restoration; AND,

- Forms as low-profile beds or aggregations with little elevation above the surrounding substrate (0.05 - 0.15 m) or high-profile reef raised above the surrounding substrate (> 0.15 m).

Exclusions:

- Native flat oyster reefs that form on maintained infrastructure such as aquaculture infrastructure, pylons, jetties, and seawalls.

Consultation Questions on the key diagnostic characteristics

- Are the key diagnostic characteristics suitable? If not, how should these key diagnostic characteristics be amended to ensure appropriate inclusion/exclusion of native flat oyster reefs as the ecological community?

- Please provide any evidence of native flat oyster reefs occurring in waters deeper than 20 m.

2.2 Additional information to assist in identifying occurrences of the ecological community

The following information should also be taken into consideration when applying the key diagnostic characteristics to assess if the ecological community is present at a site.

2.2.1 Identifying an occurrence

An occurrence of the ecological community is described as a patch of native flat oyster reef. To be identified as a patch of the ecological community, an occurrence must meet at least one of the following definitions:

1) Single patch: a single patch of oyster reef is present that (a) has an oyster reef area of equal to or greater than 250 m^2, and (b) is located greater than 20 m from any other patch of oyster reef that is equal to or greater than 5 m^2 (<u>Figure 2a</u>).
2) Mosaic patch: encompasses multiple patches of oyster reef that (a) are located within 20 m from at least one other oyster reef patch that is equal to or greater than 5 m^2[*], (b) individually are greater than or equal to 5 m^2[*], and (c) make up a total collective (sum) of oyster reef area of greater than or equal to 250 m^2 (area between the individual oyster reef patches is not included in the calculation) (<u>Figure 2b</u>).

[2] This includes native flat oyster reefs that form on razorfish as their hard settlement substrate.
[*] Native flat oyster reef patches within the mosaic boundary footprint that are less than 5 m^2 will still be protected under the EPBC Act but will not be used as an oyster reef patch to delineate a patch boundary or to calculate the total oyster reef patch area.

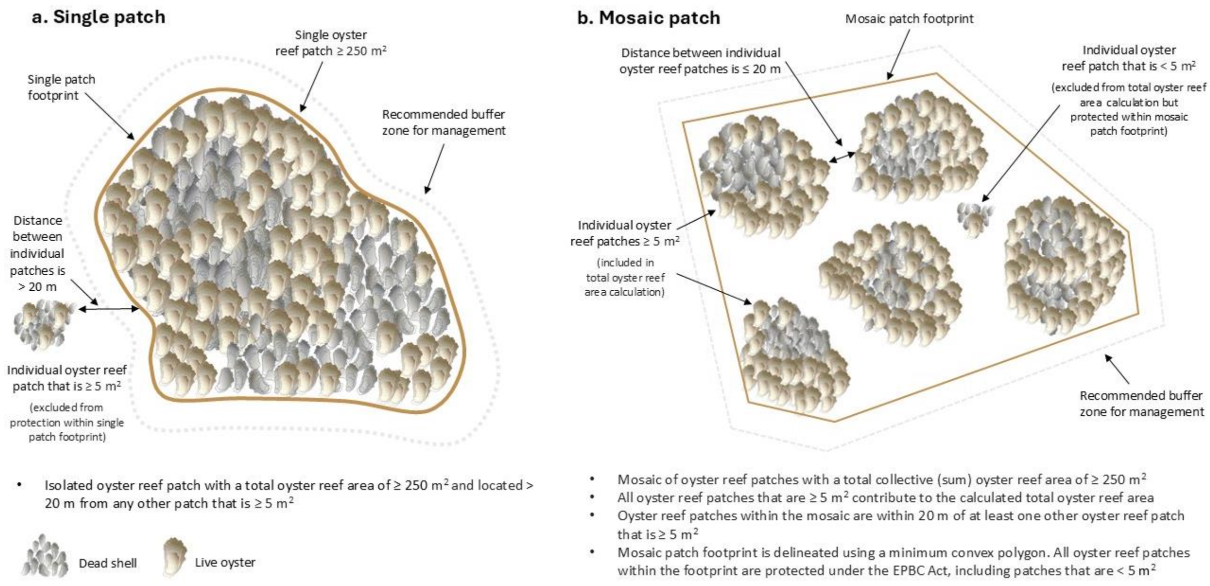


Figure 2. Illustration of definitions for (a) a single patch and (b) a mosaic patch of native flat oyster reefs. Image credit: Oyster symbols - Tracey Saxby, Integration and Application Network (ian.umces.edu/media-library).

Although there are no studies on the patch dynamics of native flat oyster reefs, there is evidence in other oyster species to suggest that multiple small reefs may provide similar benefits to a single larger oyster reef (Harwell et al. 2011; Pine 2021). Similarly, distance between patches has been indicated as important for biodiversity, and epifauna and fish abundance and richness generally decrease with increasing distance between patches in reefs of other oyster species (Pine 2021; Leong 2022). Smaller patches with a greater perimeter to area ratio in other oyster species have been documented to support high numbers of fish and crustaceans that forage and refuge in greater numbers within edge habitat (Griffitt et al. 1999; Hanke et al. 2017; Pine 2021). Individual small patches of other oyster species, when part of a larger mosaic, confer ecological function through their connection with other patches and as a source of larval oyster recruits (Harwell et al. 2011; Gilby et al. 2018; Theuerkauf et al. 2021).

2.2.2 Delineating a single patch boundary

A single native flat oyster reef patch should be delineated using standard on-ground surveying approaches for oyster reefs and may include small areas of interspersed sediment or other marine habitat (e.g. NSW DPI Oyster Reef Mapping Criteria; NSW DPI 2020).

2.2.3 Delineating mosaic patch boundary footprint

The mosaic patch boundary footprint is delineated using a minimum convex polygon around the outer individual oyster reef patches that are greater than 5 m^2 (Figure 2b). The entire area of the mosaic patch footprint is protected as the ecological community under the EPBC Act, including native flat oyster reef patches that are less than 5 m^2. Where terrestrial habitat beyond the intertidal zone is comprised within the minimum convex polygon of a mosaic patch of the ecological community, this terrestrial area may be excluded on a case-by-case basis when considering likely 'significant impacts' on the ecological community during EPBC Act decision-making.

2.2.4 Variation within a patch

Patches of the ecological community may contain areas that vary in structural or biological characteristics. Configurations of native flat oyster reef patches can vary on a spectrum from low profile beds (0.05–0.15 m) to high profile reefs (> 0.15 m) (Figure 3). Variation in configuration, oyster coverage, structure or quality across a patch are not evidence of multiple patches, provided the patch meets the key diagnostics (section 2.1), patch definition (section 2.2.1) and condition thresholds (section 2.3).

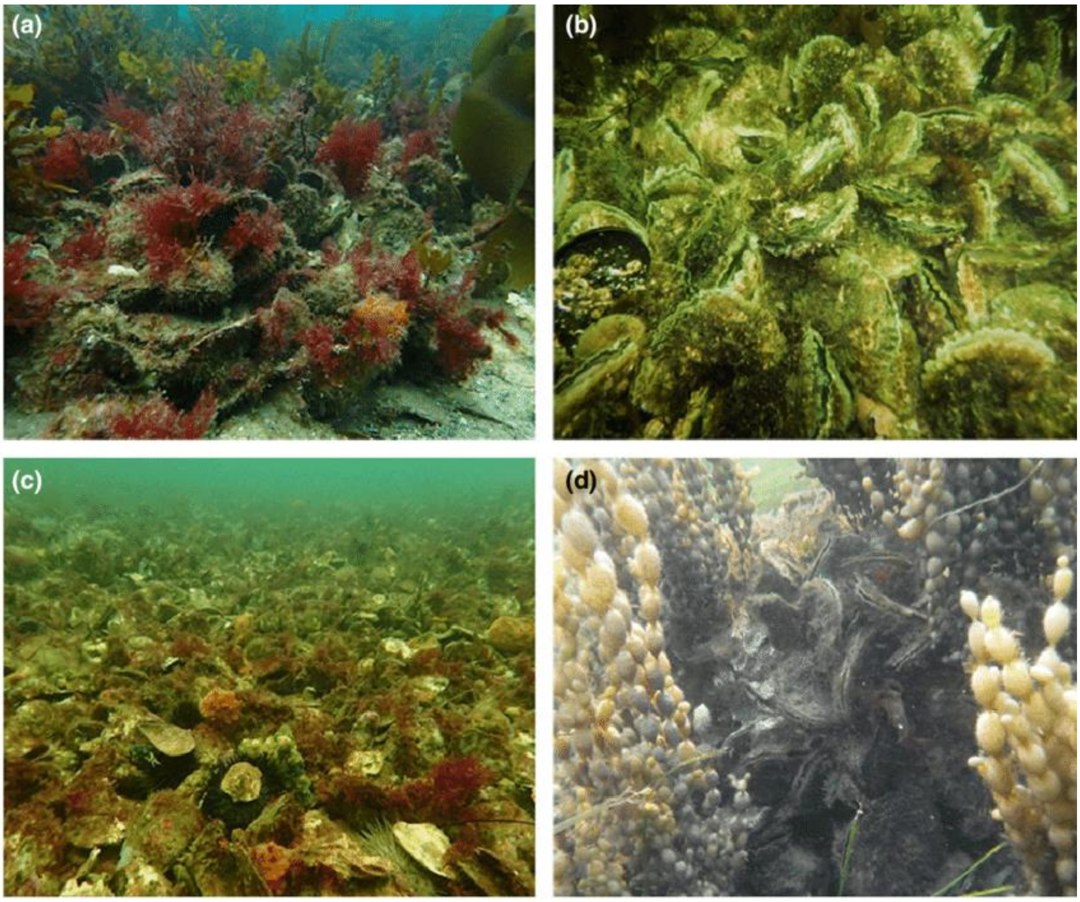


Figure 3. Remnant *Ostrea angasi* oyster reefs in Georges Bay, Tas, displaying different vertical profiles and reef structure: a) & d) high profile reefs approximately 0.4 m in height, and b) & c) low profile beds approximately 0.1 m in height. Adapted from Gillies et al. 2017. Photo credits: C. Gillies, The Nature Conservancy.

2.2.5 Recommended buffer zone for management

An additional buffer zone of a contiguous area directly adjacent to the edge of a patch of the ecological community can protect its integrity and is recommended for consideration for management of the ecological community. (Figure 2). Buffer zones enhance the protection of a patch by avoiding or minimising potential disturbance from surrounding land and sea uses or activities (e.g. dredging, boating activities, new foreshore developments). Larger buffer zones can also provide habitat corridors for transient assemblages associated with the ecological community (e.g. many oyster reef associated fish species).

The size of the buffer zone should be determined based on the site characteristics, intensity of threats, ecological assemblages and the hydrological conditions associated with the ecological community. Generally, the size of the buffer zone should increase with increasing intensity and likely impact of a threat. For example, intertidal oyster reefs may require larger landward buffers in urbanised areas due to a higher risk of coastal foreshore development directly impacting on the ecological community. Similarly, subtidal oyster reefs may be frequently exposed to localised impacts such as boat damage from boat strike and anchoring and smaller, targeted buffer zones are encouraged in these instances. A buffer zone of 10-30 m may be a suitable guideline for smaller, more localised impacts.

To ensure the integrity of the ecological community and overall species diversity, larger buffer zones such as 50-100 m may be used. This could be used to protect a broader intertidal wetland, ensuring protection of reef and avoiding any impacts in its area. Similarly, larger buffer zones could connect surrounding habitat (e.g. seagrass) to the native flat oyster reef ecological community and could be considered as a way to provide wildlife corridors for migratory species (Newton 2012). This is particularly relevant for transient oyster reef-associated species that often follow tidal migration patterns between intertidal and subtidal zones (Gilby et al. 2018; McAfee et al. 2020a).

While the buffer zone is not formally part of the ecological community and not protected as a Matter of National Environmental Significance, it should be taken into account when considering likely 'significant impacts' during EPBC Act decision-making.

Consultation Questions on identifying an occurrence

- Is the patch definition suitable? If not, how should it be amended to ensure appropriate inclusion/exclusion of native flat oyster reefs as the ecological community?
- Is the recommended buffer zone range appropriate? If not, how should the recommended buffer zone be amended to ensure appropriate application?
- Is the connectivity distance between native flat oyster reef patches within a mosaic that is needed to provide key ecological functions appropriate?
- Is the minimum total reef area value of a singular native flat oyster patch or the cumulative area of native flat oyster patches within a mosaic that is needed to provide key ecological functions appropriate?

2.2.6 Restoration sites

Restoration sites are part of the listed ecological community and protected under the EPBC Act if the site meets the key diagnostic characteristics (section 2.1), patch definition (section 2.2.1) and minimum condition thresholds for the ecological community (section 2.3). There are several native flat oyster reef restoration sites throughout southern Australia delivered by partnerships of Government, non-government and community stakeholders with a diverse range of source funding. These reef restoration sites include, 13 occurrences co-delivered through the Commonwealth funded Reef Builder Program with support from other funding programs, that are considered likely to meet the key diagnostic characteristics, patch definition and condition thresholds for the ecological community (TNC 2022, 2024a; NSW DPIRD Fisheries 2024 unpublished data; TNC 2024 unpublished data). There may be other native flat oyster restoration projects that are of similar size or many smaller-scale projects. However, the monitoring data for these sites was either not available or not provided at the time of listing to determine whether they would likely meet the ecological community definition. In most cases, historically damaged native flat oyster reefs are unlikely to re-establish naturally to pre-disturbed levels due to a lack of hard settlement substrate or local adult seed stock, coupled with unsuitable environmental conditions, which is evidenced by the lack of wide-scale natural recovery across the historical extent of occurrence of the ecological community over the last century in the absence of the primary threat of historical overharvesting (Gillies et al. 2018; McAfee et al. 2024).

Restoration of oyster reefs can occur through assisted regeneration and reconstruction through the mitigation of limiting factors, such as lack of suitable substrate, depleted supply of larvae and degraded water quality/sedimentation (Gillies et al. 2017). Planning for oyster reef restoration should be based on site feasibility studies that assess threatening processes (e.g. climate change, water quality, disease risk), environmental suitability (e.g. physical conditions), and logistical viability (e.g. access to hatcheries, management and approval processes) (Gillies et al. 2017; Howie & Bishop 2021). Oyster reef restoration actions should follow established oyster reef restoration guidelines (e.g. Baggett et al. 2014; Fitzsimons et al. 2019; NSW DPI 2021) and specific advice for native flat oyster reef reference conditions and restoration targets (Gillies et al. 2017).

To determine the overall short-term and long-term success of restoration of native flat oyster reef patches, other additional relevant metrics should be monitored and assessed following published standards of monitoring and proof of oyster reef and marine ecosystem restoration success (Baggett et al. 2014; Fitzsimons et al. 2019). Common metrics that are monitored include: abundance of age classes present of native flat oysters (e.g. adults, juveniles and recruits) and changes to these over time, number of age classes (e.g. four or more age classes represent multiple reproductive cohorts), persistence of reef and ongoing recruitment over 3-4 reproductive cycles, diversity of associated transient, infauna or resident species, native flat oyster density, impact of disturbance events (e.g. disease, flooding) on recovery of native flat oyster density and live oyster cover, percentage of native flat oysters compared to other reef-forming species, provision of ecosystem services comparable to existing or reference condition oyster reefs and reef accretion or change in shell budget from original restoration structure (Gillies et al. 2017; McAfee et al. 2024; TNC 2024a; NSW DPIRD 2024 unpublished data). Success of restoration projects is also hindered by the state of the physical environment in which the native flat oyster reef restoration project has been implemented. Monitoring of key environmental variables (e.g. salinity, temperature, dissolved oxygen, pH) and threats (e.g. flooding, disease, sedimentation) can provide valuable information on the likelihood of restoration success or on areas that may require additional local or State management action to improve chances of success (Gillies et al. 2017; NSW DPI 2021; TNC 2024a).

Since 2014, a range of native flat oyster reef restoration projects have commenced within the historical extent of occurrence of native flat oyster reefs in NSW, Vic, SA, WA and Tas (Gillies et al. 2015; Colella et al. 2017; Gillies et al. 2018; TNC 2024a). The largest of these projects, the $20 million Reef Builder program that was implemented between 2021 and 2023 involving partnerships between numerous stakeholders including The Nature Conservancy, federal, state and local governments, coastal landholders, marine and coastal managers, coastal and marine planners, researchers, community members, recreational fishers, oyster farmers and First Nations communities. Through Reef Builder and associated partnerships, restoration of shellfish reef was conducted over 40 hectares across 13 projects. More broadly, The Nature Conservancy in continued partnership with stakeholders, aims to rebuild 60 shellfish reef ecosystems across Australia by 2030 to restore 30% of lost habitat.

There are early indications that restoration of native flat oyster reefs is possible at the smaller-scale and could lead to functional states comparable to remnant reefs (e.g. McAfee et al. 2024; TNC 2024a). However, there is no guarantee that restoration of the ecological community will be successful at all sites. This includes standards outlined by oyster reef restoration guidelines (e.g. the Restoration Guidelines for Shellfish Reefs; Fitzsimons et al. 2019 and the Oyster Habitat Restoration Monitoring and Assessment Handbook; Bagget et al. 2014), and reference condition targets describing characteristics comparable to existing reefs at similar sites or historical benchmark states (Gillies et al. 2017; and see Table 1). Restoration of native flat oyster reef to a functional state comparable to reference condition reefs may take time, and repeated seeding may be necessary in some locations. or recovery may never occur (Gillies et al. 2017; Hemraj et al. 2022; TNC 2024a & b). Monitoring of restoration sites of native flat oyster reefs should occur for at least 10 years (i.e. approximately 4 reproductive cycles) to determine the success of recovery of restored reefs to a functional state (Gillies et al. 2017). Further research and monitoring are required to understand the persistence of restoration sites through time and their response to disturbance events. If suitable conditions for the habitat are not provided (e.g. temperature, salinity, turbidity), the timeframe for recovery will likely be longer and the success of functional outcomes variable or non-existent (Lee et al. 2012; La Peyre et al. 2014; Walles et al. 2016; Gillies et al. 2017).

To be considered within the listing assessment, a native flat oyster reef restoration site must meet the ecological community key diagnostic characteristics (section 2.1), patch definition (section 2.2.1) and minimum condition thresholds (section 2.3) and restoration specific reference conditions set out in Table 1. The restoration reference conditions require native flat oyster reef restoration occurrences to persisted for at least 10 years and meet several key attribute criteria (e.g. density of live oysters, viable spawning population) after this period (Table 1 in section 2.2.6).

Table 1. Native flat oyster reef restoration site reference condition metrics to be measured and met after 10 years (e.g. approximately four reproductive cycles) for a patch to be included in the EPBC listing assessment (this is in addition to meeting the standard ecological community definition (section 2.2), diagnostic characteristics (section 2.1) and condition thresholds; (section 2.3). Note – restoration sites that meet the standard ecological community definition, diagnostic characteristics and condition thresholds will be considered the ecological community for protection under the EPBC Act.

Metric	**Restoration site reference condition**
Average density	> 50 individual oysters/m^2
Age classes	Four or more age classes (multiple reproductive cohorts)
Viable spawning population	> 5 % population two+ year class or older 20-30 % of females ripe during spawning season
Oyster recruitment	Annual or regular recruitment documented Increase in no. of oyster recruits/m^2 compared to pre-restored conditions

Shell budget	Rate of accretion exceeds shell loss
Shellfish composition	Greater percentage of native flat oysters compared to other shellfish reef-forming species
Assemblage composition	Common fish, invertebrate and algae species are represented as part of local species assemblages (i.e. comparable to remnant sites)

Restoration efforts have had variable results for key reef characteristics, such as oyster density and fish abundance. A restoration site in Glenelg, SA, exceeded 2400 oysters/m^2 19 months after restoration (TNC 2024a). Oyster density at restoration locations has also been variable over time, such as in Wilson Spit in Vic, which displayed oyster densities of 724 /m^2 at 7-12 months post construction, 119 /m^2 at 13-18 months, 1289 /m^2 at 25-30 months and 120 /m^2 when surveyed after 30 months (TNC 2024a). Enhancement of fish production is also variable, with some reefs reporting 12,738 kg/ha/year enhancement in Margaret Reef in Vic, but the restoration location at Glenelg in SA only displaying 1.4 kg/ha/year (Connolly et al. 2024). Species richness generally increased as restoration sites matured for pelagic fish and invertebrates, though this trend was less pronounced in cryptic fish and invertebrate species (TNC 2024a).

Consultation Questions on restoration

• Is 10 years (approximately four reproductive cycles) an appropriate timeframe to measure restoration site comparability to remnant reefs and as evidence of likely persistence of reefs through time? Do you have any additional information on the reproductive cycles of *Ostrea angasi*?

• Which restoration site reference condition variables in Table 1 should be included to be measured and met after 10 years (approximately four reproductive cycles) for a restored native flat oyster reef site to be included in the EPBC listing assessment? Are there any other variables that should be considered for inclusion, and what is the evidence to support this?

• Are there other substantial native flat oyster reef restoration sites not within the Reef Builder program and associated partnerships that may meet the key diagnostic characteristics, patch definition and condition thresholds to be considered the ecological community? Please provide the relevant information to support this.

2.2.7 Survey requirements

Patches of the ecological community can vary markedly in their shape, size, condition and features. Thorough and representative surveys are essential to accurately assess the extent and condition of a patch. The Restoration Guidelines for Shellfish Reefs (Fitzsimons et al. 2019), the Oyster Habitat Restoration Monitoring and Assessment Handbook (Bagget et al. 2014), NSW Shellfish Reef Restoration Project Planning and Implementation Guidelines (NSW DPI 2021) and scientific literature (e.g. Bagget et al. 2015; Gillies et al. 2017; McAfee et al. 2024) can provide useful guidance.

Typical survey techniques to monitor and assess oyster reef characteristics and condition include intertidal surveys or diver-swum surveys using transects or quadrats to access faunal/floral assemblages and oyster density/size/height/coverage. Boat or diver GPS surveys, satellite imagery, geographic information systems (GIS), remote operated underwater video and underwater acoustic and echo sounder technologies can also be used to identify and map patches of the ecological community and track changes in horizontal and vertical extents of oyster reefs over time (see Appendix C for additional information on survey techniques for subtidal oyster reefs).

The size, number and spatial distribution of surveys and information must be of an appropriate resolution to detect variation across the patch. Sampling should address hypothesised variations in species composition, and significant variation in the oyster reef substrata (including areas of different condition), landscape/seascape qualities and management history (where known) across the patch. Recording the search effort (e.g. identifying the number of person hours spent per quadrat/transect and across the entire patch; along with the surveyor's level of expertise and limitations at the time of survey) is useful for future reference. Whilst identifying the ecological community and its condition is possible at most times of the year, consideration must be given to the role that tidal cycle, season, climatic-events and disturbance history may play in an assessment.

Timing of surveys should allow for a reasonable interval after a disturbance (natural or human-induced) to allow for regeneration of native flat oyster reef and the associated assemblage to become evident and be timed to enable diagnostic species to be identified. Similarly, longer survey durations (e.g. over multiple years or reproductive cycles) may be beneficial to capture different levels of recruitment across different years. At a minimum, it is important to note climate and environmental conditions and what kind of disturbance may have happened within a patch, and when that disturbance occurred. To determine if native flat oyster reef patches at restoration sites are to be included within the EPBC listing assessment, surveys of the variables outlined in Table 1 must be undertaken after at least 10 years (i.e. approximately four reproductive cycles).

2.2.8 Mapping and habitat classifications

Native flat oyster reefs can form mosaics with other intertidal and subtidal ecosystems within estuarine and marine environments, such as seagrass, mudflats, seaweed and, rocky reefs. Habitat structures created and dominated by native flat oysters are the key distinguishing feature of this ecological community and mean that it is readily distinguished from other habitat types.

The native flat oyster ecological community may also occur proximate to other shellfish reefs or may integrate with other shellfish species to form mixed reefs. Gillies et al. (2018) identified at least 14 oyster or mussel species in Australia, that may form reefs. Sydney rock oysters are one of the more commonly occurring oyster reef-forming species that partially overlaps in distribution with native flat oyster reefs in parts of NSW and far northern Vic and have undergone similar historical declines (Gillies et al. 2020). However, compared to Sydney rock oyster reefs, native flat oyster reefs more commonly form as low-profile beds and can occur in deeper subtidal areas (Gillies et al. 2018; Overton et al. 2024) (see Figure 4). The shell morphology of native flat oysters and Sydney rock oysters also differ in their appearance. Sydney rock oysters have smooth thick ridged shells with small teeth and native flat oysters have flaky and layered flat shells (see Figure 4) (Museums Victoria 2022; NSW DPI 2022). The introduced *Magallana gigas* (Pacific oyster) is also an oyster reef-forming species that overlaps in distribution with native flat oyster reefs in parts of NSW, Vic, SA and Tas, where the species occupies the intertidal and shallow subtidal habitat zone (DAWE 2022a). Pacific oyster shells have differing morphology to the native flat oyster, with moderately cupped shells that are white in colour with purple to red patches, and have irregular, rounded radial folds that overlap (DAWE 2022a).

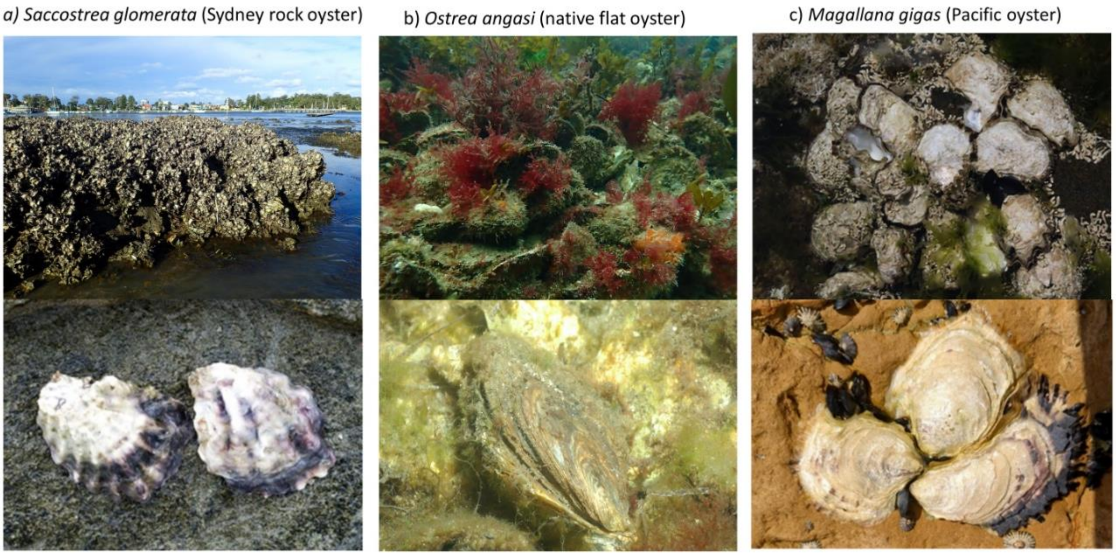


Figure 4. Reef structures and shells of a) Sydney rock oyster b) native flat oyster and c) Pacific oyster**.** Photo credits: a) above by Ian McLeod and Steve McOrrie/James Cook University, a) below by Queensland Museum, b) above by C. Gillies/The Nature Conservancy, b) below by G. Edgar, c) above by Kat Haas/iNaturalist and c) below by Ian D B Moodie/iNaturalist.

There have also been reports of the introduced *Ostrea edulis* (European flat oyster) in WA, though in small numbers relative to the native flat oyster (Morton et al. 2003; Wells et al. 2009). The European flat oyster has been identified as occurring in intertidal and subtidal environments (Wells et al. 2009; AFD 2024) and is difficult to distinguish from native flat oyster through morphology (Morton et al. 2003). The two flat oyster species were previously identified as closely related, having only recently diverged (Heasman et al. 2004; Hurwood et al. 2005; Danic-Tchaleu 2011; Salvi et al. 2014, 2022; Guo et al. 2018; Hu et al. 2019; Li et al. 2021). Many studies suggest the two species' lineages may actually form a single species, however further research is required to confirm this (Heasman et al. 2004; Hurwood et al. 2005; Danic-Tchaleu 2011; Salvi et al. 2014, 2022; Guo et al. 2018; Hu et al. 2019; Li et al. 2021). *O. angasi and O. edulis* are listed as separate species on the World Register of Marine Species (WoRMS) and Australian Faunal Directory (AFD) (AFD 2024; WoRMS 2024). *Ostrea stentina/equestris* has also been reported in NSW as a native species (Commissioners of Fishereries 1889; Hu et al. 2019; AFD 2024; WoRMS 2024), where these species may be related enough to form a single species across populations in the Western Pacific and Americas (Hu et al. 2019; Sutton et al. 2020). *Ostrea stentina/equestris* is generally considered to be a small, economically unimportant species that does not form reefs and inhabits subtidal and intertidal waters with high salinity (Galtsoff & Merill 1962; Dinamani & Beu 1981; Markwith 2010 cited in Sutton et al. 2020).

Ostrea stentina/equestris has historically been noted as *O. virescens* and as an edible oyster occurring naturally in NSW oyster beds (Commissioners of Fisheries 1889; AFD 2024; WoRMS 2024).

There are several mapping and habitat classification schemes used nationally and in NSW, Vic, SA, WA and Tas (Appendix B). Although none of these mapping and classification schemes directly map areas of the ecological community according to the key diagnostics, patch definition and condition thresholds, they may still provide useful information on the likely occurrence of the ecological community.

Appendix B outlines the map units or classifications of several common mapping and classification systems that may be useful for mapping the ecological community.

2.2.9 Other relevant listed ecological communities

There are several other EPBC-listed ecological communities that may intergrade with native flat oyster reefs as outlined in Table 2. *Posidonia australis* seagrass meadows of the Manning-Hawkesbury Ecoregion may intergrade with native flat oyster reefs in this part of NSW. Giant Kelp Marine Forests of South East Australia may intergrade with native flat oyster reefs across Vic, SA and Tas. If listed, *Saccostrea glomerata* oyster reefs of eastern Australia may intergrade with or form near to native flat oyster reefs that extend into lower intertidal and shallow subtidal areas in NSW and far eastern Vic (see section 2.2.8 for features that can be used to distinguish between these oyster reef ecological communities). Subtropical and Temperate Coastal Saltmarsh may occur near to native flat oyster reefs but is unlikely to intergrade with, or be confused with, the ecological community.

Table 2. Nationally listed threatened ecological communities (TEC) that may intergrade or occur near to native flat oyster reefs

Threatened Ecological Community	Status	Distribution
Posidonia australis seagrass meadows of the Manning-Hawkesbury ecoregion’	Endangered	NSW
Giant Kelp Marine Forests of South East Australia	Endangered	Vic, SA, Tas
Saccostrea glomerata oyster reefs of eastern Australia	Under Assessment	Qld, NSW, Vic

Source: EPBC Act list of Threatened Ecological Communities.

Consultation Questions on additional identification information

- Are the survey requirements for the ecological community appropriate?
- Are all the relevant/intergrading habitats and listed ecological communities mentioned?
- Are there additional habitat classification and mapping systems that should be documented in Appendix B?

2.3 Condition classes, categories and thresholds

Land/seascape use, disturbance history and other factors that may cause degradation or loss of its features will influence the condition of patches of the ecological community. National listing focuses legal protection on patches of the ecological community that are the most functional, relatively natural and in comparatively good condition. These patches are identified through *minimum condition thresholds*.

Condition classes are also used to distinguish between patches of the ecological community of different qualities, to aid environmental management decisions.

In order to be protected as a matter of national environmental significance, occurrences of the ecological community must meet both:

- the key diagnostic characteristics (section 2.1) AND
- at least the minimum condition thresholds (Table 3).

Table 3 outlines the different condition classes and categories that apply to the ecological community. The minimum condition thresholds are designed to identify occurrences that retain sufficient conservation values to be considered a matter of national environmental significance, to which the referral, assessment, approval and compliance provisions of the EPBC Act apply. These include all patches in Classes A, B and C. Minimum condition thresholds for the native flat oyster reef ecological community have been set to a lower level than likely historical benchmark reference condition reef as occurrences now exist mostly in a comparatively degraded and fragmented state.

Patches that do not meet the minimum condition thresholds for at least Class C (i.e. patches that are listed as 'Not Protected' in Table 3) are excluded from protection under the EPBC Act. In some cases, the loss and degradation are irreversible because natural characteristics have been permanently removed. However, although not protected under the EPBC Act, many of these patches may still retain important natural values and may be protected or considered in State and local laws or planning schemes. For instance, small patches of the ecological community that do not meet the minimum total area threshold value in the patch definition or the minimum live oyster densities in the condition thresholds may still be important for providing native flat oyster larval stock to the oyster reef network or hard substrata for native flat oyster larval settlement.

In addition, patches that do not meet the minimum condition thresholds or other defining characteristics that can be restored (see section 2.2.4) should not be excluded from recovery and other management actions as these actions may improve condition or area, such that it subsequently can be included as part of the ecological community fully protected under the EPBC Act. Management actions should be designed to restore patches to high density, where practical. Restoration sites of the ecological community that meet the key diagnostic criteria (section 2.1), patch definition (section 2.2) and minimum condition thresholds (Table 3) are considered the ecological community for the purposes of management and protection under the EPBC Act. If these patches also meet the restoration reference condition metrics (Table 1) when monitored after 10 years since implementation, they will also be considered as an existing occurrence of the ecological community within the listing assessment (section 6.2).

When assessing the condition of a patch of the ecological community it is important to refer to the key diagnostic characteristics (section 2.1) and the information on defining an occurrence (section 2.2) to determine the area to assess for condition.

The broadest area that meets the key diagnostic characteristics of the ecological community should be used in determining condition. Where condition is variable and the condition of the total area falls below the minimum thresholds, the largest area or areas within the overall area that do meet the minimum condition thresholds should be identified. This may result in multiple protected occurrences of the ecological community being identified within the overall area first considered.

Table 3. Condition classes, categories and thresholds for native flat oyster reefs

HIGH DENSITY^	MODERATE DENSITY	LOW DENSITY	NOT THE ECOLOGICAL COMMUNITY
Average density of live oysters of a reproductive age/size on oyster patches is > 50 live oysters per m^2	Average density of live oysters of a reproductive age/size on oyster patches is between 10-50 per m^2	Average density of live oysters of a reproductive age/size on oyster patches is between 5 - 9 per m^2	Average density of live oysters of a reproductive age/size on oyster patches is < 5 per m^2
CLASS A A dense patch that meets the key diagnostics and patch definition.	**CLASS B** A moderately dense patch that meets key diagnostics and patch definition.	**CLASS C** A low-density patch that meets key diagnostics and patch definition.	**NOT PROTECTED** (but may be a focus for local protection or restoration)

^ For mosaic patches, density of live oysters of reproductive age/size is the average value, calculated on oyster reef patches within the mosaic.*To be considered the ecological community, single or mosaic patches of existing or restoration occurrences of oyster reef must meet (1) the minimum condition thresholds (Class C) outlined in Table 3 (above), (2) the key diagnostic characteristics (section 2.1), and (3) have an area equal to or greater than 250 m^2 as described in the patch definition (section 2.2.1).
*See section 2.2.7 for additional considerations when surveying a patch.

Consultation Questions on condition classes, categories and thresholds

- Are the condition thresholds appropriate for this ecological community? If not, please suggest and justify alternatives, including providing any relevant supporting evidence.

2.4 Habitat critical to the survival of the ecological community

The habitat requirements for an ecological community include areas with the necessary biological, physical, geological and climatic conditions for its survival. The ecological community provides its own habitat, as areas of the ecological community represent the habitat for the individual species comprising it. Of critical importance to the survival of the ecological community is an ongoing connection with the hydrological tidal regime, such that the diagnostic features and associated assemblages of the ecological community are maintained. In addition, patches located away from freshwater sources or run-off points may be critical to the survival of the ecological community, by buffering the overall impacts associated with runoff sources such as sedimentation, pollutant run-off, increased prevalence of disease, and changes to environmental characteristics (e.g. salinity and temperature). Key physical conditions required for the survival of the ecological community includes marine and coastal areas with relatively stable salinities ranging from 25-35 ppt (with acute episodes of low salinity common during heavy rainfall), temperatures between 10-29 °C, relatively sheltered locations, and no prolonged periods of hypoxia (Thomson 1954; O'Sullivan 1980 cited in Gillies et al. 2017; O'Connor et al. 2015; Cole et al. 2016; Crawford 2016; Gillies et al. 2017). The habitat or areas most critical to the survival of the ecological community are those patches that are in the best condition (i.e. Class A in Table 3). These represent those parts of the ecological community closest to the benchmark state of the ecological community. They are the reef patches/beds that retain the most intact structure and ecological function and have the highest chance of persisting in the long-term.

However, this does not mean that areas that otherwise meet the moderate or minimum condition thresholds (i.e. Classes B and C in Table 3) are unimportant for the survival of the ecological community. These occurrences are critical to the survival of the ecological community if they occur in locations that are particularly important for biodiversity or function and/or may contain suites of species or habitat features that are important in a regional or local context (see section 2.5).

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

Consultation Questions on habitat critical to the survival

- Can you recommend what areas are critical to the survival of the ecological community, either in terms of condition or other attributes?

2.5 High value occurrences - surrounding environment and landscape/seascape context

Patches of the ecological community do not occur in isolation. The surrounding ecosystems and other landscape/seascape considerations will also influence how important a patch is to the ecological community as a whole. Patches that are spatially linked, whether ecologically or by proximity, are particularly important as wildlife habitat and to the viability of those patches of the ecological community into the future. For actions that may have 'significant impacts' and require approval under the EPBC Act, it is important to consider the whole environment surrounding patches of the ecological community.

For example, in areas that have been historically dredged and degraded, some patches that meet the minimum condition thresholds may occur in isolation. Such patches could benefit from restoration activities to link them with other patches to achieve the minimum total reef area threshold in the key diagnostics to be protected under the EPBC Act, and to increase overall ecosystem resilience.

The ecological community often occurs in association with other native marine and coastal ecosystems. Patches of the ecological community that remain connected with other native marine and coastal ecosystems may have a better chance of future survival and restoration success, as connected patches may be more resilient to disturbance (Gilby et al. 2018; McAfee et al. 2020, 2022).

The following indicators of high value should be considered when assessing the impacts of proposed actions under the EPBC Act, or when determining priorities for protection, recovery, management, and funding:

- Patches that meet or are closest to the high quality (Class A) condition for this ecological community.
- Presence of a high diversity of known oyster reef-associated faunal and floral species (Appendix A).
- Presence of nationally or State/Territory listed threatened species, key functional species, or close proximity to other nationally or State/Territory listed threatened ecological communities.

- Connectivity to other oyster reefs or marine habitat. Of particular importance are (1) oyster reefs positioned between (or linking) other oyster reefs or other marine habitats (e.g. seagrass, mangroves), and (2) patches that contribute to a mosaic of oyster reef patches at a site, especially patches that are close to large remnant oyster reefs.
- Patches/beds with minimal invasive species or in locations where these can be managed easily.
- Patches/beds with minimal disturbance (i.e. threats reduced to sufficiently allow oyster recruitment, growth and survival).
- Physical conditions that support the growth and survival of the ecological community (e.g. appropriate water temperature, salinity, pH, dissolved oxygen; see O'Connor et al. 2015; Cole et al. 2016 Crawford 2016; Gillies et al. 2017; Pereira et al. 2019).
- Hydrological regimes sufficient to ensure connectivity and ecological function between the oyster reef, estuary, coastal embayment, and marine areas surrounding the oyster reefs.
- Patches/beds located away from freshwater sources or run-off points (e.g. stormwater drains, freshwater river mouths) to buffer the potential impacts of sediment build-up, degraded water quality, prevalence of disease, and changes to water salinity and temperature.
- Areas protected from swell/storm surge that have relatively stable substratum to allow for oyster larval settlement.
- Patches at the edge of the range of the ecological community.
- Patches that show evidence of recruitment or the presence of a range of age cohorts (including through successful assisted regeneration/restoration or management of sites).

Consultation Questions on areas of high value

- Are there any additional areas that may be of high value that are not listed above, or are there areas that are listed and should not be? Please provide supporting evidence.

3 Cultural significance

The cultural, customary, and spiritual significance of ecological communities are diverse and varied for First Nations Australians and their stewardship of Land and Sea Country. This section describes some examples of this significance but is not intended to be comprehensive or applicable to, or speak for, First Nations Australians. Such knowledge may be held by First Nations Australians who are the custodians of this knowledge and have the rights to decide how this knowledge is shared and used.

The oyster has been described in many First Nations Australians languages. For example, the Dharawal peoples of southern Sydney in NSW call the mud oyster 'dainya' (Bursill & Jacobs 2001), the Wadawurrung peoples near Melbourne, Geelong and the Bellarine Peninsula in Vic call the oyster 'barnabil' (Deadly Story 2024), the Nukunu peoples near Spencer Gulf in SA refer to the oyster as 'pirra' (Hercus 1992), and in palawa kani, the language of Tasmanian Aboriginals, the oyster is called 'taralangkana' (IMAS 2024a).

Over centuries, oyster reefs have provided significant cultural, subsistence and social value to First Nations communities in Australia (Thurstan et al. 2020; Gibbs et al. 2024). Oyster shells have been found in living sites along the Australian Coastline that can include large masses of shell (Gillies et al. 2015; Gillies et al. 2018; Thurstan et al. 2020; Gibbs et al. 2024), including along the NSW coastline (Stockton 1977; Sullivan 1981, 1982, 1984), Vic (Godfrey 1989 cited in Gillies et al. 2018), Tas (Lourandos 1968) and in some parts of SA (Luebbers 1978; Radford & Campbell 1982 cited in Gillies et al. 2015). Damage to living sites may remove evidence of historical connection to shellfish reefs, with shells having been utilised for lime and cultch, and rising sea levels potentially eroding older living sites (Oyster Culture Commission 1877; Dortch et al. 1984; Gillies et al. 2015).

In NSW, oyster shells have been documented to be used as fishing hooks (Ogburn et al. 2007; Ogburn 2011) and masses of shell are present in hundreds of living sites, including native flat oyster shells over 6000 years old (Sullivan 1982; Gibbs et al. 2024). In Vic, records show that oyster reefs were of great importance to First Nations Australians communities around Corner Inlet and western Port Phillip Bay (Ford & Hamer 2016). In Tas, native flat oysters were a major component of the diet of Tasmanian Aboriginal people as evident from numerous living sites documented around the Tasmanian coastline, with large amounts of shell documented in Great Oyster Bay and Little Swanport and east coast living sites dating from 6,000 to 8,700 years old (Reber 1965 in cited Lourandos 1968; Lourandos 1968; Gillies et al. 2015; Crawford 2016). The oyster is a traditional food source for Tasmanian Aboriginal people, including the Mumirimina people of the Oyster Bay Tribe, being a major food source that was once abundant in places such as the Derwent River (Timtumili Minanya) (Clarence City Council 2024; TasTAFE 2024). First Nations Australians also consumed native flat oyster in SA, with the species found in living sites along parts of the coastline (Radford & Campbell 1982 cited in Alleway & Connell 2015; Godfrey 1989 cited in Alleway & Connell 2015). Proficient oyster harvest by the Nauo people in Coffin Bay in SA was recognised in early European accounts (Wallace-Carter 1987 cited in Martin et al. 2025).

In WA, there has been a lack of living site documentation that describe large amounts of shell (Dortch et al. 1984). In some areas of SA and in southern WA, it is likely that native oysters were not a significant component of the diet of First Nations Australians (Luebbers 1978). Patterns of use in these regions reflect consumption of shellfish species that were easier to forage or were non-existent because of it being considered taboo to consume shellfish (Dortch et al. 1984). Other groups believed that oysters caused illness and were not consumed until after colonisation, when groups began to cook oysters before consumption (Nind 1831; Young 1997 cited in Gillies et al. 2015).

During peak periods of commercial oyster harvest, First Nations Australians maintained a connection to oysters. First Nations Australians were often employed to collect and cull oysters across NSW (Oyster Culture Commission 1877). For instance, in Durras Lake, First Nations Australians were employed to pick young oysters of rocks and throw them into deep water to grow larger for subsequent harvesting (Oyster Culture Commission 1877; Commissioners of Fisheries 1889).

First Nations groups have collaborated with The Nature Conservancy and associated partners on the Reef Builder project that has been working to restore native flat oyster reefs and other shellfish reefs between 2021 and 2023 across WA, SA, Vic, Tas, NSW and Qld (TNC 2024b). Many of these restoration projects are continuing with the Nature Conservancy and associated partners.

Consultation Questions on cultural significance

- Are you (or please direct us to appropriate people and organisations in the area who may have information) able/willing to share information about the cultural significance of the native flat oyster and reefs or surrounding seascape generally? If so, please provide information and advice on appropriate use, including what consent has been obtained or should be sought.
- In particular, can you provide information to support or clarify information that you don't agree with?

4 Threats

Native flat oyster reefs have been primarily impacted by historical overharvesting through commercial fishing using destructive fishing methods (i.e. dredging and skinning). Ongoing threats to this ecological community include coastal and catchment development and degraded water quality, disease, infestations and invasive species, climate change and extreme weather events, and other anthropogenic impacts, such as commercial and recreational fishing and boating, and possibly offshore activities (e.g. mining and drilling) and aquaculture if the activities are not appropriately regulated. The cumulative impacts of these threats have caused a reduction in the extent, structure, function of native flat oyster reefs and limited natural recovery of the ecological community across its historical geographic distribution. See section 4.1 for more information on these key threats.

4.1 Threat table

Table 4 outlines the key threats facing the ecological community, which represent the *main factors that cause it to be eligible for listing* as required by section 266B (2) (a) (ii) of the EPBC Act. This information supports the assessment against the criteria at section 6. Although presented as a list, in reality these threats often interact, rather than act independently.

Table 4. Summary of threats facing the native flat oyster reef ecological community

Threat factor	Threat Status*	Threat impacts
Historical commercial overharvesting, particularly using destructive fishing methods	*Timing*: past *Severity*: extreme *Scope*: whole	Overharvesting has been attributed as the primary cause of decline of native flat oyster reefs (Alleway & Connell 2015; Ford & Hamer 2016; Gillies et al. 2018). Harvests of native flat oyster reefs supplied meat for consumption and shells for crushing into material for roads or for burning to supply lime for building (Alleway & Connell 2015). Native flat oyster reefs were extensively harvested and dredged in bays and inlets in NSW (Gillies et al. 2018), Vic (Saville-Kent 1891a cited in Nell 2001), Tas (Calder 1886; Sumner 1972 cited in Nell 2001), SA (Olsen 1994 cited in Nell 2001) and WA (Gillies et al. 2018) in the 1800s and the early 1900s. As a result of these activities, reefs were largely exhausted by the mid-1900s and, in most cases, have not naturally recovered (Oyster Culture Commission 1877; Nell 2001; Alleway & Connell 2015; Crawford 2016; Ford & Hamer 2016; Gillies et al. 2018). Oyster fishers on native flat oyster reefs primarily used dredge fishing methods that were non-selective and captured all sizes of oyster shells

Threat factor	Threat Status*	Threat impacts
		(Calder 1886; Alleway & Connell 2015). Multiple dredges were dragged back and forth across oyster beds, which were 'worked down' until the catch was low, nil or not meeting market requirements otherwise, and the dredging would then move on to another location (Fuentes et al. 1990; Alleway & Connell 2015). Dredging was unselective and broke up, removed or buried all sizes of oysters and shell, which resulted in loss of oyster biomass, removal of settlement substrate, reduced ecosystem function, fragmentation of remaining patches or a shift toward an unconsolidated or soft sediment substrate (Alleway & Connell 2015; Crawford 2016; Gillies et al. 2020). Intertidal oyster beds may have also been harvested through skinning, which involved raking live oysters together at low tide that were then loaded onto berthed vessels (Ogburn et al. 2007; Ogburn 2011). Loss of native flat oyster biomass and the complex, biogenic oyster reef substrate likely reduced the ability of reefs to recover naturally due to the decline in oyster spawning stock and a reduction in reef-associated chemical cues or noises and hard substrate used by oyster larvae to settle and recruit (Tamburri et al. 2008; Alleway & Connell 2015; McAfee et al. 2023). The reduction in the number and extent of native flat oyster reefs within a reef system through destructive practices likely also reduced the resilience of the remaining isolated patches against other stressors, such as disease, predation, degraded water quality and climate change (Gillies et al. 2018). This likely also contributed to limited natural recovery of the reefs once historical commercial harvesting via dredging and skinning ceased (Ford & Hamer 2016; Gillies et al. 2018).
Coastal/catchment development and degraded water quality, including sedimentation	*Timing*: ongoing *Severity*: major *Scope*: whole	Historic colonisation, ongoing coastal and catchment development and agriculture in catchments along coastlines has resulted in sedimentation and degraded water quality that has likely exacerbated the loss of native flat oyster reefs and has hindered the process of natural recovery after the historic overharvesting of reefs across the ecological community's historic extent of occurrence (Gillies et al. 2015; Ford & Hamer 2016; Cook et al. 2021). Ongoing catchment modifications and increasing foreshore development are altering flow from rivers into estuarine waters and can result in changes to suitable hard substrate availability, salinity gradients, increase suspended sediments, heavy metals and nutrient concentrations, and decrease dissolved oxygen, which can reduce the growth, survival, and reproductive success of oyster reefs (Lenihan & Peterson 1998; Barnes et al. 2007; Gillanders et al. 2011; Gillies et al. 2020). Increasing foreshore development may also directly result in the loss of native flat oyster reefs through the direct removal or smothering of oysters in development, channelling or land reclamation areas, or degradation through damage to the reef structure and altering of salinity and hydrology through activities such as dredging, where this has impacted other oyster species (e.g. Sydney rock oyster) (MacKenzie 1997 cited in McLeod et al. 2019; Stokes et al. 2012; McLeod et al. 2019). Being comprised of an estuarine and marine bivalve species that are commonly exposed to varied environmental conditions, native flat oyster reefs are likely to be able to adapt to some changes in water quality through actions such as closing their valves and subsisting on energy stores in unfavourable conditions (Bartlett et al. 2020). However, periods of extreme exposure to pollutants, nutrients or sedimentation in particular, may lead to mortality, conversion of oyster reefs to soft sediment habitat that have limited hard substrate for recruitment, the smothering of oysters by sediment/particulates or algae from excessive nutrients that limit their ability to filter feed and grow, and facilitation of pests or disease (Saville-Kent 1891b; Mount et al. 2005; Ogburn et al.

Threat factor	Threat Status*	Threat impacts
		2007; Hamer et al. 2013; Gillies et al. 2020). For example, high rainfall events can lead to periods of unfavourable water quality caused by runoff (e.g. increased herbicides, sediment, sewage and/or natural sources of toxins such as *Eucalyptus nitens* leaf extract) and salinity levels that negatively impact the fitness of oysters with freshwater flowing into in Georges Bay, St Helens, Tas, where remnant native flat oyster reefs occur (Break O'Day Council et al. 2012; Bleaney et al. 2015). Several events of high levels of oyster mortality were reported in farmed oysters in Georges Bay after heavy rainfall, with one major flood event resulting in more than 90% oyster mortality in 2004 (Scammell 2004; Break O'Day Council et al. 2012; Bleaney et al. 2015). Similarly, increased silt loads in rivers and bays as a result of colonisation with extensive land clearing and agriculture were noted as a reason for mortality of oyster beds in Georges Bay (Parliamentary Report 1885 cited in Beck et al. 2009; Gillies et al. 2015). In NSW, the Parramatta River was reported to have lost its native flat oysters a few years before the Oyster Culture Commission in 1877, which was attributed by some to discharged sewage matter (Oyster Culture Commission 1877). Saville-Kent (1891b) also noted that mudworm affected oyster fisheries in NSW belonged to rivers experiencing sediment pollution from inland watersheds. While oysters can present a high tolerance to heavy metals, elevated heavy metal loads in amounts that may cause harm to oysters have been reported in estuaries and bays that comprise remnant or restoration sites of native flat oyster reefs, such as in Corio Bay, Vic and the Derwent Estuary, Tas (Fabris et al. 1999; Luo et al. 2017; Chan & Wang 2019; Macleod & Coughanowr 2019). Responses of the native flat oyster to heavy metal contaminated sediments in NSW demonstrated impaired fitness in individuals through increased lysosomal membrane stability, whole energy disturbance and reduced embryo development, but documented low mortality (Bartlett et al. 2020). Studies on other oyster species under exposure to various elevated heavy metals documented other negative impacts, including weakened shell structures and increased predation risk, inhibited filtration, shift in sex ratios, and reduced shell growth rate (Liu et al. 2014; Weng & Wang 2014; Stewart et al. 2021; Jamal et al. 2022). These effects differed based on oyster species, location and metal combination. Several estuaries along the east coast of Australia also continue to be strongly affected by acidification caused by acid sulfate soil run-off that can cause significant mortality and stress in oysters, but impacts have not been documented for native flat oysters to date and are likely to vary by species and habitat zone (Dove & Sammut 2007a & b; Amaral et al. 2012). There are reports of favourable conditions for native flat oyster in terms of water flow, sedimentation and water quality in some areas across the historical extent of occurrence of the ecological community, such as in Dromana, Vic and Oyster Harbour, WA, where reports highlight good water quality (Hamer et al. 2013; Gillies et al. 2017; DWER 2019; EPA Victoria 2024; NSW DPIRD 2024a). However, continued coastal development, catchment modification and population growth may further alter these conditions to a state that has a negative impact on native flat oyster populations. This coastal urbanisation pressure, particularly when coupled with climate change, may result in increased stress and risk of degraded water quality and associated impacts on

Threat factor	Threat Status*	Threat impacts
		native flat oyster reefs if appropriate water quality management plans are not implemented and adhered to. For instance, greater water temperature and ocean acidity predicted under climate change may lead to increased metal uptake and toxicity for bivalves, or negative synergistic effects with changing salinity conditions (Peck 2019; Kibria et al. 2021).
Climate change and extreme weather events	*Timing*: ongoing *Severity*: major *Scope*: whole	Oyster reefs are threatened by climate change through extreme events, sea level rise and the alteration of biophysical conditions required for oyster survival, growth, and reproduction (e.g. increased temperature, decreased pH, dissolved oxygen, salinity) (Gillanders et al. 2011; Gillies et al. 2020; Tilbrook & Lenton 2021). These changes can alter the distribution and composition of oyster reefs and exacerbate existing threats (Clark & Johnson 2017). *Increased temperature and acidification* Southeast Australia, including Tas, which encompasses parts of the native flat oyster reefs distribution, is one of several identified global hotspots of ocean warning because of climate change, with rates of warming above the global average (Hobday & Pecl 2014; CSIRO & Bureau of Meteorology 2022, 2024). Sea surface temperature warming across large areas of the Indian Ocean region has also affected the west coast of Australia (CSIRO & Bureau of Meteorology 2022, 2024). In estuarine environments, temperatures have warmed at a median average of 0.039 °C yr^{-1} between 1985 to 2022, with more rapid warming occurring in the east coast compared to the west (Prum et al. 2024). By 2090, sea surface temperature is projected to increase between 1.5-5.7 °C under a high emissions scenario throughout the range of the ecological community, with the east coast expected to see the highest overall potential rise, where Vic and Tas will experience the largest rise in southern Australia (CSIRO & Bureau of Meteorology 2015a). It is also expected that marine heatwaves will become more frequent and longer lasting, leading to increased stress on marine environments (CSIRO & Bureau of Meteorology 2024). There is also very high confidence that the ocean around Australia will continue to become more acidic, with acidification rates proportional to emissions growth (CSIRO & Bureau of Meteorology 2015a, 2020, 2024). This change in acidity is strongest south of Australia, where it is considered likely to impact commercially important shellfish in the future (CSIRO & Bureau of Meteorology 2024). Experimental studies on native flat oyster adults indicate that higher water temperatures can result in higher rates of mortality, decreased oyster condition and an increased risk of *Bonamia* infected oysters dying (Pereira et al. 2019; Bradley et al. 2020). In a closely related species, European flat oyster, experimental exposure to high water temperatures (36° C) resulted in 100% adult mortality (Eymann et al. 2020). Juvenile native flat oysters also faced reduced survival times under simulated intertidal conditions when emersed under increased temperatures, approaching higher rates of mortality more rapidly, particularly for smaller oysters (Overton et al. 2024). There is some evidence to show native flat oyster larvae during brooding may be able to develop tolerance to elevated $pC0_2$ or acidification (Cole et al. 2016; Pereira et al. 2019). This larval tolerance may be sufficient for expected future ocean acidification, but excessive exposure can still lead to sublethal effects such as impaired feeding and smaller sizes in larvae (Cole et al. 2016; Pereira et al. 2019). When native flat oyster larvae are exposed acidification alongside increased temperature or reduced salinity there

Threat factor	Threat Status*	Threat impacts
		can be delayed development, reduced size and more frequent abnormalities (Cole et al. 2016). Increased water temperatures and ocean acidification predicted under climate change may also lead to increased metal uptake and toxicity for bivalves, or negative synergistic effects with changing salinity conditions (Peck 2019; Kibria et al. 2021). Overall, the response of the native flat oyster to increases in temperature and acidification is likely complex, with oysters exhibiting some resilience but having greater vulnerability under multiple climate stressors or as juveniles. Increased vulnerability during early life stages may result in bottlenecks or issues of persistence of native flat oyster populations/reefs under climate change. *Extreme events* In southern and eastern Australia, there has been a documented general shift to drier conditions due to natural variability on decadal timescales and climate change, particularly in the south-west and south-east on mainland Australia (CSIRO & Bureau of Meteorology 2022, 2024). However, as the climate warms, there is an increased likelihood of more intense heavy rainfall events, even in parts of Australia where average rainfall is expected to decrease (CSIRO & Bureau of Meteorology 2022, 2024). This will likely increase the risk of flooding and associated run-off, particularly in urban catchments (CSIRO & Bureau of Meteorology 2022, 2024). Gillies et al. (2020) describes flooding in historical and contemporary times as a catastrophic threat to native flat oyster reefs. Heavy rainfall and flooding, particularly after dry periods, can lead to increased sedimentation in areas with native flat oyster reefs, resulting in the smothering of oysters, reduced hard substrate for recruitment and facilitation of pests, infestations and disease (e.g. mudworm) (Ogburn et al. 2007; Break O'Day Council et al. 2012; Hamer et al. 2013). The effects of these impacts can lead to oyster mortality, reduced recruitment, and a decline in overall oyster fitness. For example, after heavy rainfall in 2004, a major flood event in Georges Bay, Tas, where remnant native flat oyster reefs occur, resulted in 90% mortality in farmed oysters (Break O'Day Council et al. 2012). Increased flooding can also lead to reduced salinity and possible decreased benthic dissolved oxygen levels through hypoxic blackwater events that may reduce the fitness or survival of oysters, particularly if coupled with heat stress or after other extreme events (e.g. bushfires) (Cole et al. 2016; Gillies et al. 2020; Tilbrook & Lenton 2021; CSIRO & Bureau of Meteorology 2022). Native flat oysters are associated with conditions that have relatively stable salinity but acute seasonal episodes of reduced salinity such as from heavy summer rainfall in south-eastern Australia can be expected (Thomson 1954; Cole et al. 2016). Climate change is increasing the extent and severity of bushfires in Australia, especially in southern Australia (CSIRO & Bureau of Meteorology 2022, 2024). Ash run-off can smother aquatic environments and lead to toxic macroalgal blooms from excessive nutrients that can reduce dissolved oxygen concentrations in the water column (Herbert-Read et al. 2022). The extent and duration of impact of bushfires and ash run-off specifically on marine bivalves, including native flat oysters, is not well studied, or documented (Santori et al. 2023). Extreme events affected by climate change such as fires, flood and drought can also increase heavy metal loads in water, which can impair fitness of oysters (Bartlett et al. 2020; Kibria et al. 2021). *Sea level rise*

Threat factor	Threat Status*	Threat impacts
		The average rate of relative sea level rise along the coast of Australia was 1.4 mm per year from 1966 to 2009 (CSIRO & Bureau of Meteorology 2015b). This does not differ heavily from the global sea level rise from 1901 to 2000 at 1.5 mm per year, however in recent decades from 1993 to 2023 this rate is approaching 4 mm per year, where sea level rise in the north and south-east of Australia has been significantly higher than the global average unlike other parts of the continent that have been below average (CSIRO & Bureau of Meteorology 2024). There is very high confidence that mean sea level will continue to rise, along with the height of extreme sea levels (CSIRO & Bureau of Meteorology 2015b). A rise of between 0.39 to 0.89 m is projected by 2090 under the high emissions scenario across the range of the ecological community (CSIRO & Bureau of Meteorology 2015b). The likely impacts of this sea level rise on the native flat oyster reef ecological community are unknown. The main possible impact is the shifting of intertidal reefs to subtidal areas, though there is evidence that some intertidal oyster reefs (comprised of other species) may be able to keep up with sea level rise whereas existing and restoration sites of native flat oyster reefs are predominately found in subtidal waters (Rodrigeuz et al. 2014). Impacts on these shifted intertidal reefs could include increased predation, competition and disease or mortality due to reduced emersion but could also lead to less mortality related to heat stress and desiccation (Rodrigeuz et al. 2014; Overton et al. 2024).
Exotic disease & infestations	*Timing*: ongoing *Severity*: major *Scope*: majority	Disease is an important contributor to declines of native flat oyster reefs (Hickman et al. 2000 cited in Ford & Hamer 2016; Ogburn et al. 2007; Gillies et al. 2018). Bonamiosis is the main disease that affects native flat oysters (Heasman & Lyall 2000; Buss et al. 2020a). This parasitic protozoan microcell infects the oyster's haemocytes (immune cells) and can eventually kill the oyster if it is badly infected (Crawford 2016). The primary species for infection is reported to be *Bonamia exitiosa* (Engelsma et al. 2014; Bradley et al. 2019). Bonamiosis was initially reported in Australia in Port Phillip Bay, Vic, in 1991, in Georges Bay, Tas, in 1992, and in Albany, WA, in 1993 (Hine & Jones 1994; Bradley et al. 2019). Initial introduction of the disease into Australia was thought to be via biofouling on shipping (DAFF 2020). Since its introduction, transmission has occurred through human movements of sub-clinically infected oysters or from host to host via infective stages carried between oyster reefs by water currents (DAFF 2020). Clinical disease and mortality from *Bonamia* sp. have been recorded in native flat oysters in Vic and WA, and *Bonamia* sp. infection has been confirmed in native flat oysters in Tas, SA and NSW (Corbeil et al. 2009; Buss et al. 2019; DAFF 2020). Incidences of *Bonamia sp. i*n natural populations of native flat oyster have been found to be variable across southern Australia (Heasman et al. 2004; Corbeil et al. 2009; Crawford 2016; Buss et al. 2019). In Port Phillip Bay in Vic, dense oyster reefs were decimated in 1991 from *Bonamia* infection (Hickman et al. 2000 in Ford & Hamer 2016). In NSW the disappearance of the wild native flat oyster fishery from estuaries in the mid-1800s was possibly due to the introduction of *Bonamia sp.* (Ogburn et al. 2007; Ogburn 2011), where across five sites in southern NSW, Heasman et al. (2004) has more recently documented a 13-44 % prevalence of *Bonamia* sp. *i*n wild native flat oyster. While in SA, Buss et al. (2019) found > 50 % prevalence of *Bonamia* sp. infections on native flat oyster farms, but at low intensity. Under experimental conditions, Buss et al. (2020a) found that rapid

Threat factor	Threat Status*	Threat impacts
		infection of *B. exitiosa* occurred in juveniles exposed to infected adults, with 50% mortality reached after 21 days and >85 % by day 40. *Bonamia* sp. *i*nfections are usually associated with poor oyster condition, but infection can also occur in oysters that appear healthy (Buss et al. 2020a). There is some indication that native flat oysters can cope with sub-clinical Bonamiosis infections or that there is some resistance due to the documented persistence of populations in the presence of *Bonamia* sp. (Corbeil et al. 2009; Ford & Hamer 2016). However, increased stress (e.g. from other described threats) appears to increase the likelihood of mortality and large-scale spread of the infection (Hickman et al. 2000 cited in Ford & Hamer 2016). For example, an experimental study on native flat oyster adults indicated that *Bonamia*-infected oysters are at increased risk at higher temperatures, with the greatest risk of death associated with high water temperatures, starvation, and increased water motion (Bradley et al. 2020). Increased intensity of infection is also associated with increased density and proximity of oysters in farms (Bradley et al. 2019; Buss et al. 2019), where density and proximity could have a greater influence on infection intensity than other environmental parameters (Buss et al. 2020b). The latest Quarterly Aquatic Animal Disease Report for the Asia-Pacific Region (NACA 2024) indicates that *B. exitiosa* has not been reported during passive surveillance in SA since 2019, WA since 2017 and Vic since 2016 and passive surveillance in all other States has never reported *B. exitiosa*. While Bonamiosis has decimated aquaculture populations in the past, the extent to which the disease may prevent natural recovery or inhibit restoration efforts of native flat oyster reefs is still unclear (Crawford 2016; Gillies et al. 2017). Buss et al. (2019) suggests that native flat oyster in Australia appear to be characterised by low *Bonamia* intensity. The likely ongoing prevalence and severity of Bonamiosis on native flat oyster reefs into the future is unknown, but the cumulative negative effects of temperature and disease may cause increased risks under climate change if *Bonamia sp.* is still prevalent. Similarly, the documented prevalence of *Bonamia sp.* in native flat oyster farms could facilitate transmission to restoration sites and create mutual disease risk (Buss et al. 2020b). Several polychaete worms of *Polydora* spp. are known to infest native flat oysters. The mudworm, *Polydora websteri*, has been suggested as the most damaging to natural populations of native flat oysters, particularly in NSW (Nell 2001; Ogburn et al. 2007). Ogburn et al. (2007) and Ogburn (2011) speculated that an exotic mudworm species introduced from New Zealand between 1880 and 1900, via the translocation of oysters for subtidal oyster farming, was a driving factor of the decimation of subtidal oyster reefs along the east coast of Australia. However, Diggles (2013) refutes this suggestion, and proposes that some, possibly all, of the mudworms associated with the disease outbreaks in Sydney rock oysters in QLD in the late 1800s were endemic species that increased in numbers due to increased siltation following land clearing and flood events. Sedimentation and nutrient loading in estuaries where native flat oyster beds inhabit has assisted the spread and virulence of the mudworm (Nell 2007). Historic accounts note that the oyster fisheries devasted by the mudworm belonged to riverine systems that became altered in character and were polluted by sedimentary deposits as a result of the clearance of inland watersheds (Saville-Kent 1891b). It is not known whether mudworms are still currently impacting native flat

Threat factor	Threat Status*	Threat impacts
		oyster reefs, but interactions may increase with restoration or recovery of native flat oyster reefs in areas in which it is known to occur.
Invasive species	*Timing*: ongoing *Severity*: minor *Scope*: majority	Invasive alien species have caused historical degradation and still present a threat to native flat oyster reefs throughout their historical extent of occurrence. Interactions with native flat oyster reefs by these pests can include infestation, competition and predation. Biological surveys on the remnant native flat oyster reefs in Georges Bay, Tas, did not identify invasive pests as an issue (Crawford et al. 2019). However, the seasonally abundant alga *Undaria pinnatifida* has been observed in Georges Bay as a threat to juvenile native flat oysters by attaching to the oyster and dislodging them from the underlying reef structure (Gillies 2017. pers obs). This species is an established pest on the Australian Priority Marine Pest List (APMPL) and extends to other locations in Tas, Vic and more recently SA (DAWE 2022b; PIRSA 2024a). In this range there is concern, the species may compete for space with oysters in oyster farms, so it could pose a threat to native flat oyster recruitment on existing reefs (DAWE 2022b). The overall extent of the *U. pinnatifida* threat to native flat oyster reefs is currently unknown. *Asterias amurensis* (Northern Pacific seastar) is an established marine pest on the APMPL that is reported to be having major impacts on native bivalves, including oysters, due to it being a voracious predator and competitor for food and space (Hayes et al. 2005; Wells et al. 2009; DAWE 2022c; NSW DPI 2023a). The species was first introduced in the Derwent River, Tas in 1985 and then spread to Port Phillip Bay, Vic by 1996, likely via ship ballast water and possibly through oyster translocation (Grannum et al. 1996 cited in Parry 2017; Parry & Cohen 2001 cited in Parry 2017; Vic DSE 2002; Richardson et al. 2016). The species has been reported to predate on farmed oysters in Tas in locations that also historically comprised native flat oyster reefs (e.g. Pipe Clay Lagoon and D'Entrecastreux Channel, Vic DSE 2002). Observations of the species have also been confirmed in other areas in Tas where remnant native flat oyster reefs exist (e.g. Georges Bay), in locations with native flat oyster restoration sites (e.g. Derwent Estuary), as well as on remnant native flat oyster clumps (e.g. Ralphs Bay), but no information on the level of prevalence or interactions with the native flat oyster were noted (Crawford & Cahill 2008; NRM South 2022; Strain et al. 2024). The species is now considered prevalent in Port Phillip Bay, Vic and poses a risk to natural recovery or restoration of native flat oyster reefs in that area (Ford & Hamer 2016; Dutka et al. 2022). Unmanaged, the Northern Pacific seastar could impact the survival or restoration of native flat oyster reefs in Tas and Vic. The Northern Pacific seastar has also been reported to have an interactive effect with *Carcinus maenas* (European shore crab), another established pest and bivalve predator on the APMPL list, that has also been suspected to cause mortality in farmed native flat oysters in NSW and Tas, and it may pose a threat as a voracious predator of shellfish beds across the historical extent of occurrence of native flat oyster reefs (Thresher et al. 2003; Hayes et al. 2005; Crawford & Cahill 2008; Well et al. 2009; Crawford 2016; DAWE 2023a; NSW DPI 2023b). The European shore crab has been observed occurring on remnant native flat oyster clumps in Tas (Strain et al. 2024). Introduced benthic filter feeders that compete for substrate and food with bivalves include *Sabella spallanzanii* (European fan worm), *Varicorbula gibba* (European clam), *Maoricolpus roseus* (New Zealand screw shell), *Musculista senhousia* (Asian date mussel), the European flat

Threat factor	Threat Status*	Threat impacts
		oyster, the Pacific oyster, Venus clam, *Pinctada sugillata* (pearl oyster) and *Mya japonica* (soft-shell clam) (Hewitt et al. 2004; Hayes et al. 2005; Wells et al. 2009; Gillies et al. 2015, 2018; PIRSA 2017; Brand et al. 2022; DAWE 2022d, e & f, 2023b, 2024). It should be noted that while *Pinctada sugillata* is native to Australia it is not native to parts of native flat oyster range such as in SA (Gillies et al. 2015; PIRSA 2017). Collectively, these species occur across the historical extent of occurrence of the ecological community and in areas with existing native flat oyster reefs or restoration sites and can form extensive beds or dense covers that inhibit settlement, cause growth impacts to bivalves through food competition, and impact survivorship (Crooks 2001; Talman & Keough 2001; Crawford & Cahill 2008; Ford & Hamer 2016; Gillies et al. 2018; NRM South 2022; DAWE 2022e & f, 2023b, 2024; Strain et al. 2024). The European fan worm has specifically been noted to have potential implications for natural recovery of oysters (Ford & Hamer 2016). Similarly, the Pacific Oyster has been reported to likely be increasing in extent in NSW, Tas and SA (Gillies et al. 2018), which may increase competition with the native flat oyster reef for food and space, particularly in the intertidal zone (e.g. Coffin Bay, SA). However, the current and future extent of the threat on native flat oyster reefs of this species, and the other introduced benthic filter feeders noted above, is unknown.
Commercial fishing of the native flat oyster	*Timing*: ongoing *Severity*: minor (if appropriately regulated) *Scope*: minority	Direct take of native flat oyster individuals through commercial fishing removes the primary reef habitat-forming species of the ecological community and may result in damage to the oyster reef structure that can lead to a reduction in the extent or quality of oyster reef habitat, modify ecosystem service function and lead to increased susceptibility of remaining native flat oyster individuals to other threats (e.g. disease and pests). Commercial fishing poses a potential negative impact to the ecological community if not properly regulated or sustainably managed through relevant jurisdictions. At the time of listing, there is one active commercial hand collection dive fishery for native flat oysters in Australia, which is in Georges Bay, St Helens, Tas. The fishery has operated since approximately 1985 and since 2007 and there has been a Total Allowable Commercial Catch (TACC) based on 10% of the estimated total biomass within the harvest area every 2-3 years (Jones & Gardner 2016; Keane 2021, 2024). For several years, the TACC has been below the 10% estimated total biomass, having not increased with the increasing biomass estimates documented in the harvesting area (Keane 2021, 2024). Biomass is calculated from diver quadrat counts that are extrapolated across the area of the oyster beds to provide an overall biomass estimate (Jones & Gardner 2016; Keane 2021, 2024). A minimum size limit of 70 mm shell length has been selected based on market demand, but also ensures that animals can spawn multiple times before they enter the fishery (Keane et al. 2024; NRE Tas 2024a). The current active fishing grounds established in 2016 are 82,540 m^2 in size, having increased from 55,036 m^2 in 2008. Harvests have remained well below TACC, staying below 30% of the TACC from 2008-2024, with most years below 10% (IMAS 2024b; Keane 2024). The estimated total biomass of native flat oyster within the current harvesting area has increased from 391.5 t to 669.2 t. between 2016 to 2024, where 2016 represents the lowest TACC since recording in 2007 (IMAS 2024b; Keane 2024). During this 2016-2024 period, the density of biomass has increased from 4.7 kg/m^2 to 9.6 kg/m^2, (Keane 2024) but this growth is not consistent throughout the estuary, with decreases of up to 87%

Threat factor	Threat Status*	Threat impacts
		previously observed in some areas (Keane 2021). While biomass was higher in 2021, lower numbers of juveniles observed in the 2021 survey compared to 2018 suggested the fished area wouldn't maintain this higher level of biomass (Keane 2021), which has since been reflected in the current report (Keane 2024). The shift to the current fishing area moved away from some previously harvested beds that had documented biomass declines of 63% and 83% since 2018, though the reasons for this decline are not documented (Keane 2021). Native flat oyster harvests tend to occur on the fringe of the reef where oysters are less aggregated and most marketable. This harvesting approach likely reduces the risk of degrading the reef structure, but potentially also limits the expansion rate of reef patches (NRE Tas 2024. pers comm 17 October). The fishery is currently managed under the provisions of the Tasmanian *Living Marine Resources Management Act and Fisheries (Shellfish) Rules (2017)* and is considered 'sustainable' and 'low-risk' for native flat oyster as a species under its most recent 2024 stock assessment at the time of listing (Keane 2024).
Commercial and recreational fishing (non-native flat oyster)	*Timing*: ongoing *Severity*: unknown *Scope*: unknown	Commercial and recreational fishing that disturbs the benthos or substrate of native flat oyster reefs may impact the survival and recovery of the ecological community. For example, the recreational harvest of razorfish may directly remove substrate used by the native flat oyster for larval settlement and development of reef substrate (Gillies et al. 2015; Martin et al. 2025). Similarly, recreational or commercial harvesting of a species that forms mixed reef alongside the native flat oyster, may disturb the structure of the native flat oyster reefs where other shellfish species may be prised out of mixed reef structures (NRE Tas 2024a). Commercial fisheries that use dredging and trawling can damage benthic habitat. The potential severity of the impact of these activities on native flat oyster reefs is unknown. The overall impact of commercial and recreational fishing that disturbs the benthos or substrate on native flat oyster reefs is unknown.
Recreational take of native flat oyster	*Timing*: ongoing *Severity*: minor (if appropriately regulated) *Scope*: unknown	Direct take of native flat oyster individuals through recreational fishing removes the primary reef habitat-forming species of the ecological community and may result in damage to the oyster reef structure that can lead to a reduction in the extent or quality of oyster reef habitat, modify ecosystem service function and lead to increased susceptibility of remaining native flat oyster individuals to other threats (e.g. disease and pests). Recreational fishing of the native flat oyster likely poses a minor threat to the ecological community if undertaken sustainably and in-line with State fisheries and waterway use regulation. In NSW, it is a requirement at the time of listing to have a recreational fishing license to catch marine and estuarine species and there is a bag limit of 50 individuals in total of native flat oysters or combination of oyster species per day[3] (NSW DPIRD 2024b). In Vic, there is a bag limit of 50 individuals in total of native flat oysters or a combination of oyster species per day at the time of listing and you can't collect oysters in waters less than 2 m deep in

[3] Refer to the NSW DPI recreational fishing guidelines online at https://www.dpi.nsw.gov.au/fishing/recreational for up-to-date information on current restrictions.

Threat factor	Threat Status*	Threat impacts
		Port Phillip Bay or in Marine National Parks and Sanctuaries[4] (VFA 2024c). In Tas, there is a bag limit of 50 native flat oyster individuals per day at the time of listing[5] (NRE Tas 2024b). In WA, there is a bag limit of 20 native flat oyster individuals per day at the time of listing[6] (WA DPIRD 2024). There are no regulations on recreational fishing of native flat oysters in SA at the time of listing[7] (PIRSA 2024b). The risk to the ecological community posed by an individual recreational fisher is likely minor. However, management regulations may not be adequate to account for high levels of participation in recreational fishing for native flat oyster. A 'Class A' condition reef patch is classified by native flat oyster densities of reproductive age/size of greater than 50/m² (Table 3), 50 individuals being the bag limit for most jurisdictions that have bag limits in place. In theory, a small group of recreational fishers could reduce the condition of the ecological community, for both existing and restoration patches, by visiting the same patch over multiple days. This is further exacerbated in SA, where bag limits do not exist for native flat oyster. However, there is no evidence of this being practise in any of the States where the ecological community is located.
Boating	*Timing*: ongoing *Severity*: minor (if regulated appropriately) *Scope*: whole	Boating activities may also cause direct damage to the oyster reef structure (e.g. anchoring or boat wakes) (Campbell 2015; Diggles et al. 2019; Gilby et al. 2020; Walters et al. 2021; Sussan & Charpentier 2024). While there is no published information present on the damage of boating activities on native flat oyster reefs, anchor damage has been observed occurring on restoration sites of oyster reefs comprised of other species (e.g. Sydney rock oyster), where the concrete hard substrata used in restoration was heavily damaged by anchors and resulted in ongoing degradation and inhibited recovery of the reef (Diggles et al. 2019). Diggles et al. (2019) observed that oyster reef restoration sites subjected to anchor damage had lower survival and settling of spat, being made prone to sedimentation due to loss of height. The heavily damaged reef saw 19.4 % survival, while reefs affected by smothering or some anchor damage saw spat survival rates of 75.4-76 %. Boating activities can also generate wakes that are capable of dislodging oysters attached to substrate. While this has not specifically been documented for native flat oyster reefs, wakes have been observed to be a significant contributor to mortality and reef loss of other oyster species (e.g. eastern oyster), where shoreward oysters in the intertidal zone are dislodged by wakes and form piles of disarticulated shell on reefs

[4] Refer to the Vic Government recreational fishing guidelines online at https://vfa.vic.gov.au/recreational-fishing/recreational-fishing-guide/catch-limits-and-closed-seasons/types-of-fish/shellfish/oysters-all-species for up-to-date information on current restrictions.
[5] Refer to Tas Government recreational fishing guidelines online at https://fishing.tas.gov.au/recreational-fishing/fishing-by-species/shellfish-and-shell-collecting for up-to-date information on current restrictions.
[6] Refer to the WA Government recreational fishing guidelines online at http://rules.fish.wa.gov.au/Species/Index/110#:~:text=Fishing%20for%20this%20species%20from,and%20line%2C%20squid%20jigging)%3B for up-to-date information on current restrictions.
[7] Refer to the SA Government recreational fishing guidelines online at https://pir.sa.gov.au/recreational_fishing/rules/species_limits for up-to-date information on current restrictions.

Threat factor	Threat Status*	Threat impacts
		(Campbell 2015; Walters et al. 2021; Sussan & Charpentier 2024). Intertidal oysters in high boating activity areas can be frequently exposed to wakes with sufficient size to move and dislodge oysters when settlement substrate is unconsolidated (e.g. dead shells or oyster clusters) (Walters et al. 2021). For native flat oyster reefs, boat wake could potentially impact the restoration and recovery of reefs forming from oyster clusters or on newly placed unconsolidated substrate, especially in shallow waters or in the intertidal area. However, the overall impact of boat wake is reduced on established reefs consolidated on hard substrata, and minimal in subtidal areas where the native flat oyster reefs are more commonly found (Gillies et al. 2017; Sussan & Charpentier 2024). Noise from heavy boating traffic can also potentially affect the larval dispersal of oysters by producing sound that masks recruitment cues or attracts larvae to recruit in the area (Williams et al. 2024). If recreational boating activities follow waterway use regulations and guidelines, the impact of these boating activities is likely minor. However, with increased awareness and restoration of native flat oyster reefs, boating regulations and management in the area of occupancy of the ecological community may need to be revised to account for increased levels of activity.
Aquaculture	*Timing:* ongoing *Severity:* Minor (if regulated appropriately) *Scope:* unknown	Marine bivalves cultivated under natural conditions in open water systems depend on food and space available in the natural ecosystem. High density bivalve populations in farmed settings can filter large quantities of water, take up phytoplankton, excrete dissolved nutrients and produce biodeposits (Smaal & Van Duren 2019). If bivalve stocks are too large, filtration may be larger than the total system can sustain and can result in phytoplankton depletion from top-down pressure (Prins et al. 1998; Gibbs 2007; Grant et al. 2007; Grant et al. 2008; Filgueira & Grant 2009; Lin et al. 2009; Filguiera et al. 2013, 2014; Smaal & Van Duren 2019). Therefore, if not managed appropriately to the system's carrying capacity, cultivated oysters, other bivalves and biofouling communities on farming structures from oyster aquaculture operations may reduce food availability for nearby oyster reefs (Souchu et al. 2001; Huang et al. 2008; Smaal & Van Duren 2019). Phytoplankton depletion is expected to be more intense at the local scale, but effects may also extend across a larger spatial scale, but at a lower intensity (Prins et a. 1998; Coen et al. 2007; Gibbs 2007; Grant et al. 2007; Grant et al. 2008; Filgueira & Grant 2009; Lin et al. 2009; Filgueira 2014). Phytoplankton depletion may lead to increased competition for phytoplankton, which could negatively impact oyster growth rates (Filguiera et al. 2013, 2014). Oyster farming and oyster translocations for aquaculture purposes may result in the introduction of the source of disease-causing parasites, predators and competitors for existing oyster reefs (Forrest et al. 2009; Coen & Bishop 2015). The high densities of oysters in farms and the movement of stock alongside aquaculture infrastructure (e.g. boat, equipment, barges) can facilitate the rapid spread of parasites and pathogens if not managed appropriately (Bishop et a. 2006; Ogburn et al. 2007; Forrest et al. 2009). Implementing biosecurity measures, such as quarantining and disease screening oysters, before translocation can assist in reducing disease risk (Sas et al. 2020).
Mining and offshore drilling and associated	*Timing*: ongoing *Severity*: unknown	Offshore drilling activities can involve oil spill accidents that can cause mass mortality events of subtidal oysters. While this threat has not been documented for native flat oyster reefs, other oyster species (e.g. eastern oyster) have experienced major reef declines following an oil spill event

Threat factor	Threat Status*	Threat impacts
onshore development	*Scope*: unknown	(Grabowksi et al. 2017). For example, in the United States in 2010, an oil spill resulted in 77% less oyster habitat in intertidal marsh areas that were heavily and persistently oiled compared to areas where oil was not observed, equating to an average loss of 320 m^2 of oyster habitat in the heavily oiled areas (Powers et al. 2015). Impacts from the oil spill were observed more than 100 km from the source oil rig (Grabowski et al. 2017). The substantial oiling of this event resulted in widespread impacts and severe losses of both intertidal (Powers et al. 2015) and subtidal oysters (Grabowski et al. 2017) around shorelines. Grabowski et al. (2017) suggests the specific effect and recovery in reefs may differ between tidal environments. The extent that oiling events may occur, or impact native flat oyster reefs is unknown. Offshore activities and infrastructure, such as mining and drilling, with the potential to generate underwater sound, may potentially affect the dispersal of oyster larvae using sound as navigation cues or cause stress to oysters (Charifi et al. 2017; Williams et al. 2022, 2024; McAfee et al. 2023) The evidence of the likelihood of impact of the sound from these activities on oyster reefs is lacking. Onshore development in coastal areas associated with offshore activities and infrastructure and associated dredging, barge use or land reclamation activities undertaken to develop infrastructure to service the offshore activities may also cause direct damage to native flat oyster reefs or associated water quality issues that may negatively affect the health or survivorship of native flat oysters. The overall impacts of these offshore activities and associated onshore development on native flat oyster reefs are unknown.

****Timing*** – the threat occurs in the **past** (and unlikely to return), is **ongoing** (present/continuing), is likely to occur/return in the **future,** or timing is **unknown**

Severity – the threat causes or has the potential to cause impacts that are **extreme** (leading to loss or transformation of affected patches/occurrences), **major** (leading to degradation of affected patches/occurrences), **minor** (impacting some components of affected patches/occurrences), **negligible** or **unknown**

Scope – the threat is affecting the **whole** (>90%), a **majority** (>50%), a **minority** (<50%), a **negligible** amount, or **unknown** amount of the ecological community

4.1.1 Key threatening processes

The EPBC Act provides for the identification and listing of key threatening processes. A process is defined as a key threatening process if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.

The following are EPBC-listed key threatening processes, current at the date of writing, that may be relevant to the ecological community or specific plants and animals that comprise it:

- KTP1 Novel biota and their impact on biodiversity.

Any approved threat abatement plans, or advice associated with these items provides information to help landowners manage these threats and reduce their impacts to biodiversity. These can be found at http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl.

Consultation Questions on threats

- Do you consider that all threats to the ecological community have been identified and described adequately? If not, are you able to provide additional or alternative information on threats, past, current, or potential that may adversely affect the ecological community, with supporting references?

- Is the order of the threats in the Threats table (Table 4) correct (i.e. are they in order of highest threat, starting with the greatest threat)? If not, please indicate the correct order (e.g. by numbering the Threat factors).
- Are any of the listed threats more, or less, severe, or of different timing or scope than currently proposed for this ecological community?
- To what degree are the identified threats likely to impact on the ecological community in the future?
- To what degree are the identified threats likely to act cumulatively on the ecological community?
- Please supply us with additional information and examples of threats and impacts to the ecological community that you are aware of.

5 Conservation of the ecological community

5.1 Primary conservation objective

To prevent risk of extinction of the *Ostrea angasi* oyster reef of southern Australia in the near future and promote recovery of its biodiversity and function through protecting it from significant impacts as a Matter of National Environmental Significance under national environmental law, and by guiding management and recovery actions.

5.2 Existing protection and management plans

5.2.1 Existing protections

Table 5. Existing protection that may encompass likely or known and possible existing and restoration occurrences of the native flat oyster reef ecological community

Location	Protection measure
Likely or known occurrences of existing reefs of the ecological community	
Georges Bay, Tas	Medeas Cove Conservation Area, McDonalds Point Conservation Area, Panella Conservation Area, Humbug Point Nature Recreation area (water and adjacent land), St Helens Conservation Area (water and adjacent land)
Wagonga Inlet, NSW	Batemans Marine Park (encompasses larger coastal area)
Merimbula Lake, NSW	Merimbula Lake – Nationally Important Wetlands (adjacent land)
Jervis Bay (Currumbene Creek), NSW	Jervis Bay Marine Park (NSW waters), Jervis Bay National Park (land in NSW area), Jervis Bay Territory – National Heritage Place (ACT area including land and waters)
Pambula, NSW	Pambula Estuarine Wetlands - Nationally Important Wetland, Beowa National Park (Land, north and east)
Coffin Bay, SA (near Long Beach)	Thorny Passage Marine Park (encompasses area within bay and larger coastal area), Coffin Bay Coastal Wetland System Nationally Important Wetland (encompasses whole bay area), Coffin Bay National Park (land in southern arm of bay), Kellidie Bay Conservation Park (land in southeastern and eastern edges of Kellidie Bay), Mount Dutton Bay Conservation Park (various small islands within bay), Heritage Agreement areas No.HA430 and No.HA1373 (land in parts of northern arm of bay)
Occurrences of restoration sites that are likely to meet the ecological community definition	

Margaret's Reef, Vic	-
Wilson Spit, Vic	Port Phillip Bay (Western Shoreline) and Bellarine Peninsula – Ramsar site, Lake King Nationally Important Wetlands
Nyerimiling, Vic	Gippsland Lakes – Ramsar site
Dromana, Vic	-
Glenelg, SA	Encounter Marine Park
O'Sullivan Beach, SA	Encounter Marine Park
Nepean Bay, SA	Encounter Marine Park
Wagonga Inlet, NSW	Batemans Marine Park (encompasses larger coastal area)
Woodbridge, Tas	-
Oyster Harbour Northern, WA	Oyster Harbour Nationally Important Wetland
Oyster Harbour Southern, WA	Oyster Harbour Nationally Important Wetland
Waterski (Oyster Harbour), WA	Oyster Harbour Nationally Important Wetland
Green Island, WA	Oyster Harbour Nationally Important Wetland, Green Island Nature Reserve
Possible existing occurrences of the ecological community – *condition unknown or too degraded (e.g. clumping only)*	
Cloudy Bay, Tas	Cloudy Bay Lagoon Marine Conservation Area (most of lagoon, inlets and outlet, aside from a southern portion)
Pipeclay Lagoon, Tas	Rushy Lagoon Conservation Covenant (land and adjacent inland lagoon)
Ralph's Bay, Tas	Gelibrand Point Nature Recreation Area (Northwest land and coast), South Arm Marine Conservation Area (waters in southern bay) South Arm Conservation Area (land in Southeast and Southwest)
Quarantine Bay, Tas	Quarantine Station State Reserve (Adjacent land), Marks Points Conservation Area (land on northern and eastern side of bay)
Oyster Cove, Tas	Oyster Cove Nationally Important Wetland
Hastings Bay, Tas	Hastings Bay Conservation Area (land and coast of bay)
Boomer Bay, Tas	-
Maria Island, Tas	Maria Island National Park (land, encompassing whole island but also extending from northern and north west coast)
Mercury Passage, Tas	Maria Island National Park (land from island to west of passage) Unnamed (Sandspit River) Conservation Area (land and coast to East of passage), Boot Bay Conservation Area (land and coast to Southwest of passage), Lachlan Nature Reserve (Island to North of passage), Marchwiel Cockle Bay Conservation Covenant (land and coast of bay Southwest of passage), Cape Bernier Nature Reserve (land and coast to Southwest of passage)
Bicheno, Tas	Governor Island Marine Nature Reserve (waters surrounding island and east of island)
Oyster patch, southwest Georges Bay, Tas	Medeas Cove Conservation Area, McDonalds Point Conservation Area, Panella Conservation Area, Humbug Point Nature Recreation area (water and adjacent land), St Helens Conservation Area (water and adjacent land)
Bermagui River, NSW	-

9 ft Bank, Port Phillip Bay, Vic	-
Swan-Canning, WA	Swan Estuary Marine Park, Swan Estuary – Pelican Point Marine Park, Swan Estuary – Milyu Marine Park and Swan Estuary – Alfred Cove Marine Park, Swan-Canning Estuary Nationally Important Wetlands, Swan River Management Area (terrestrial protected area that encompasses all estuary waters not covered by Marine Parks, extending from Fremantle to beyond estuary area, not including estuarine waters in Canning arm), Canning River Management Area (terrestrial protected area that encompasses estuary waters in Canning arm to beyond estuary area)
Oyster Harbour, WA	Oyster Harbour Nationally Important Wetland, Green Island Nature Reserve (land)
Possible occurrences of restoration sites that may contain the ecological community – *further information required to determine condition or does not meet ecological community definition at present*	
Kurnell, NSW	Towra Point Nature Reserve – Ramsar site, Towra Point Estuarine Wetlands
Windara reef, off Rogues Point, SA	Upper Gulf St Vincent Marine Park
9ft Bank, Port Phillip Bay, Vic	-
Taroona, Tas	-

5.2.2 Existing management plans

The following list is not comprehensive. It is intended to help identify where some other information relevant to the management of the ecological community and broader landscape may be found.

New South Wales

- **NSW Marine Estate Management Strategy 2018-2028 (MEMS).** Further information available at: www.marine.nsw.gov.au/__data/assets/pdf_file/0005/1352831/Marine-Estate-Management-Strategy-2018-2028.pdf
    - Relevant sections include the 'Management Initiative 1. Improving water quality and reducing litter' and 'Action 1.3 Facilitate and deliver on-ground activities that reduce diffuse source water pollution through investigation and provision of funding programs and financial incentives'.
    - Includes the **Oyster Reef Restoration Project** and **NSW Shellfish Reef Restoration Project Planning and Implementation Guidelines.** Further information available at: www.marine.nsw.gov.au/projects/oyster-reef-restoration-research and www.marine.nsw.gov.au/__data/assets/pdf_file/0003/1322526/16741-Shellfish-Reef-Guidelines-A-1.pdf
    - **Marine Integrated Monitoring program** to assess effectiveness of the MEMS. More information available at: www.marine.nsw.gov.au/__data/assets/pdf_file/0009/1353438/MIMP-Flyer.pdf
- **NSW Oyster Industry Sustainable Aquaculture Strategy (2021)**. The strategy provides a framework for the operation and development of a viable and sustainable NSW oyster aquaculture industry and includes specific guidance on the management of

oyster reefs around oyster lease areas. Further information is available at: https://www.dpi.nsw.gov.au/dpi/fishing/aquaculture/publications/strategies/nsw-oyster-industry-sustainable-aquaculture-strategy

- **Certified Coastal Management Programs (CMPs)** with native flat oyster related actions embedded are noted below. CMPs are the long-term strategy for the coordinated management of the coast to achieve the objectives of the *Coastal Management Act 2016.* Further information on CMPs is available at: www.environment.nsw.gov.au/topics/water/coasts/coastal-management/programs/certified-coastal-management-programs
    - Moruya River, Mummuga Lake and Wagonga Inlet Estuarine CMP (2022) which identified the oyster reef restoration site delivered through the Wagonga Inlet Living Shorelines (WILS) project: www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Water/Coasts/moruya-river-mummaga-lake-wagonga-inlet-estuarine-coastal-management-program.pdf?la=en&hash=268CE3BF9FB61C903A132A7A773EF07A3E027758
    - CMPs under development likely to embed oyster reef actions: Lower Shoalhaven River, Bermagui River and Merimbula and Back Lake.
- The NSW government is currently developing a management plan for the State's marine parks.
    - The **Draft Marine Park Management Plan** includes oyster reef actions in specific Marine Parks and generally, across the Marine Park network. Further information on the Draft Marine Park Management Plan can be found here: www.environment.nsw.gov.au/topics/parks-reserves-and-protected-areas/park-management/community-engagement/draft-marine-park-management-plan
- **Policy and Guidelines for Fish Habitat Conservation and Management 2013**. Further information available at: https://www.dpi.nsw.gov.au/fishing/habitat/publications/pubs/fish-habitat-conservation
    - Oyster reefs are currently not identified as an explicit habitat type in the policy and guidelines. A review of the policy and guidelines is underway, and it is anticipated that a future update will include oyster reefs as a habitat type.
    - Oyster reefs do currently fall under the general classification of Key Fish Habitat: 'those aquatic habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally, and the survival and recovery of threatened aquatic species' by nature of their estuarine location. More information available at: www.dpi.nsw.gov.au/fishing/habitat/publications/pubs/key-fish-habitat-maps
- **Healthy Estuaries for Healthy Oysters – Guidelines for development near waterways 2023.** Further information is available at: www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/738972/Healthy-Estuaries-for-Healthy-Oysters.pdf

- Oysters, including native flat oysters, are subject to a combined daily bag limit of 50 individuals and require a standard fishing fee/licence. Species rules and limits for saltwater recreational fishing in New South Wales can be found here: www.dpi.nsw.gov.au/fishing/recreational/fishing-rules-and-regs/saltwater-bag-and-size-limits

South Australia

- **Encounter Marine Park Management Plan 2012** and **Encounter Marine Park Management Plan Amendment 2020**. These plans detail habitat protection zones and encompass multiple reef sites of native flat oyster reef restoration conducted either for Reef Builder, the Department for Environment and Water or the Kangaroo Island Landscape Board. Habitat protection zones specifically protect the sea floor, but still allow recreational activities such as fishing. The management plan and amendment can be found here: https://www.marineparks.sa.gov.au/find-a-park/fleurieu-peninsula/encounter

- **Upper Gulf St Vincent Marine Park Management Plan Amendment 2022**. This amendment includes the addition of the Windara Reef as a Sanctuary zone, albeit with recreational fishing facilitated as a special purpose area. This is a restoration area of PIRSA. The amendment can be found here: https://www.marineparks.sa.gov.au/about/sa-marine-parks-review

- **Code of practice for environmental management of the South Australian oyster farming industry.** This details actions that should be taken to protect water quality, avoid hazardous substance release and avoid ecological effects, but with no explicit mention of oyster reefs. Protection actions are framed with respect to vegetation, aquatic vegetation, dunes and foreshore. The code of practice is available at: www.epa.sa.gov.au/articles/2017/09/14/oyster_farming_industry_code_of_practice_released

- Native flat oysters are not subject to protection or bag limits in recreational fishing, aside from any closures that affect oysters, and require no licence. Species rules and limits for recreational fishing in SA can be found here: https://pir.sa.gov.au/recreational_fishing/rules/species_limits

Tasmania

- **Shellfish Management Plan**. The Tasmanian Shellfish Fishery is managed under the Living Marine Resources Management Act 1995 and Fisheries (Shellfish) Rules 2017. Provides the Total Allowable Commercial Catch (TACC) based on 10% of the estimated total biomass based on fishery surveys, but may be further reduced by maximum economic yield, where it is currently set below TACC. Commercial licences are limited to two holders within a zone in Georges Bay. Further information is available at:
  www.tasfisheriesresearch.org/nfo/management/
  www.fishing.tas.gov.au/commercial-fishing/commercial-fisheries/shellfish-fishery
  https://www.legislation.tas.gov.au/view/html/inforce/current/act-1995-025
  https://www.legislation.tas.gov.au/view/html/inforce/current/sr-2017-010

- Recreational fishing licence holders and Tasmanian Aboriginal fishers have a daily bag limit of 50. Fishing rules are available at: https://fishing.tas.gov.au/species/oyster-native

- Environmental planning in Tasmania for Aquaculture is managed under the State's Resource Management and Planning System. The Marine Farming Planning Act 1995 and Living Marine Resources Management Act 1995 manage aquaculture and marine farming. The Environmental Management and Pollution Control Act 1994 (EMPCA) is the primary environment protection legislation for Tasmania, and includes offences related to environmental harm and pollutants that may cause environmental harm. Further information is available at:
  www.nre.tas.gov.au/aquaculture/aquaculture-and-the-environment
  www.epa.tas.gov.au/Pages/EMPCA.aspx
  https://www.legislation.tas.gov.au/view/html/inforce/current/act-1995-031
  https://www.legislation.tas.gov.au/view/html/inforce/current/act-1995-025

Victoria

- **Port Phillip Bay Environmental Management Plan 2017-2027.** Further information available at: www.mapshare.vic.gov.au/ppb-emp/?page=Introduction&views=Achievements%2C2020-2021%2CCase-studies%2CMarine-life%2CCurrent-plan%2CResults-summary---%2CFauna%2CInvertebrates%2CReef-invertebrates%2CEnvironmental-Management-Plan%2CCurrent-plan-and-goals
    - Relevant main goals include the 'Water quality is improved to ensure environmental health and community enjoyment of Port Phillip Bay' and 'Port Phillip Bay's habitats and marine life are thriving'.
    - **Port Phillip Bay Environmental Management Plan 2017-2027 – Delivery Plan** details multiple activities focused on shellfish reef restoration**.** Further information available at: www.marineandcoasts.vic.gov.au/__data/assets/pdf_file/0017/412118/Port_Phillip_Bay-Delivery_Plan-Dec_2018.pdf
        - While there are Delivery Plan Updates to assess effectiveness of the management plan, which have been prepared annually for previous years, the last reports are for 2020-2021. More information available at: www.mapshare.vic.gov.au/ppb-emp/?page=Annual-Report&views=2020-2021%2CMarine-life%2CCurrent-plan%2CDelivery-Plan%2CProgress%2C2021-Delivery-Plan-Update%2CReporting-overview

- **Guidelines for Environmental Baseline Surveys and Ongoing Monitoring of Aquaculture Fisheries Reserves in Port Phillip and Western Port.** More information can be found here: www.vfa.vic.gov.au/aquaculture/aquaculture-management/guidelines-and-ongoing-monitoring-of-aquaculture-fisheries-reserves

- Oysters of all species are subject to a daily bag limit of 50, with no collection from Marine National Parks or Sanctuaries, in addition to waters less than 2 m deep in Port Phillip

Bay. Fishing in Vic requires a standard fishing licence outside of exemptions. Fishing rules are available at: www.vfa.vic.gov.au/recreational-fishing/recreational-fishing-guide/catch-limits-and-closed-seasons/types-of-fish/shellfish/oysters-all-species

Western Australia

- **Healthy Estuaries WA Program.** A program aimed at improving the health of seven estuaries: Peel-Harvey estuary, Leschenault Estuary, Vasse-Geographe waterways, Hardy Inlet, Wilson Inlet, Torbay Inlet and Oyster Harbour. This encompasses much of the historical oyster reef extent in southwest WA, where the specific management activity varies between estuaries. Further information on the program is available at: www.estuaries.dwer.wa.gov.au/

- **Proposed South Coast Marine Park.** A currently proposed marine park that will extend from east of Bremer Bay to the border with South Australia. The park is broken into four areas, each with their own joint management plan with sanctuary zones intended to protect reefs and considerations for water quality. Further information is available at: www.dbca.wa.gov.au/management/parks/plan-our-parks/proposed-south-coast-marine-park

- Aquaculture in Western Australia is subject to environmental data reporting including Management and Environmental Monitoring Plans (MEMP). This can include monitoring regarding water quality, sediments, impact on protected species and other fauna. Further information is available at:
  www.fish.wa.gov.au/Fishing-and-Aquaculture/Aquaculture/Pages/Aquaculture-reporting.aspx
  www.fish.wa.gov.au/Documents/Aquaculture/memp_guidance_statement.pdf

- Oysters are subject to a daily bag limit of 20 individuals for recreational fishers, where a licence is not required unless fishing or transporting catch with a powered boat. Fishing rules are available at:
  www.fish.wa.gov.au/Documents/recreational_fishing/rec_fishing_guide/recreational_fishing_guide.pdf

Consultation Questions on existing protection and management plans

- Are there any other relevant management plans that should be included above? Please provide any associated links and documents.

5.3 Principles and standards for conservation

To undertake priority actions to meet the conservation objective, the overarching principle is to maintain existing occurrences of the ecological community that are relatively intact and of high quality. Larger and more intact occurrences are likely to retain a fuller suite of ecological functions. A secondary objective is to facilitate the restoration of degraded occurrences of the ecological community to support recovery throughout its historical extent of occurrence.

This principle is highlighted in the *National Standards for the Practice of Ecological Restoration in Australia* (Standards Reference Group SERA 2021):

> ***'Ecological restoration is not a substitute for sustainably managing and protecting ecosystems in the first instance.***
>
> *The promise of restoration cannot be invoked as a justification for destroying or damaging existing ecosystems because functional natural ecosystems are not transportable or easily rebuilt once damaged and the success of ecological restoration cannot be assured.'*
>
> *Standards Reference Group SERA (2021) – Appendix 2.*

The principle discourages 'offsets' where intact remnants are removed with an undertaking to set aside and/or restore other, lower quality, sites. The destruction of intact sites represents a net loss of the functional ecological community because it is unknown if all the species and ecological functions of the intact site can be replicated elsewhere. It is therefore more cost-effective and less risky to retain an intact occurrence than to allow degradation or loss and then attempt to restore it or establish an occurrence in another area to replace it.

Where restoration is to be undertaken, it should be planned and implemented with reference to established oyster reef restoration guidelines or guidance materials (see section 2.2.4). This includes guidance on restoration site suitability modelling (e.g. Howie et al. 2023, 2024), oyster reef restoration guidelines or guidance (e.g. Bagget et al. 2014; Fitzsimons et al. 2019; McAfee & Connell 2020; NSW DPI 2021; TNC 2024a) and advice for native flat oyster reef restoration targets or reference systems to measure restoration success against (e.g. Gillies et al. 2017; McAfee et al. 2024).

Restoration sites that meet the key diagnostic criteria, patch definition and condition thresholds are considered the ecological community and protected under the EPBC Act. However, to determine the overall short-term and long-term success of restoration of native flat oyster reef patches, other additional relevant metrics should be assessed following published standards of proof of marine ecosystem restoration (Baggett et al. 2014; Fitzsimons et al. 2019). Common metrics that are monitored include: abundance of age classes present of native flat oysters (e.g. adults, juveniles and recruits) and changes to these over time, number of age classes (e.g. four or more age classes represent multiple reproductive cohorts), persistence of reef and ongoing recruitment over 3-4 reproductive cycles, diversity of associated transient, infauna or resident species, native flat oyster density, impact of disturbance events (e.g. disease, flooding) on recovery of native flat oyster density and live oyster cover, percentage of native flat oysters compared to other reef-forming species, provision of ecosystem services comparable to remnant or reference condition oyster reefs and reef accretion or change in shell budget from original restoration structure (Gillies et al. 2017; McAfee et al. 2024; TNC 2024a; see also Table 1).

Success of restoration projects is also hindered by the state of the physical environment in which the native flat oyster reef restoration project has been implemented. Monitoring of key environmental variables (e.g. salinity, temperature, dissolved oxygen, pH) and threats (e.g. flooding, disease, sedimentation) can provide valuable information on the likelihood of restoration success or on areas that may require additional local or state management action to improve chances of success (Gillies et al. 2017; TNC 2024a).

5.4 Priority conservation and research actions

Priority actions are recommended for the abatement of threats and supporting recovery of the ecological community. They are designed to provide guidance for:

- planning, management and restoration of the ecological community by conservation managers, non-government organisations, NRM and community groups, coastal landholders, industry and First Nations Australians/custodians;
- conditions of approval for relevant controlled actions under national environment law (the EPBC Act); and
- prioritising activities in applications for Australian Government funding programs.

Detailed advice on actions may be available in specific plans, such as management plans for certain parks or regions. The most relevant at the time this Conservation Advice was developed are listed in section 5.2.

This Conservation Advice identifies priority conservation actions under the following key approaches:

- PROTECT the ecological community to prevent further losses;
- RESTORE the ecological community by active abatement of threats, appropriate management, restoration and other conservation initiatives;
- COMMUNICATE, ENGAGE WITH AND SUPPORT people to increase understanding of the value and function of the ecological community and encourage their efforts in its protection and recovery; and
- RESEARCH AND MONITORING to improve our understanding of the ecological community and the best methods to aid its management and recovery.

These approaches overlap in practice; and form part of an iterative approach to management that includes research, planning, management, monitoring and review.

The actions below do not necessarily encompass all actions in detail that may benefit the ecological community. They highlight general but key actions required to at least maintain survival of the ecological community at the time of preparing this Conservation Advice.

5.4.1 PROTECT the ecological community

This key approach includes priorities intended to protect the ecological community by preventing further losses of occurrences.

5.4.1.1 Conserve Remaining Patches

There should be no clearance and damage to this ecological community because of its very restricted geographic distribution.

- Protect and conserve remaining areas of the ecological community, particularly areas that are habitat critical to survival.
- Protect culturally important reefs and/or prioritise restoration of culturally important reef sites (e.g. near First Nations living sites).

- Incorporate oyster reef protection within state aquaculture policies.
- Consider designation of new Ramsar wetland sites to include native flat oyster reefs (where appropriate) and prioritise the inclusion of oyster reef habitat mapping and habitat surveys when updating the information sheets on Ramsar Wetlands.
- Prohibit the permitting of destructive fishing practices (e.g. dredging and skimming) to harvest native flat oysters from occurrences of the ecological community.
- Sustainably manage commercial and recreational hand collection fisheries.

5.4.1.2 PLAN FOR PROTECTION

- Liaise with local councils and state authorities to ensure that cumulative impacts to the ecological community are reduced as part of broader strategic planning or large projects (e.g. catchment management plans, boating and recreational fishing regulations, commercial fisheries, aquaculture plans, coastal developments, offshore activity development, stormwater management plans, water utility management plans).
- Undertake activities to mitigate future climate change and therefore, reduce the impacts of climate stress, particularly hydrological impacts, on this ecological community. For example, consider activities such as planting estuary riparian revegetation and/or restoring coastal wetlands to reduce the impact of run-off from flooding during high rainfall events.
- Review state policies and legislation and incorporate oyster reef priority management, restoration, and conservation actions. Ensure collaboration across sectors (e.g. fisheries, aquaculture, and threatened species management and conservation). For example, advance the draft NSW oyster reef policy and develop a Priority Action Statement for oyster reefs.

5.4.1.3 MANAGE ACTIONS TO MINIMISE IMPACTS

- Apply the mitigation hierarchy to avoid, then mitigate potential impacts on the ecological community from development or other actions. The priority is to avoid clearance and fragmentation of remnant patches and to minimise residual impacts that cannot be avoided. Plan projects to avoid the need to offset, by avoiding significant impacts to the ecological community.
- Consider that approval of even a relatively small loss and/or degradation of one patch can work in concert with other such actions and threats, and so have major negative cumulative impacts on an already heavily fragmented and degraded ecological community such as this one. For this reason, when considering how to minimise the significance of impacts and/or achieve a nature positive outcome, it is essential to gather evidence and consider other recent, current and likely near future losses and/or degradation if ac ions are approved (without avoidance of any negative impacts).
- Minimise the risk of indirect impacts to the ecological community from actions outside but near to patches of the ecological community, including avoiding disruption to hydrological processes in surrounding estuarine and upstream areas through limiting or mitigating catchment and estuary modifications (e.g. vertical seawalls).

5.4.1.4 APPLY BUFFER ZONES

- Apply buffer management zones that are targeted for specific threats to patches of the ecological community that meet criteria for protection (see section 2.2.5). A buffer zone is a contiguous area adjacent to a patch that is important to protect the integrity of the ecological community. The risk of indirect damage is usually greater where actions are close to a patch. The buffer zones can minimise this risk by absorbing and reducing impacts.
    - A buffer zone of 10-30 m may be a suitable guideline for smaller, more localised impacts, but sizes should be calculated on a case-by-case basis based on the severity and likely extent of impact of threat and the existing patch condition of the ecological community (i.e. greater severity and extent equates to a larger buffer zone; see section 2.2.5).
    - Consider larger buffer zones (e.g. 50-100 m) to protect patches that are part of a broader intertidal wetland or of other very high conservation value. These larger buffers could also be used to protect seascape and land-sea connections that support the ecological function of patches of the ecological community.
- Where it is not feasible to apply a wide buffer, other means should be used to minimise impacts of activities in the vicinity of patches.

5.4.1.5 PREVENT THE INTRODUCTION AND SPREAD OF EXOTIC SPECIES

- Implement or maintain state and national biosecurity programs to prevent the introduction or spread of invasive or pest species, including domestic species.

5.4.2 RESTORE and MANAGE the ecological community

This key approach includes priorities to restore and maintain the remaining occurrences of the ecological community by active abatement of threats, appropriate management, restoration and other conservation initiatives. Act to increase the remaining extent, condition, and seascape connectivity of this ecological community (including connectivity with other surrounding marine and coastal habitat).

5.4.2.1 MANAGE PESTS, INFESTATIONS AND DISEASES

- National and state biosecurity teams to work together to mitigate incursion of pests, infestations (e.g. mudworm) and diseases on native flat oyster reefs through developing and implementing up-to-date biosecurity plans for aquaculture and oyster reef restoration sites, including appropriate policies on translocation of oyster material.
- Establish or continue culling or control programs of invasive species from patches of the ecological community or within the broader catchment and estuary (e.g. continue or scale up culling programs for the Northern Pacific seastar).
    - Culling and control programs should be risk-assessed and managed to avoid impacting non-target species, disturbing the benthos of the ecological community or having unintended consequences.
    - Plan and budget for initial control actions and for follow up actions as long as this is needed.

- Manage water quality through catchment management plans, as degraded water quality (including sedimentation and Acid Sulfate Soil run off) can facilitate the risk and negative impacts of disease and invasive species.

5.4.2.2 Manage habitat degradation and water quality

- Implementation of catchment management or other relevant natural resource management plans in areas that contain native flat oyster reefs, including actions that minimise water quality impacts caused by run-off into rivers, estuaries and coastal areas, including pollution, acidic water, increased nutrients, chemical contamination, turbidity and sedimentation by protecting buffer zones and implementing measures to reduce erosion within river catchments (e.g. riparian restoration, coastal wetland restoration, sediment fences, stormwater pit protection, stormwater management and water sensitive urban design).

- Implementation of catchment management or other relevant natural resource management plans in areas that contain native flat oyster reefs to minimise negative impacts and major alteration of hydrology of estuaries or coastal catchments from activities such as surface water and ground water extraction, riverine regulatory infrastructure (e.g. reservoirs) and other infrastructure (e.g. breakwaters).

- Commercial fisheries that directly harvest native flat oysters or disturb the benthos or substrate of native flat oyster reefs may impact the survival and recovery of the ecological community and will need to be evaluated against having a significant impact under the EPBC Act. New commercial fisheries that intend to directly harvest native flat oysters off native flat oyster reefs or disturb the benthos or substrate of native flat oyster reefs would need to adhere to State regulations and be permitted under the EPBC Act or referral processes.

- Implementation or revision of recreational fishing regulations for the take of native flat oyster (e.g. fishing licences, bag limits, management areas, and waterway use guidelines) in the area of occupancy of the ecological community to minimise possible negative impacts of increased interest in recreational harvest of the species.

- Implementation or revision of boating regulations (e.g. speed limits, no anchoring zones and habitat buffer zones) in the area of occupancy of the ecological community to minimise negative impacts of boating activities, such as anchor damage or boat wake dislodgement.

5.4.2.3 Undertake Restoration

- Establish or continue co-management of oyster reef restoration programs with First Nations groups on Sea Country.

- Develop guidelines for Australian oyster reef restoration that include jurisdictional requirements and approval pathways.

    - While these are being developed, follow restoration standards outlined by established oyster reef restoration guidelines (e.g. the Restoration Guidelines for Shellfish Reefs; Fitzsimons et al. 2019 and the Oyster Habitat Restoration Monitoring and Assessment Handbook; Bagget et al. 2014) and interim native flat oyster reef reference condition targets (Gillies et al. 2017).

- Continue to develop updated native flat oyster reef specific restoration guidelines, communication materials and training programs from learned experience from successful restoration projects.
- Continue to conduct restoration site suitability analysis to identify feasible sites for restoration efforts that have appropriate ecological, biophysical and socio-economic characteristics that will facilitate the survival of native flat oyster reefs.
- Continue to develop public and private sector partnerships to allocate resources to and partner with oyster reef restoration projects to facilitate local restoration implementation and success.
- Partner with international practitioners and projects to effectively apply best practice oyster reef restoration methods to Australian restoration projects.
- Consider the landscape and seascape context and other relevant species and ecological communities when planning restoration works to ensure adjacent ecological communities and threatened species are not adversely impacted by restoration works (e.g. deployment of hard substrata) and additional co-benefits are realised.
- Undertake restoration of poorer and moderate quality patches to restore them to high quality (see section 2.3), including restoration of patches that don't currently meet the minimum condition thresholds for protection to a condition that does. The possible occurrences of the ecological community listed in Table 5 provide some potential location opportunities for restoration.

5.4.3 COMMUNICATE, engage with and support

This key approach includes priorities to promote awareness of the ecological community and to encourage people and groups to contribute to its recovery. This includes communicating, engaging with and supporting the public and key stakeholders to increase their understanding of the value and function of the ecological community and to assist their efforts in its protection and recovery. Key groups to communicate with include coastal landholders, marine and coastal managers, coastal and marine planners, researchers, community members, recreational fishers, oyster farmers and First Nations communities.

5.4.3.1 Raise Awareness

- Development of communication campaigns, materials and learning activities for educators and community groups, such as:
    - Citizen science programs that monitor the health and species composition of existing and restoration sites of native flat oyster reefs and raise local awareness of the importance of the ecosystem in supporting biodiversity and ecosystem services. An existing example includes the Wagonga Inlet Living Shoreline (WILS) Citizen Science Program supported by the NSW MEMS.
    - Develop a national public platform that allows citizens to record locations of possible existing native flat oyster reef occurrences, with corresponding public education campaigns that raise awareness about native flat oyster reefs.

  - Curriculum aligned learning modules for school-age students to increase the recognition of oyster reefs as a coastal and marine ecosystem found within Australian waters.
  - Aa historical timeline of native flat oyster reefs to be used within university and school-age courses as an Australian example of large-scale ecosystem decline.
  - First Nations led shellfish reef education campaigns, and citizen science and school programs.
- Recognition of shellfish ecosystems, particularly oyster reefs, as discreet marine or coastal ecosystems that should be included in coastal ecosystem classification, mapping, and management processes (see NSW DPI Oyster Reef Mapping Project for an example of this process; NSW DPI 2019a).
- Raise the profile of shellfish ecosystems by increasing education and communication on their function and value to increase community support and engagement in protection and restoration actions.

5.4.3.2 Coordinate Efforts

- Develop or support existing First Nations sea-ranger programs to help manage native flat oyster reefs, monitor and establish restoration projects, and generate community awareness.
- First Nations-led or involvement in restoration activities and surveys of existing native flat oyster reefs through investing in programs that support the inclusion of Traditional Ecological Knowledge and First Nations people's participation. An existing example includes NSW DPIRD and Eurobodalla Shire Council working with local First Nations people to weave cultural values, language, stories and connections into the WILS project through artwork, signage, sculpture and language word plates. Prioritise First Nations leadership or involvement in research relating to native flat oyster reefs.
- Community support and involvement in oyster reef restoration projects to facilitate long-term success, including participation in the construction and/or monitoring of oyster reef restoration sites. An existing example includes NSW DPIRD via the MEMS training and employing the Joonga Land and Water Aboriginal Corporation Divers to assist with monitoring the growth and recruitment of native flat oysters to the subtidal Wagonga Inlet Living Shoreline oyster reef.
- Exchange knowledge and skills between academic, government and community institutions engaged in oyster reef restoration to facilitate success and compliance with biosecurity regulations.
- Collaborate across catchment managers, landowners, land use planners, community, and industry to improve water quality flowing into estuaries (e.g. through enhancing riparian buffers or installation of water sensitive urban design features (WSUD)).
- Create a register/list of past, current, and future oyster/shellfish reef restoration activities, to facilitate community recognition, support and involvement, as well as to assist in understanding and management of sites.

- Adopt best practice for effective threat management through an adaptive management approach based on partnerships around co-design, co-implementation and social learning. Promote wide acceptance and capacity building, including explicit use of local knowledge in planning, management actions. and monitoring supported by cost-effectiveness and risk-based collective decision making.

5.4.4 RESEARCH and monitoring

This key approach includes priorities for research into the ecological community, and monitoring, to improve understanding of the ecological community and the best methods to aid its recovery through restoration and protection. Relevant and well-targeted research and other information gathering activities are important in informing the protection and management of the ecological community.

5.4.4.1 Survey and Mapping

- As a high priority, develop or continue to implement a standardised mapping process and conduct baseline mapping to assist with identification of native flat oyster reefs and to determine the location, extent, status, and vulnerability of remaining native flat oyster reefs to support the implementation of protection mechanisms and restoration actions.

- Map and survey the extent and condition of the possible native flat oyster reef locations identified in Table 5 to determine if they are likely to contain the ecological community.

- Undertake deep water surveys (> 20 m) to determine the presence of native flat oyster reef within this deeper subtidal habitat zone.

- Create a national centralised database of oyster reef spatial data to be readily available to inform management.

- Undertake surveys of recreational fishers to determine the full impact of recreational take of native flat oysters to reefs in relevant jurisdictions.

- Undertake surveys of oyster farmers within relevant estuaries in each State to assist with identification of potential native flat oyster reefs sites and determine level of knowledge and identify practices which may assist with development of restoration methodologies. Examples include the NSW Oyster Farmer Survey (NSW DPI 2019b) and Shellfish Reef Reporter Tool (NSW DPIRD 2021).

5.4.4.2 Research

- Measure and quantify the ecosystem service benefits (e.g. fish productivity, fish nursery function, coastal protection, biodiversity, cultural significance, recreational value, nitrogen cycling, water filtration capacity) of Australian native flat oyster reef ecosystems to help support the importance/funding of protection and recovery actions and establish ecological baselines to guide restoration efforts.

- Identify the biological attributes and assemblages that use existing native flat oyster reef ecosystems to better understand their vulnerability to threatening processes, and the biological characteristics that are required to be maintained in order for the ecosystem to function.

- Determine the influence of seascape connectivity on the growth and survival of existing native flat oyster reefs.

- Determine native flat oyster reefs' role as sources or sinks of atmospheric carbon dioxide.
- Undertake an assessment of genetic diversity within existing native flat oyster populations to determine the threat of genetic bottlenecks.
- Determine the larval dynamics between remnant native flat oyster reef populations to assist with understanding the risk of ecosystem collapse due to recruitment limitations.
- Map the availability of hard substrate for recruitment in known historical locations of native flat oyster reefs.
- Measure water quality impacts on native flat oyster reef assemblages and health of oyster reef structure, and as a vector of disease.
- Understand the distribution and abundance of known detrimental invasive species and Bonamiosis within the native flat oyster reefs to help determine the risk of invasive species on this ecological community.
- Conduct ecosystem extent, distribution and condition response modelling under climate change scenarios to better understand the impact of climate-related threats on the likely persistence/risk of ecosystem collapse and possible adaptive capacity of native flat oyster reefs.
- Conduct cumulative threat models to predict the outcome of combined stressors on the ecosystem extent, distribution, condition and likely persistence/risk of ecosystem collapse of native flat oyster reefs in the future (e.g. flooding and disease outbreaks).
- Determine the possible impacts of offshore activities on native flat oyster reefs to understand whether they are a threat to the ecological community.

5.4.4.3 Research for Restoration

- Continue to implement First Nations oral history research across the distribution of native flat oyster reefs to better understand and integrate cultural connection and Sea Country Knowledge in to why and how we restore reefs (where consent is provided, and Indigenous Cultural and Intellectual Property rights are adhered to).
- Determine the influence of seascape connectivity on the success of native flat oyster reef restoration projects and build a knowledge base to potentially support restoration permitting frameworks that promote seascape restoration.
    - Determine the value of co-restoring neighbouring structured habitat (e.g. kelp, seagrass, rocky reefs).
    - Quantify the value of long-distance facilitation between habitats.
- Evaluate success of different restoration techniques for native flat oyster reefs in terms of recruitment, associated fauna and flora assemblages, structural complexity, and oyster health.
- Conduct socio-economic analysis of native flat oyster reef restoration projects to demonstrate their value.

- Determine what stage of restoration (how many years) do reefs provide the same ecological role of existing oyster reefs and whether this varies across the distribution of native flat oyster reefs.

- Continue to develop model/guide/support research identifying suitable sites for reef restoration across the historical extent of occurrence of the ecological community, including conducting restoration site suitability analysis that considers ecological, biophysical, climate change response and socio-economic parameters (e.g. see Howie et al. 2023).

- Continue to measure and evaluate recruitment success within oyster reef restoration sites and in nearby locations.

5.4.4.4 Monitoring

- Develop a standard monitoring process for existing native flat oyster reefs, that includes surveys of associated fauna and flora, oyster condition metrics, ecosystem function (e.g. water filtration, shoreline protection and stabilisation) and biophysical environmental conditions (e.g. see Gillies et al. 2017; NSW DPI 2018).

- Develop a standard monitoring process and guidelines for surveying native flat oyster reefs in turbid water conditions and at depth.

- Monitor changes in native flat oyster condition and survival in response to management actions or threat events and use this information to increase understanding of the ecological community and inform recommendations for conservation and recovery planning.

- Review location and status of remnant native flat oyster reefs to understand any potential resilience factors that may have contributed to their survival.

- Develop monitoring protocols of native flat oyster reefs to assess disease prevalence and adaptive capacity to determine disease risk to restoration projects, remnant reefs and oyster cultivation.

- Conduct monitoring of restoration sites, including variables from the restoration condition reference matrix in Table 1, to determine their likely persistence through time (see section 2.2.6).

Consultation Questions on priority actions

- Have the relevant protection, management or conservation priorities for the ecological community been adequately identified? If not, please provide additional actions and supporting information.
- Have the relevant research and monitoring priorities for the ecological community been adequately identified? If not, please provide additional actions and supporting information.
- Have the relevant priorities for restoration of the ecological community been adequately identified? If not, please provide additional actions and supporting information.

6 Listing assessment

This assessment outlines the *grounds on which the community is eligible to be listed* as required by section 266B (2) (a) (i) of the EPBC Act.

The Threatened Species Scientific Committee has provided this draft for assessment for consultation.

6.1 Assessment process

6.1.1 Reason for assessment

This assessment follows prioritisation of a nomination from the public.

6.2 Eligibility for listing

An ecological community is eligible for listing under section 182 of the EPBC Act if it meets the prescribed criteria outlined in section 7.02 of the EPBC Regulations. This assessment uses the criteria set out in section 7.02 the EPBC Regulations and the TSSC Guidelines for nominating and assessing the eligibility for listing of threatened ecological communities (TSSC 2017), as in force at the time of the assessment.

Information on listing eligibility under the IUCN Red List for Ecosystems criteria (Bland et al. 2017) is included for information only.

6.2.1 Consideration of native flat oyster reef restoration sites in the assessment

To be considered within the assessment, a native flat oyster reef restoration site must meet the ecological community key diagnostic characteristics (section 2.1), patch definition (section 2.2.1) and minimum condition thresholds (section 2.3) and restoration specific reference conditions set out in Table 1 in section 2.2.6. The restoration reference conditions require native flat oyster reef restoration occurrences to persisted for at least 10 years and meet several key attribute criteria (e.g. density of live oysters, viable spawning population) after this period (Table 1 in section 2.2.6). To date, there are not well-documented restoration sites of native flat oyster reefs greater than 10 years. These sites have not been in existence or monitored for a long enough period to determine their likely persistence through time. Subsequently, no native flat oyster reef restoration sites have been considered in this listing assessment. However, the likelihood and opportunity for native flat oyster reef restoration to contribute to the persistence of the ecological community has been discussed and considered in the assessment, where appropriate.

6.2.2 Criterion 1 – decline in geographic distribution

Eligible under Criterion 1 for listing as **Critically endangered.**

	Category		
	Critically Endangered	**Endangered**	**Vulnerable**
Its decline in geographic distribution is:	very severe	severe	substantial
decline relative to the longer-term/1750 timeframe	*≥90%*	*≥70%*	*≥50%*
decline relative to the past 50 years	*≥80%*	*≥50%*	*≥30%*

Source: TSSC 2017

Evidence:

Historical reports of decline

Historically, native flat oyster reefs comprised extensive patches across the southern Australian coastline in subtidal and lower intertidal areas (Alleway & Connell 2015; Ford & Hamer 2016; Gillies et al. 2018; see Table 10 in Appendix D). There are now six known remnant native flat oyster reefs that are likely to contain the ecological community, with only two locations likely to contain good condition reef (Crawford et al. 2019; McAfee 2024. pers comm 1 July). Patches of the ecological community are now described as small and fragmented compared to past reports of extent and area of occurrence (Table 10 in Appendix D). Other historical locations that comprised native flat oyster reefs now either contain no reef, clumping aggregations or few individuals of live native flat oysters as opposed to consolidated reef structures (TNC 2024. pers comm 11 April; NSW DPIRD 2024. pers comm 4 June; Alleway & Connell 2015; Ford & Hamer 2016; Crawford 2016). The primary cause of historical decline of native flat oyster reefs occurred between the 1800s and 1950s as a result of historical overharvesting using destructive fishing methods, such as dredging or skinning (Alleway & Connell 2015; Ford & Hamer 2016; Gillies et al. 2017, 2018; see section 4.1). Other threats, including disease, infestation and pests, and coastal and catchment development and modification that result in changes to water flow and declining water quality (including sedimentation), have also likely contributed to the historical and ongoing decline and inhibited natural recovery of native flat oyster reefs (Ford & Hamer 2016; Gillies et al. 2018; Gillies et al. 2020, see section 4.1).

In NSW, native flat oyster reefs were commercially harvested by dredge and hand methods from first European colonisation in Sydney in 1788 (Attenbrow 2002 cited in Ogburn et al. 2007; Ogburn et al. 2007; Ogburn 2011; Gillies et al. 2018). The disappearance of most of the wild native flat oyster fisheries from NSW estuaries in the mid-1800s, was possibly due to infection by *Bonamia sp.* (Ogburn et al. 2007; Ogburn 2011). The Commission on Oyster Culture (1877) reported that mud oysters could be found from Darling Harbour to the Flats but became almost extinct from over-dredging across this extent earlier in the 1870s. A Sydney oyster merchant also reported to the Commission on Oyster Culture (1877) that mud oysters were historically over-dredged within the Parramatta River, resulting in significant deterioration of oyster beds and loss of spawning stock.

In Vic, during the early-mid 1800s, oyster beds were dredged for carbonate shell for lime production (Pearson 1990) and food (Hannan & Bennet 2010 cited in Ford & Hamer 2016). From the mid-1800s, the oyster fishery rapidly developed to supply local food trade but was officially closed in 1885 due to stock depletion (Ford & Hamer 2016). However, the two main fisheries; the Corner Inlet Fishery and Westernport Fishery, were considered already depleted by the early 1860s (Bowen 2012 cited in Ford & Hamer 2016). Since the mid-1990s, no substantial natural recovery has been documented in Victoria, likely being hampered by water quality, pollution and sedimentation, lack of shell substrate for settlement, disease (i.e. *Bonamia*), and introduced species (Ford & Hamer 2016).

In SA, between 1860 and 1885, an extensive native flat oyster fishery existed (Nell 2001). This large-scale harvesting depleted the beds and only a few native flat oyster fishery vessels remained after 1855 (Alleway & Connell 2015). Catch per unit effort decreased from 470 bags per month in December 1886 to 190 bags per month in June 1887 (Alleway et al. 2015). By 1905, the fishery barely existed (Olsen 1994 cited in Nell 2001). Native flat oyster beds were worked down to where the catch was low or nothing and then fishers moved on to other oyster reef locations (Alleway & Connell 2015). Recorded catch of the native flat oyster was 2342 bags in 1886 and reached a peak of 3549 bags in 1890, before declining to < 1000 bags/annum from 1910 onwards (see Figure 5, Alleway & Connell 2015). The last reported catch was 139 bags in 1944 (see Figure 5, Alleway & Connell 2015).

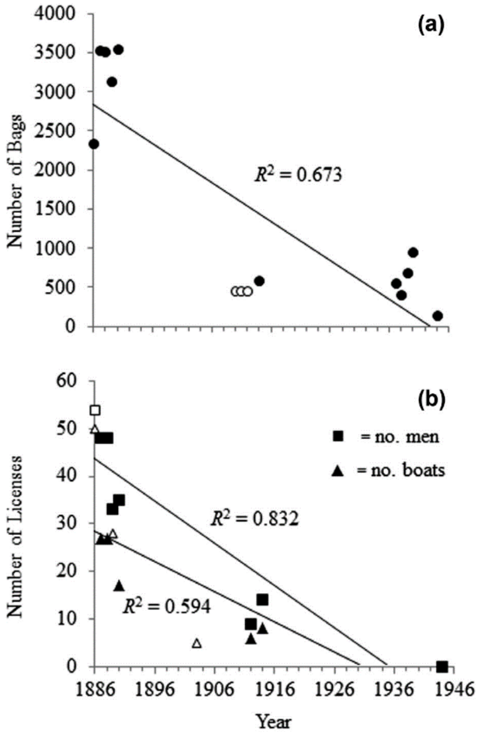


Figure 5. Example historical estimates of native flat oyster decline from South Australia. Historical statewide (a) total number of bags of oysters (approximately 350 oysters per bag) and (b) number of licenses (as a measure of effort) in the South Australian *O. angasi* fishery from 1886 to 1946 (open symbols, values retrieved from secondary references only). Figure from Alleway & Connell (2015).

In WA, the native flat oyster has historically been recorded in many estuaries and bays along the southern and lower western coasts (Cook et al. 2021). A substantial oyster dredge fishery existed from the mid-1800s until approximately 1880 in the Albany area, including in Oyster Harbour, Princess Royal Harbour and King George Sound/Taylor's Inlet (Gillies et al. 2015; Cook et al. 2021). In the late 1800s, the fishery was recorded as being significantly depleted due to mudworm (Saville-Kent 1893). By 1940, native flat oyster beds in estuaries in southwest WA were described as lost (Warnock & Cook 2015 cited in Gillies et al. 2020). The dredge fishery degraded the native flat oyster beds to the point that natural recovery was limited by the lack of hard substrate available to facilitate the settlement of new oyster spat (Gillies et al. 2015).

In Tas, there was a large native flat oyster fishery in the 1800s with 22.5 million oysters dredged annually between 1860 and 1870 (Royal Commission of the Fisheries of Tasmania 1883 cited in Nell 2001; Department of Primary Industries and Water 2007). The large-scale harvesting of native flat oysters around Tas decimated oyster reef populations (Department of Primary Industries and Water 2007; Gillies et al. 2018). Restrictions on oyster harvesting were imposed in 1853, but by the late 1860s the industry was deteriorating and by the early 1880s, the fishery was considered almost negligible (Gillies et al. 2015). Natural recovery of the overharvested and dredged native flat oyster beds in Tas has been inhibited by low recruitment and a lack of suitable settlement substrate, disease, mussel encroachment, and changing estuarine conditions (Gillies et al. 2015, 2017; Crawford 2016).

Published literature estimates of decline

The published literature suggests over a 90 % decline in native flat oyster reefs across their historical geographic distribution based on the abundance or presence of historical and existing native flat oyster reefs, oysters or oyster shell (Edgar & Samson 2004; Beck et al. 2011; Alleway & Connell 2015; Ford & Hamer 2016; Gillies et al. 2018, 2020; see Table 11 in Appendix D for additional information). Since these studies were published, four additional sites have been identified in NSW as containing native flat oyster reefs in moderate condition (Keating 2024. pers comm 27 September) and one site in SA containing high condition native flat oyster reefs (McAffee 2024. pers comm 1 July). Observations of possible clumping native flat oysters or degraded native flat oyster reefs have also been noted at locations in Tas, NSW, Vic and WA, but as these sites haven't been verified or are ineligible to be the ecological community, they have not been considered in the assessment (see Table 5) (Heller-Wagner 2017; NRM South 2024 pers comm. 15 February; NSW DPIRD 2024. pers comm 4 June; Strain et al. 2024; TNC 2024. pers comm 11 April).

Scenario analysis of estimates of percentage decline

Scenarios of estimates of percentage decline using presence/absence analysis with different data caveats and assumptions (see Table 6) were calculated to account for:

1) the four new existing locations of remnant native flat oyster reefs identified since the most recent estimate of decline of 99% in Gillies et al. (2020) calculated from presence/absence analysis;
2) the uncertainty in terms of data completeness of the existing location list of native flat oyster reefs;
3) the uncertainty in terms of data completeness of the historical location list of native flat oyster reefs used in the estimates of decline in Gillies et al. (2018, 2020); and
4) a lack of quantitative historical and current spatial data to calculate area-based decline across the entire geographic distribution of the ecological community.

Scenarios were based on the historical and current presence and absence of native flat oyster reefs at the locality scale as per Gillies et al. (2018, 2020) as opposed to quantitative area estimates of percentage decline due to lack of spatial data availability, both historical and present (see Figure 6). Using the locality and presence/absence calculations as the basis to inform percentage decline has limitations and may result in an underestimation of the percentage decline in geographic distribution of the ecological community. This underestimate may be present for the native flat oyster reef ecological community as the magnitude in reduction in area from the large, extensive reefs documented historically, to the smaller, more fragmented existing reefs now observed, is not accounted for in presence/absence calculations. Similarly, an under or overestimate of historical locations could occur due to misinterpretations of species historically comprising the reef as a result of different commonly used oyster typologies (e.g. dredge, drift, tidal, bank, mud, rock) in reporting and a lack of genetic or species level identification at the time or through the misrepresentation of locations that are differently named through time. 'Mud Oyster' was assumed to represent the native flat oyster in historical reports. Moreover, some historical locations may have been cultivated or artificial storage oyster beds.

There is a range of uncertainty in the data due to limitations associated with spatial accuracy of presence/absence point locations and a lack of detailed spatial data for historical and existing locations. Scenarios 1 and 2 provide an estimated decline range to encompass some of this data uncertainty. Scenario 1 only includes historical locations identified in Gillies et al. (2018, 2020) that likely contained commercially harvested native flat oyster reefs that are ≥ 1 ha. This scenario analysis assumes that all commercially harvested locations identified in Gillies et al. (2018, 2020) are accurate (see Table 6). Scenario 2 includes all other lines of evidence noted from those studies and any additional historical locations identified from expert consultation and additional literature sources that indicate native flat oyster reefs may have been present (see Table 6). Sites that appeared to overlap across different lines of evidence were removed, with commercially harvested locations used as the primary baseline location in areas where this line of evidence was present, but uncertainty for the historical location list is still present due to the limitations of using location point data from multiple evidence sources (see Appendix E for list of historical locations used collectively across the scenario analysis).

Percentage decline estimates from the scenarios ranged from 97 % across the entire historical extent of occurrence of the ecological community, 71-86 % for NSW, 100 % for Vic, 97-98 % for Tas, 99 % for SA and 100 % for WA (see Table 7).

Table 6. Scenario outlines for the analysis of percentage decline of native flat oyster reefs using presence/absence at the locality scale relative to the longer-term/1750 timeframe (European colonisation to ~1950s).

Assumptions / Caveats	Scenarios		
	Gillies et al. 2018/ 2020	1	2
Historical locations			
Historical native flat oyster commercial fishery and remnant reef locations identified in Gillies et al. (2018 & 2020) that are assumed to be ≥ 1 ha in size and are located within the geographic distribution of the ecological community.[+]	Y	Y	N
All known remnant reef locations of the ecological community that are ≥ 1 ha are assumed to have been present historically, regardless of whether they are noted in Gillies et al. (2018, 2020).	N	Y	N
All known remnant reef locations of the ecological community are assumed to have been present historically, regardless of whether they are noted in Gillies et al. (2018, 2020).	N	N	Y
Assumed historical native flat oyster reef locations identified from Gillies et al. (2018) that contained the name 'Oyster' or 'Limeburner' or have modern shellfish aquaculture in Vic, Tas, SA, and WA.* Modern aquaculture areas for native flat oysters in NSW were identified from the NSW Oyster Industry Sustainable Aquaculture Strategy.	N	N	Y
Historical native flat oyster reef locations that have been identified through expert consultation, the NSW DPI mapping project and other literature sources.	N	N	Y
Existing locations that may contain native flat oyster reefs from Table 5 that do not meet the current ecological community definition (e.g. patches are too degraded or small or more information needed) are assumed to have been present historically.	N	N	Y
All restoration sites that have been implemented through the Reef Builder Program and associated partnerships and that are likely to meet the ecological community definition and restoration reference conditions set out in Table 1 are assumed to have been present historically.	N	Y	Y

Some historical native flat oyster reef locations may have been cultivation or artificial storage beds.	Y	Y	Y
Existing locations			
Remnant native flat oyster commercial fishery and remnant reef locations that are only identified in Gillies et al. (2018 & 2020) that are ≥1 ha in size and are located within the geographic distribution of the ecological community.	Y	N	N
Remnant native flat oyster commercial fishery and remnant reef locations identified in Gillies et al. (2018 & 2020), the NSW DPI Mapping Project, other literature sources and through expert elicitation that are > 1 ha in size and likely to meet the ecological community definition.	N	Y	N
All remnant native flat oyster reefs identified in Gillies et al. (2018 & 2020), the NSW DPI Mapping Project, other literature sources and through expert elicitation that are likely to meet the ecological community definition.	N	N	Y
Restoration sites that are ≥ 1 ha in size, are likely to meet the ecological community definition and meet the restoration reference conditions set out in Table 1 that have been implemented through the Reef Builder program and associated partnerships.	N	Y	N
Restoration sites that are likely to meet the ecological community definition and restoration reference conditions set out in Table 1 that have been implemented through the Reef Builder program and associated partnerships.	N	N	Y
Not all estuaries, coasts, bays, and inlets within the historical extent of occurrence of the ecological community have been extensively surveyed for remnant native flat oyster reefs. Some native flat oyster reef occurrences that are classified as remnant reef may be on legacy farming structures.	Y	Y	Y

+ Historical commercial fishing is assumed to have not likely occurred in area where oyster reef ecosystem extent was less than 1 ha in size. (see Gillies et al. 2018 for further details). All NSW locations are assumed to have been Sydney rock oysters from Gillies et al. (2018), however, NSW sites in the historical list from this study have been included in the scenario 1 analysis as native flat oyster locations if they have been identified as a native flat oyster reef historical site through expert consultation or other literature.

**Modern shellfish aquaculture is assumed to indicate historical shellfish ecosystems, as historical accounts often described the development of aquaculture in the same locations as historical harvesting. Locality names containing 'Oyster' or 'Limeburner' are assumed to represent areas historically that had shellfish as a clear distinguishing feature of the local geography or as evidence that commercial fishing occurred in close proximity and shells were burnt in kilns to generate lime for building materials (see Gillies et al. 2018 for further details).*

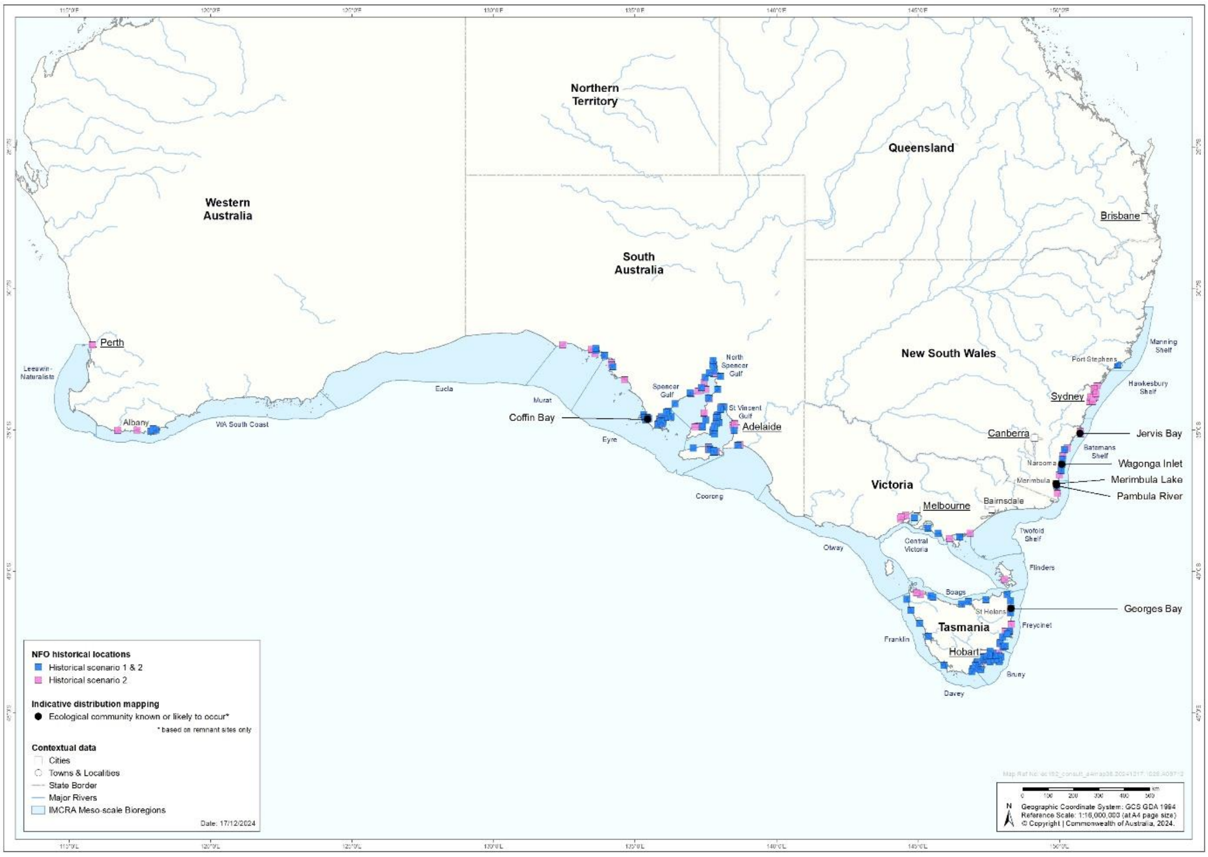


Figure 6. Indicative distribution of remnant and historical native flat oyster reefs of southern Australia at the locality scale (historical locations are split into the scenarios 1 and 2 assumptions and caveats from Table 6 and Table 7).

Source: Localities, 1:250,000 © Commonwealth of Australia, Geoscience Australia, 2004. Interim Marine and Coastal Regionalisation (IMCRA) for Australia, © Commonwealth of Australia, Geoscience Australia, 1997. Coastline and State Borders, 1:100,000 © Commonwealth of Australia (Geoscience Australia), 1990. Native Flat oyster reefs, compiled from several sources: Gillies et al. 2018 & 2020, NSW DPI oyster reef mapping project, through expert elicitation and other key literature.

Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein. The map has been collated from a range of sources, with data at various resolutions. Data used are assumed to be correct as received from the data suppliers.

This map has been compiled from datasets with a range of scales and quality from various sources. Data used are assumed to be correct. Historical locations comprise historical locations identified in Gillies et al. (2018, 2020) that likely contained commercially harvested native flat oyster reefs that are ≥ 1 ha (see Table 6) and also includes all other lines of evidence noted from those studies and any additional historical locations identified from expert consultation and additional literature sources that indicate native flat oyster reefs may have been present (see Table 6). Sites that appeared to overlap across different lines of evidence were removed, with commercially harvested locations used as the primary baseline location in areas where this line of evidence was present, but uncertainty for the historical location list is still present due to the limitations of using location point data from multiple evidence sources (see Appendix E for list of historical locations). The ecological community distributions included in this map are only indicative and not meant for local assessment. Planning decisions at a local scale should seek some form of ground truthing to confirm the existence of the ecological community at locations of interest. Such assessments should refer to the text of the Listing and Conservation Advice for the ecological community.

Table 7. Scenario analysis outcomes of percentage decline of native flat oyster reefs using presence/absence of existing sites at the locality scale relative to the longer-term / 1750

timeframe (European colonisation to ~ 1950s). H = Historical, E = Existing and EPBC Criterion = Critically Endangered (CE), Endangered (EN), and Vulnerable (VU).

Scenario	**1**			**2**		
	H	**E**	**EPBC**	**H**	**E**	**EPBC**
National	**126**	**4**	**97 % CE (≥ 90 %)**	**207**	**6**	**97 % CE (≥ 90 %)**
NSW*	7	2	71 % EN (≥ 70 %)	28	4	86 % EN (≥ 70 %)
Vic	4	0	100 % CE (≥ 90 %)	9	0	100 % CE (≥ 90%)
Tas	39	1	97 % CE (≥ 90%)	55	1	98 % CE (≥ 90%)
SA	73	1	99 % CE (≥ 90 %)	108	1	99 % CE (≥ 90 %)
WA	3	0	100 % CE (≥ 90 %)	**7**	0	100 % CE (≥ 90 %)

**Gillies et al. (2018, 2020) assumes that historical oyster reef sites in NSW are Sydney rock oyster reefs not native flat oyster reefs, so historical location numbers are likely underestimated in this State in scenarios 1 and 2. However, NSW sites in the commercially harvested historical list from Gillies et al. (2018, 2020) have been included in the scenario 1 analysis as native flat oyster locations if they have been identified as a likely native flat oyster reef historical site through expert consultation or other key literature.*

#Multiple locality points were grouped where locations were in close proximity or had the same name across evidence types or references.

Maximum extent of possible occurrence

There is currently no readily available spatial data to represent the historical extent of the native flat oyster reef ecological community that can be used to measure a historical area of occupancy. There are point coordinates for current and historical locations or reported likely reef locations as referenced in the Gillies et al. (2018, 2020), as well as from the NSW DPI Mapping Project, expert contributions and other key literature sources (e.g. Oyster Culture Commission 1877; Stonehouse Research 2022a & b) Using a habitat to develop a maximum extent of possible historical occurrence (i.e. depth range, surrogate habitat) is likely to vastly over-estimate the area within which the native flat oyster reef ecological community would have occupied.

Conclusion

The present listing assessment evaluates a broad range of information that includes different types of evidence and their associated caveats and limitations to make an inference about the decline in geographic distribution for the native flat oyster reef ecological community under Criterion 1. When all the aforementioned information is considered, the Committee's preliminary assessment is that native flat oyster reefs have undergone a very severe decline in geographic distribution relative to the 1750 timeframe, particularly between the 1800s to 1950s, whereby decline at the national scale is most plausibly ≥ 90 %. This represents a **very severe** decline in geographic distribution. After preliminary assessment, the Committee considers that the ecological community may have met the relevant elements of Criterion 1 to make it eligible for listing as **Critically Endangered.**

This decline in geographic distribution since 1750 would also represent a Critically Endangered status under Criterion A3 of the IUCN Red List of Ecosystems (Bland et al. 2017).

Consultation Questions on listing assessment – Criterion 1

- Do you agree with the estimates of decline relative to the 1750 timeframe?

- Do you have any feedback on the preliminary assessment under Criterion 1 or further data or information that would support or update the assessment?
- In particular, are there any additional known historical or remnant locations of the ecological community that are not noted in Table 5 and in Appendix E? Please relevant provide supporting information.
- Are you aware of any native flat oyster reef restoration sites that are likely to meet the ecological community definition and restoration condition matrix thresholds to be considered in the listing assessment? Please provide relevant supporting evidence.

6.2.3 Criterion 2 – limited geographic distribution coupled with demonstrable threat

Insufficient data to determine eligibility under Criterion 2.

Its geographic distribution is:		very restricted	restricted	limited
Extent of occurrence (EOO)		*< 100 km2 = <10,000 ha*	*<1,000 km2 = <100,000 ha*	*<10,000 km2 = <1,000,000 ha*
Area of occupancy (AOO)		*< 10 km2 = <1,000 ha*	*<100 km2 = <10,000 ha*	*<1,000 km2 = <100,000 ha*
Average patch size		*< 0.1 km2 = <10 ha*	*< 1 km2 = <100 ha*	-
AND the nature of its distribution makes it likely that the action of a threatening process could cause it to be lost in:				
the immediate future	***10 years*** *or 3 generations (up to a maximum of 60 years)*	**Critically Endangered**	**Endangered**	**Vulnerable**
the near future	***20 years*** *or 5 generations (up to a maximum of 100 years)*	**Endangered**	**Endangered**	**Vulnerable**
the medium term future	***50 years*** *or 10 generations (up to a maximum of 100 years)*	**Vulnerable**	**Vulnerable**	**Vulnerable**

Source: TSSC 2017

Evidence:

Extent of occurrence (EOO)

The current EOO of the ecological community is greater than 1,000,000 ha / 10,000 km^2, calculated as the minimum convex polygon around the six known remnant native flat oyster reefs likely to contain the ecological community: Georges Bay in Tas, Coffin Bay (near Long Beach) in SA and Merimbula Lake, Pambula, Jervis Bay (Currumbene Creek) and Wagonga Inlet in NSW (Figure 1 & 6). This exceeds the threshold for a limited geographic distribution.

Area of occupancy (AOO)

The estimated area of occupancy (AOO) of remnant native flat oyster reefs in Georges Bay in Tas is between 14 - 39 ha (< 1 km^2), based on the area calculated from detailed spatial data of the patches that contain the native flat oyster fishery as the lower bound (Keane 2021) and analysis undertaken using the R package 'redlistr' and the ecological community occupying 39 x 10,000 m^2 cells as the upper bound (nomination analysis). Based on expert observations, the estimated area of occupancy of remnant native flat oyster reefs in Coffin Bay (near Long Beach) in SA is 3.5 ha (< 0.1 km^2), and in NSW in Merimbula Lake and Pambula is 1 ha (< 0.1km^2), in Jervis Bay (Currumbene Creek) is 0.88 ha (< 0.01 km^2) and in Wagonga Inlet is 0.75 ha (< 0.01 km^2) (McAfee 2024. pers comm 1 July; NSW DPIRD 2024. pers comm 4 June). Based on these estimates, the current AOO of the ecological community occurs across a **very restricted** distribution (< 10 km^2 / 1,000 ha).

Patch size

Patches of native flat oyster reefs within Georges Bay in Tas are the only occurrences of the ecological community documented in spatial detail. They have been reported to vary in size from 0.44 - 1.49 ha (< 0.1 km^2) in Heller-Wagner (2017) to 1 – 9 ha (< 0.1 km^2) from spatial patch size analysis of old and current fished areas identified in Keane (2021). The median patch size in Georges Bay calculated from the spatial analysis is 1.18 ha (< 0.1 km^2). Based on the documented range of patch sizes within Georges Bay and the good condition of native flat oyster reefs at this site and the total oyster reef area values at all other locations being less than 3.5 ha (< 0.1 km^2), it is inferred that the average patch size of remnant native flat oyster reefs is < 0.1 km^2 / 10 ha. This represents a **very restricted** geographic distribution.

Risk of collapse

The risk of collapse is assessed against the immediate (10 years), near (20 years) and medium-term future (50 years).

As described in Gillies et al. (2020), the native flat oyster reef ecological community has collapsed when there are no remaining locations dominated by living oysters and oyster shells, and the spatial complexity and presence of hard substrate has significantly decreased. Other characteristic changes may include changes to microclimates and local hydrodynamics, and species assemblage shifts from a diverse range of sessile and mobile reef-associated organisms to a system that is predominantly characterised by infauna and deposit feeders (when shifted to soft sediments) or lower diversity and biomass of reef-associated species (when shifted to bare rock).

The primary cause of historical decline, overharvesting through destructive fishing practices, on the ecological community has ceased. Lack of hard substrate due to the degradation of reef structure by historical destructive fishing practices has been documented as key reason for the lack of natural recovery of native flat oyster reefs (McAfee et al. 2024). However, as outlined in section 4.1, the ecological community is subject to ongoing threats, including degraded water quality and coastal and catchment development, climate change, invasive species, disease, recreational boating and fishing, commercial fishing and possibly indirect impacts of offshore activities. In the absence of historical destructive fishing practices, these threats to the ecological community have been suggested to have contributed to the lack of natural recovery of native flat oyster reefs across their historical extent of occurrence (Ford & Hamer 2016; Gillies et al. 2018, 2020). The historical loss of substrate continues to be an ongoing issue for the recovery of native flat oyster reefs across their historical extent of occurrence.

Given that remnant patches of the ecological community are inferred to be small (median < 1.5 ha) and are fragmented across their known historical extent of occurrence, the resilience of existing patches to disturbance, especially occurring within short-succession or extreme environmental conditions, is likely reduced (Ford & Hamer 2016; Gillies et al. 2020; Howie & Bishop 2021; Powers et al. 2023). The cumulative effects of ongoing threats may continue to contribute to reduced hard substrate availability and recruitment, sub-optimal conditions for oyster growth and survival, and limited natural recovery, without active human intervention and appropriate management (Gillies et al. 2020). Impacts from these threats could range from being sublethal to whole reef degradation depending on the condition of the physical environment and reef structure when exposed to a catastrophic event or cumulative threats (see section 4.1). For instance, healthy reefs may recover from high mortality events if estuarine conditions are favourable or there has been a long enough interval between catastrophic events to support recruitment and recovery. Alternatively, poor condition reefs with degraded estuarine water quality may be more susceptible to disease outbreaks. Similarly, smaller or less structurally elevated reefs may be more susceptible to smothering from increased sedimentation from extreme climatic events and catchment modification (Crawford 2016; Ford & Hamer 2016; Gillies et al. 2020). Over the last decade, there has been reports that water quality and management are improving in some areas across the known historical extent of occurrence of the ecological community (Gillies et al. 2017; McAfee et al. 2024). These improvements may assist with decreasing the risk of collapse of the ecological community due to potentially increased reef resilience and/or recovery, though will only assist in areas with suitable hard substrate and oyster spat available for recruitment (natural or provided through restoration).

The likely adaptive capacity of native flat oyster reefs to respond to predicted ongoing threats, such as increased frequency of extreme events (e.g. high intensity flooding and heatwaves) under climate change, is still uncertain at both the patch and broader ecosystem scale (Gillies et al. 2020). Over long time periods, oyster reef ecosystems have the potential to migrate within an estuary or colonise new estuaries to avoid stress and remain within physiological thresholds, but this is dependent on sufficient substrate and oyster biomass available for breeding, recruitment, settlement and reef creation, and ongoing favourable physical conditions (Gillies et al. 2020). The overall resilience of native flat oyster reefs to disturbance and recovery post-disturbance, is currently naturally limited by the availability of local oyster spat (recruits), adult stock to undertake fertilisation and brooding, lack of hard substrate and the likely reduced capacity of larval dispersal between fragmented remnant reefs (Ford & Hamer 2016; Gillies et al. 2020; Powers et al. 2023). There is some evidence that there may be clumps or individuals of the native flat oyster across the historical extent of occurrence of the ecological community that could provide larval recruits to re-establish reefs if suitable hard settlement substrate becomes available or is provided through restoration efforts and environmental conditions are suitable, but the overall capacity for natural recruitment across the historical extent of the ecological community is unknown (Crawford 2016; Gillies et al. 2018; Cook et al. 2021; McAfee et al. 2024).

Conclusion

Despite the likely increased risk of ecosystem collapse of the native flat oyster reef ecological community due to the small patch sizes of remnant reefs, the fragmented nature of patches across its historical extent of occurrence, small area of occupancy, and documented ongoing threats, there is limited information available on the likely adaptive response of native flat oyster reefs to withstand the cumulative impacts of ongoing threats under predicted climate change scenarios and increasing coastal population growth to determine the likelihood of collapse of the ecological community within a given timeframe (Gillies et al. 2020). Moreover, there are early indications that oyster reefs may be able to be restored on a small-scale provided larval recruits are seeded and/or suitable hard settlement substrata is provided, and environmental conditions are managed to provide adequate water quality and physical characteristics for oyster growth and survival (McAfee et al. 2024). The ability to restore native flat oyster reefs reduces the risk of collapse of the ecological community due to an expected increase in the extent of occurrence and area of occupancy of the ecological community and subsequently likely increased larval connectivity and recruitment capacity to assist with resilience and recovery to stressor events and persistence of reefs through time. However, as restoration of any substantial size of native flat oyster reefs has been occurring for less than 10 years, the ability of these restoration sites to successfully achieve these broader ecosystem functions and their own capacity to withstand the predicted increased pressures relating to climate change (e.g. extreme flooding events) or disturbance events (e.g. disease outbreaks) is still uncertain.

Following preliminary assessment, the Committee considers that there is unlikely to be sufficient information to determine the eligibility of the ecological community for listing in any category under Criterion 2.

Consultation Questions on listing assessment – Criterion 2

- Do you have any feedback on the preliminary assessment under Criterion 2 or further data or information that would support or update the assessment? Please provide additional supporting information.
- Do you agree with the estimates of the current extent of occurrence (EOO), area of occupancy (AOO) or average patch size provided in the assessment? If not, can you provide an estimate of the current geographic distribution (EOO and AOO in km^2) and average patch sizes (in km^2), with supporting data?
- Based on your knowledge and expertise, do you think it is likely that the ecological community could be lost in the immediate (10 years), near (20 years) or medium-term future (50 years)? If so, please provide supporting information

6.2.4 Criterion 3 – decline of functionally important species

Insufficient data to determine eligibility under Criterion 3

	Category		
	Critically Endangered	**Endangered**	**Vulnerable**
For a population of a native species that is likely to play a major role in the community, there is a:	very severe decline	severe decline	substantial decline
*Estimated decline over the last **10 years** or three generations (up to a maximum of 60 years), whichever is longer*	*80%*	*50%*	*20%*
to the extent that restoration of the community is not likely to be possible in:	the immediate future	the near future	the medium-term future
timeframe	***10 years** or 3 generations (up to a maximum of 60 years)*	***20 years** or 5 generations (up to a maximum of 100 years)*	***50 years** or 10 generations (up to a maximum of 100 years)*

Source: TSSC 2017

Evidence:

The native flat oyster is the primary habitat forming species of the ecological community. Despite there being a documented decline in native flat oyster reefs since European colonisation, there is limited data available to assess the decline of the species specifically in the last 10 years (standard timeframe used). Following preliminary assessment, the Committee considers that there is unlikely to be sufficient information to determine the eligibility of the ecological community for listing in any category under Criterion 3.

Consultation Questions on listing assessment – Criterion 3

- Do you have any feedback on the preliminary assessment under Criterion 3 or further data or information that would support or update the assessment? Please provide additional information and supporting evidence.

6.2.5 Criterion 4 – reduction in community integrity

Eligible under Criterion 4 for listing as **Endangered**

	Category		
	Critically Endangered	**Endangered**	**Vulnerable**
The reduction in its integrity across most of its geographic distribution is:	very severe	severe	substantial
as indicated by degradation of the community or its habitat, or disruption of important community processes, that is:	very severe	severe	substantial
such that restoration is unlikely (even with positive human intervention) within	*the immediate future (10 years or 3 generations up to a maximum of 60 years)*	*the near future (20 years or 5 generations up to a maximum of 100 years)*	*the medium-term future (50 years or 10 generations up to a maximum of 100 years)*

Source: TSSC 2017

Evidence:

The native flat oyster reef ecological community has undergone **severe** changes in structure and function relative to a 1750s benchmark state of the ecological community as a result of the threats outlined in Section 4.

Pre-major disturbance, native flat oyster reefs were extensive across the southern Australian coastline and comprised patches that had high oyster densities and hard shell substrate required to sustain key ecological and biological processes, such as oyster recruitment, nutrient cycling and water filtration, sediment stabilisation, and the provision of resources for a diverse marine flora and fauna assemblage (refer to section 1.2; Gillies et al. 2018, 2020). Declines in patch size and condition, area of occupancy, and geographic distribution restricts the ability or extent for which the ecological community can provide the key functions outlined above. Ongoing threats, such as coastal and catchment development and degraded water quality (including sedimentation), climate change, disease and invasive species, outlined further below and in detail in section 4, are likely to continue to impact the functional integrity of the ecological community in the future and limit recovery to pre-disturbance conditions without active human intervention through restoration and sustained or improved management.

The ecological community has experienced a reduction in integrity primarily because of:

- A reduction in recruitment due to loss of oyster biomass, degradation of reef structure and patch fragmentation
- A reduction in ecological function due to loss of oyster biomass and reef structure
- Changes in the composition of foundational or benthic species as a result of invasive species
- Changes in environmental characteristics needed for optimal oyster growth and oyster reef persistence.

Reduction in recruitment due to loss of oyster biomass, degradation of reef structure and patch fragmentation

Native flat oyster reefs across their historical extent of occurrence have declined in functional and structural integrity due to an overall reduction in recruitment capacity. This is a result of loss of oyster biomass, degradation of reef hard substrata and patch fragmentation caused by threats, such as historical overharvesting, coastal and catchment development and degraded water quality, disease and extreme events (see detailed information on threats in Table 4 in Section 4). Reduced recruitment capacity results in native flat oyster reef patches with lower oyster density and reproductive capacity, reduced structure, reduced size, or the complete loss of patch persistence through time if recruitment failure is prolonged and thereby, also contributes to limiting the ability of native flat oyster reefs to naturally recover post-disturbance (Lipcius et al. 2021; Powers et al. 2023).

Native flat oysters are brooders that hold their eggs within the female mantle cavity to be fertilised. Because of this, the reduction in biomass of adult native flat oysters due to threats has led to a reduction in fertilised larvae being released to settle and recruit and contribute to the persistence of native flat oyster reefs (Ford & Hamer 2016; Gillies et al. 2017). Moreover, degradation of native flat oyster reef structure from historical and ongoing threats, has led to a reduction in available hard substrata required for larval settlement and recruitment success across the historical extent of occurrence of the ecological community (Alleway & Connell 2015; Ford & Hamer 2016; Gillies et al. 2018; Cook et al. 2022). Historical dredging was unselective and removed or buried oysters and shell of all sizes/ages. This often resulted in a shift toward unconsolidated or soft sediment habitat with little hard substrate (Alleway & Connell 2015). The degradation of reef structure also made the reefs more vulnerable to other stressors, such as increased sedimentation, that smothered reefs and facilitated a shift to soft sediment habitat (Crawford 2016; Gillies et al. 2018; McLeod et al. 2019). The loss of oyster reef hard substrate reduced the available area for larval settlement and the reef-associated chemical cues or noises used by larvae to navigate to suitable settlement habitat (Alleway & Connell 2015; Gillies et al. 2020; Williams et al. 2022). For example, initial findings on a restoration site at a historical native flat oyster reef location in SA demonstrated that recruitment increased significantly when suitable hard substrate was deployed at the site, suggesting that hard substrate had been a bottleneck for oyster recruitment in that area (McAfee et al. 2024).

Only six locations have known occurrences of remnant native flat oyster reefs that are likely to contain the ecological community, a substantial decline from over 100 former documented locations across the historical extent of occurrence of the ecological community (Gillies et al. 2018). The remaining occurrences of the ecological community are fragmented across the broader range of the ecological community's geographic distribution, with four of these occurrences located in NSW, and only one in Tas and one in SA. Within these locations, patches are considered to be generally small and fragmented, compared to the larger, more extensive reefs historically documented (Alleway & Connell 2015; Ford & Hamer 2016; Gillies et al. 2018; Cook et al. 2021). While oyster larvae can disperse up to tens of kilometres using currents, oyster larvae have demonstrated a preference toward settling in the presence of conspecifics, using reef-related chemical or noise cues to navigate toward adult habitat (North et al. 2008; Tamburri et al. 2008; Rodriguez-Perez et al. 2020; Williams et al. 2022). With few, small existing native flat oyster reef patches and greater distances between them, the ability of dispersal between geographically distinct native flat oyster reefs is likely reduced and especially limited for historical sites without the presence of suitable hard substrata and/or conspecifics. This reduced capacity for larvae to navigate to suitable conspecific settlement habitat was likely another limiting factor in the ability of degraded native flat oyster reefs or extirpated historic locations to assist repopulation and reef recovery after extreme events or anthropogenic disturbance (Williams et al. 2022). However, there are reports that native flat oyster individuals or clumps still occur throughout the geographic range of the ecological community, which can provide natural recruitment opportunities in some areas, provided hard substrata is available or added to the system through human intervention, and there are suitable environmental conditions (Crawford 2016; Gillies et al. 2018; McAfee & Connell 2020; Cook et al. 2021; McAfee & Connell 2023; McAfee et al. 2024).

Reduction in ecological function due to loss of oyster biomass and reef structure

The native flat oyster reef and bed structure is created through the bounding of living and dead oysters. When living oysters are removed from the physical structure due to threats, such as overharvesting using destructive fishing practices, disease or coastal/catchment development and sedimentation, the reef structure is decimated, reduced, or smothered and shifted toward unconsolidated habitat (Gillies et al. 2020; McAfee et al. 2024). The complete decimation of patches of native flat oyster reef in many locations it once existed, or the degradation of the physical habitat of remnant patches to a less structurally complex reef, has likely reduced key processes provided by the ecological community, such as fisheries productivity, habitat provision and water filtration/nutrient cycling. While this hasn't been directly measured for native flat oyster reefs pre- and post-historical disturbance and decline, some inferences can be made from monitoring of remnant reef sites or remnant clumps of native flat oysters. For instance, in Georges Bay, Tas, faunal abundance was observed to be three times greater on good condition remnant native flat oyster reef compared to surrounding soft sediment habitat (Crawford et al. 2019), suggesting that a loss of oyster reef structure would likely result in a loss of faunal abundance. Similarly, remnant clumps of native flat oysters in Tas demonstrated particulate matter filtration rates of up to approximately 98,000 particles m^2 h^1 and denitrification rates of up to approximately 3380 μmol N_2-N m^2 h^1, which both exceed rates documented for other shellfish species (e.g. Sydney rock oyster, eastern oyster and New Zealand green-lipped mussel (Strain et al. 2024). These findings and the documented reports of the water quality services that intact and larger oyster reefs provide suggest that water quality condition has likely declined, and the possible risk of eutrophic conditions are likely greater in locations with degraded native flat oyster reefs or with reduced or no oyster biomass (Nelson et al. 2004; Howie & Bishop 2021). Reduced water quality may then degrade remaining oyster condition, as well as the ability of other estuarine and coastal habitat to grow and survive (e.g. seagrass) (NSW DPI 2019a; Gillies et al. 2020; Howie & Bishop 2021).

Decline in integrity relating to changes in the composition of foundational or benthic species as a result of invasive species

Invasion by non-native foundation species or benthic species that occupy the same substrate and habitat zone, compete for food and space, or predate on the native flat oyster has likely contributed to a decline in the compositional integrity of native flat oyster reefs after historical overharvesting, and could be inhibiting natural recovery of the ecological community in areas where novel ecological communities formed by these invasive species now occur (see Table 4 in section 4; Ford & Hamer 2016; Gillies et al. 2018; Dutka et al. 2022; McAfee et al. 2024). For example, the Northern Pacific seastar is prevalent across benthic habitat in Port Phillip Bay in Vic and poses a risk to the restoration or recovery of native flat oyster reefs in that area (Ford & Hamer 2016; Dutka et al. 2022). Similarly, ecosystems developed by the introduced Pacific oyster have been reported to likely be increasing in extent in NSW, Tas and SA, possibly occupying areas where native flat oyster reefs once inhabited within the same intertidal to lower-subtidal habitat zone and thereby, potentially limiting reestablishment by native flat oyster reefs in those areas (Gillies et al. 2018). Changes in the composition of benthic species can lead to a transition from native flat oyster reefs to other dominated benthic ecosystems that can have impacts to broader ecological functions in an area, such as changes in species assemblages or possible reduction in water quality condition/filtration capacity.

Decline in integrity relating to changes in environmental characteristics needed for optimal oyster growth and oyster reef persistence

Historic and ongoing land use change, coastal development and catchment modifications have resulted in increased pollutants and sediments entering waterways, altered hydrology and modified physical characteristics of the coastal and estuarine environments (e.g. salinity, pH, dissolved oxygen) that support native flat oyster reefs. These actions have, and may continue to, negatively impact environmental conditions required by native flat oyster reefs for growth, reproduction and persistence through time (Gillies et al. 2017, 2018, 2020). For example, extensive land clearing and agriculture that resulted in increased silt loads entering into bays and rivers were noted as a reason for historical mortality of oyster beds in Georges Bay, Tas (Parliamentary Report 1885 cited in Beck et al. 2009; Gillies et al. 2015). These changes in environmental conditions are further exacerbated by climate change through extreme events that are increasing in intensity, ocean warming, sea level rise, ocean acidification and possible changes to salinity and dissolved oxygen (Table 4 in section 4; CSIRO & Bureau of Meteorology 2015a & b, 2020, 2021, 2022; Gillies et al. 2020; CSIRO 2021a & b). For example, one major flood event in Georges Bay, Tas, resulted in more than 90% farmed oyster mortality (Break O'Day Council et al. 2012). Declines in environmental condition integrity can also facilitate other stressors, such as disease, infestation and invasive pests, with exposure to increased sediment loads or temperatures being linked with poor oyster condition and a greater likelihood of mortality or infection by Bonamiosis or mudworm (Ogburn et al. 2007; Hickman et al. 2000 cited in Ford & Hamer 2016; Pereira et al. 2019; Bradley et al. 2020).

While there are some indications that environmental conditions (e.g. water quality) have improved in some areas due to better management (Gillies et al. 2017; McAfee et al. 2020b; McAfee et al. 2024), it is unknown if the growing pressures of climate change and increasing coastal and catchment development and population growth will have a negative impact on this trend and limit natural recovery or constrain restoration efforts of native flat oyster reefs.

Potential for restoration

There is initial evidence to suggest that restoration of native flat oyster reefs to some form of functional state at the small-scale may be possible within 10 years with active human intervention, including the reseeding of oyster spat and/or the deployment of hard substrata (McAfee et al. 2024; TNC 2024a). At a native flat oyster restoration site in Glenelg in SA, adult native flat oysters provided the primary biogenic habitat after 2.5 years at densities that exceed 50 mature oysters/m^2 and include the presence of four age classes (McAfee et al. 2024). This initial phase of the restoration at this site reached these densities through seeding from sparsely spread remnant native flat oysters. However, restoration sites seeded by a limited number of adults may restrict genetic diversity, potentially compromising longer-term restoration success and it is uncertain what impact the high density of these restored oysters may have on disease prevalence (Reynolds et al. 2012; McAfee & Connell 2023; McAfee et al. 2024). Moreover, not all small-scale restoration projects have had similar results. At Windara Reef, a nearby location in SA, competition for space from other rapid colonizers (e.g. turf-forming algae) has limited oyster recruitment and slowed the restoration progress (McAfee et al. 2021). Additionally, some restoration sites have been seeded multiple times (TNC 2024) and sites may need continued seeding until natural recruitment occurs and a self-sustaining population persists, which could take time.

While there are some early indications of restoration success at the small-scale, to determine the likely ability of a native flat oyster restoration site to persist through time and perform relatively comparable functions to existing native flat oyster reefs, monitoring of restoration outcomes should be measured over at least 3-4 reproductive cycles (Gillies et al. 2017). Restoration sites may take longer to achieve these outcomes, or not succeed at all, especially if the environmental conditions needed for oysters to grow or survive are not present or a disturbance event occurs (e.g. disease outbreak or extreme event) (Gillies et al. 2017; McAfee et al. 2021; Leong et al. 2022; McAfee et al. 2024). Hemraj et al. (2022) suggests that shorter-term restoration monitoring (< 5 years) of oyster reef restoration may capture the initial boost in recovery, but not the subsequent progressive change in community composition that is integral to recovering full ecosystem complexity and that globally, full recovery of oyster reef system structure, functions and services will be on decadal scales. Monitoring of restoration success within dynamic environments requires frequent monitoring to understand responses to short and longer-term environmental variation and functions across the broader scale of the ecological community (Hemraj et al. 2022; La Peyre et al. 2022).

Restoration across the natural range of the historical extent of occurrence of the ecological community is unlikely in the near future due to logistical, environmental and financial constraints and may never be possible at the same scale of historical area of occupancy. Restoration spanning areas across the historical geographic distribution of native flat oyster reefs may be possible with significant financial investment and resource capacity, but likely not at the scale of area once reported, and the reduced environmental conditions in some areas due to coastal development and urbanisation, invasive pests and disease and degraded water quality may limit success of restoration at sites across parts of the historical extent of occurrence of the ecological community. If the supply of wild recruits of native flat oyster is not sufficient to yield densities that form self-sustaining populations, native flat oyster reefs would need to be seeded during restoration, which poses additional financial or logistical constraints to achieving successful restoration across the entire historical extent of occurrence of the ecological community.

Conclusion

The combination of these threats has impacted the structure, species assemblage and ecological function across the historical extent of occurrence of the ecological community.

This represents a **severe** reduction in integrity across most of its geographic distribution, as indicated by a **severe** degradation of the community of its habitat and disruption of important community processes. After preliminary assessment, the Committee considers that the ecological community may have met the relevant elements of Criterion 4 to make it eligible for listing as **Endangered**.

Consultation Questions on listing assessment – Criterion 4

- Do you have any feedback on the preliminary assessment under Criterion 4 or further data or information that would support or update the assessment? Please provide additional information and supporting evidence.
- Based on your knowledge and expertise, how long would it likely take for site-based restoration of native flat oyster reefs to reach a comparable state to remnant reefs in terms of structure and function? Please provide any relevant supporting information

6.2.6 Criterion 5 – rate of continuing detrimental change

Insufficient data to determine eligibility under Criterion 5.

	Category		
	Critically Endangered	**Endangered**	**Vulnerable**
Its rate of continuing detrimental change is: as indicated by:	very severe	severe	substantial
(a) rate of continuing decline in its geographic distribution, or a population of a native species that is believed to play a major role in the community, that is: OR	very severe	severe	serious
(b) intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is:	very severe	severe	serious
*an observed, estimated, inferred or suspected detrimental change over the immediate past, or projected for the immediate future (**10 years** or 3 generations, up to a maximum of 60 years), of at least:*	*80%*	*50%*	*30%*

Source: TSSC 2017

Evidence:

Following preliminary assessment, the Committee considers that there is unlikely to be sufficient information to determine the eligibility of the ecological community for listing in any category under Criterion 5.

Consultation Questions on listing assessment – Criterion 5

- Do you have any feedback on the preliminary assessment under Criterion 5 or further data or information that would support or update the assessment? Please provide additional information and supporting evidence.

6.2.7 Criterion 6 – quantitative analysis showing probability of extinction

Insufficient data to determine eligibility under Criterion 6.

	Category		
	Critically Endangered	**Endangered**	**Vulnerable**
A quantitative analysis shows that its probability of extinction, or extreme degradation over all of its geographic distribution, is:	at least 50% in the immediate future	at least 20% in the near future	at least 10% in the medium-term future
timeframes	*10 years or 3 generations (up to a maximum of 60 years)*	*20 years or 5 generations (up to a maximum of 100 years)*	*50 years or 10 generations (up to a maximum of 100 years)*

Source: TSSC 2017

Evidence:

Quantitative analysis of the probability of extinction or extreme degradation over the ecological community's entire geographic distribution has not been undertaken.

Following preliminary assessment, the Committee considers that there is unlikely to be sufficient information to determine the eligibility of the ecological community for listing in any category under Criterion 6.

Consultation Questions on listing assessment – Criterion 6

- Do you have any feedback on the preliminary assessment under Criterion 6 or further data or information that would support or update the assessment? Please provide additional information and supporting evidence.

Appendix A – Species lists

This Appendix lists the assemblage of native species that is likely to characterise the ecological community throughout its range at the time of listing at Table 8 (based on the sources cited).

The species listed may be abundant, rare, or not necessarily present in any given patch of the ecological community, and other native species not listed here may be present. The total list of species that may be found in the ecological community may be considerably larger than the species listed here.

Species presence and relative abundance varies naturally across the range of the ecological community based on factors such as historical biogeography, hydrology, bathymetry, and climate. They also change over time, for example, in response to disturbance (e.g. coastal development), or to the climate and weather (e.g. floods, extreme heat or cold). The species recorded at a particular site can also be affected by sampling scale, season, effort and expertise.

Due to the small number of remnant native flat oyster reef patches that have been extensively surveyed, some key references that document species presence at native flat oyster reef restoration sites have also been used to populate Table 8.

Scientific names used in this Appendix are nationally accepted names from the scientific community, as at the time of writing.

A1 Flora and Fauna

Table 8. Indicative list of flora and fauna associated with the native flat oyster reef ecological community, including evidence from both existing and restoration reef occurrences

Scientific name	Common name/s	EPBC status[8]	State status[9]
Algae and seaweeds			
Acrosorium sp.	red seaweed, red algae	-	-
Asparagopsis taxiformis	red seaweed	-	-
Ecklonia radiata	golden kelp	-	-

[8] Species listed under the EPBC Act at the time this document was prepared. Source: https://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

[9] Species listed under the state act or regulation at the time this document was prepared as threatened or protected. Sources:
https://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl
https://legislation.nsw.gov.au/view/html/inforce/current/act-2016-063
https://legislation.nsw.gov.au/view/html/inforce/current/sl-2019-0407
https://www.legislation.vic.gov.au/in-force/acts/flora-and-fauna-guarantee-act-1988/048
https://www.legislation.vic.gov.au/in-force/statutory-rules/fisheries-regulations-2019/006
https://www.legislation.tas.gov.au/view/html/inforce/current/act-1995-083
https://www.legislation.tas.gov.au/view/html/inforce/current/sr-2016-030
https://www.legislation.sa.gov.au/lz?path=%2FC%2FA%2Fnational%20parks%20and%20wildlife%20act%201972
https://www.legislation.sa.gov.au/lz?path=%2FC%2FR%2FFisheries%20Management%20(General)%20Regulations%202017
https://www.dbca.wa.gov.au/management/threatened-species-and-communities
https://www.legislation.wa.gov.au/legislation/statutes.nsf/main_mrtitle_1458_homepage.html

Scientific name	Common name/s	EPBC status[8]	State status[9]
Sargassum sp.	gulf weed, brown seaweed	-	-
Ulva sp.	sea lettuce	-	-
Undaria pinnatifida *introduced	wakame, undaria seaweed, Japanese seaweed, Japanese kelp	-	-
Zonaria sp.	brown seaweed, brown algae	-	-
Anemones			
Anthothoe albocincta	orange and white stripe anemone, striped anemone	-	-
Arthropods			
Ampithoidae *sp.*	amphipods	-	-
Apseudidae *sp.*	tanaids	-	-
Ceradocus rubromaculatus	amphipod	-	-
Galathea australiensis	striated craylet	-	-
Guinusia chabrus	red rock crab	-	-
Halicarcinus ovatus	three pronged sea-spider	-	-
Leptomithrax gaimardii	giant spider crab	-	-
Litocheira bispinosa	two-spined slender-clawed crab	-	-
Lysiosquilloidea *sp.*	banded mantis shrimps	-	-
Melitidae *sp.*	melitid amphipods	-	-
Ovalipes australiensis	sand crab	-	-
Ozius truncates	reef crab	-	-
Pagurixus handrecki	Clarrie's hermit crab	-	-
Palaemon intermedius	striped prawn	-	-
Palaemon serenus	rock pool shrimp	-	-
Portunus armatus	blue swimmer crab	-	-
Pyromaia tuberculata *introduced	fire crab	-	-
-	barnacles	-	-
Ascidians			
Ascidians	sea squirts	-	-
Bristle worms			
Eunicidae *sp.*	eunicid worms	-	-
Neptyidae *sp.*	-	-	-
Nereididae *sp.*	-	-	-
Sabellidae *sp.*	fan worms	-	-
Syllidae *sp.*	-	-	-
Terebellidae *sp.*	-	-	-
Bryozoans			
Celleporaria foliata	-	-	-
Cornucopina grandis	-	-	-
Cnidarians			
Plesiastrea versipora	hard coral	-	-
-	hydroids	-	-
-	zoanthids	-	-
Echinoderms			
Coscinasterias muricata	eleven-arm seastar, eleven-arm starfish	-	-
Echinometra mathaei	rock boring urchin	-	-
Heliocidaris erythrogramma	short-spined sea urchin, purple sea urchin	-	-
Ophiactis sp.	ophiactid brittle stars	-	-
Fishes			

Scientific name	Common name/s	EPBC status[8]	State status[9]
Acanthaluteres spilomelanurus	bridled leatherjacket	-	-
Acanthopagrus australis	yellowfin bream	-	-
Acentrogobius pflaumii	striped sandgoby	-	-
Aracama ornata	ornate cowfish	-	-
Arripis georgianus	Australian herring	-	-
Arripis trutta	Australian salmon	-	-
Blennidae *sp.*	blennies	-	-
Centropogon australis	eastern fortescue	-	-
Cheilodactylus nigripes	magpie perch	-	-
Chrysophrys auratus	australasian snapper	-	-
Cryptocentroides gobioides	crested oystergoby	-	-
Diodon nicthemerus	slender-spined porcupine fish	-	-
Gerres subfasciatus	silver biddy	--	
Girella elevata	rock blackfish	-	-
Girella tricuspidata	luderick	-	-
Hippocampus abdominalis	big-bellied seahorse	Marine	Protected: NSW, Vic, SA, Tas
Hyporhampus melanochir	southern garfish	-	-
Labridae *sp.*	wrasses	-	-
Leptatherina presbyteroides	silver fish	-	-
Liza agentea	mullet	-	-
Meuschenia freycineti	six-spined leatherjacket	-	-
Meuschenia scaber	velvet leatherjacket	-	-
Monacanthus chinensis	fanbelly leatherjacket	-	-
Mugil cephalus	sea mullet	-	-
Mullidae *sp.*	goatfishes	-	-
Nelusetta ayraud	ocean jacket	-	-
Nemadactylus macroptera	jackass morwong	-	-
Neoodax balteatus	little weed whiting	-	-
Nesogobius sp.	gobies	-	-
Notolabrus tetricus	blue-throated wrasse	-	-
Ophthalmolepis lineolatus	southern Maori wrasse	-	-
Ostorhinchus rueppellii	western gobbleguts	-	-
Parapercis haackei	wavy grubfish	-	-
Parequula melbournensis	silverbelly	-	-
Pelates octolineatus	western striped grunter	-	-
Pelates sexlineatus	eastern striped grunter	-	-
Pempheris multiradiata	bigscale bullseye	-	-
Phycodurus eques	leafy seadragon	Marine	Protected: Vic, WA, SA
Platycephalus bassensis	southern sand flathead	-	-
Platycephalus caeruleopunctatus	bluespotted flathead	-	-
Platycephalus fuscus	dusky flathead	-	-
Pomatomus saltatrix	tailor	-	-
Pseudocaranx georgianus	araara, blue trevally, blurter	-	-
Pseudolabrus rubicundus	rosy wrasse	-	-
Rhabdosargus sarba	tarwhine, silver bream, goldlined seabream	-	-
Scorpaenodes evides	cheekspot scoprionfish	-	-
Scorpis aequipinnis	sea sweep	-	-

Scientific name	Common name/s	EPBC status[8]	State status[9]
Sillago ciliata	sand whiting	-	-
Siphamia cephalotes	Wood's siphonfish	-	-
Sphyraena novaehollandiae	Australian barracuda	-	-
Tetractenos glaber	smooth toadfish	-	-
Thamnaconus degeni	bluefin leatherjacket	-	-
Trachurus novaezelandiae	yellow-tailed scad	-	-
Tranchinops caudimaculatus	southern hulafish	-	-
Upeneichthys vlamingii	blue spotted goatfish	-	-
Mangroves			
Avicennia marina	grey mangrove	-	-
Molluscs			
Cardita aviculina	cardita	-	-
Haliotis cyclobates	whirling abalone	-	-
Haliotis roei	Roe's abalone	-	-
Haliotis rubra	blacklip abalone	-	-
Haliotis scalaris	staircase abalone	-	-
Hapalochlaena maculosa	southern blue-ringed octopus	-	-
Hiatella australis	Australian rock-borer	-	-
Maoricolpus roseus *introduced	New Zealand screw shell	-	-
Mitra glabra	sea snail	-	-
Mimachlamys asperrimus	doughboy scallop	-	-
Mytilus galloprovincialis	blue mussel	-	-
Nudibranchs	sea slugs	-	-
Octopus sp.	octopuses	-	-
Pinna bicolor	razor clam, razor shell	-	-
Sepia sp.	cuttlefish	-	-
Sepioteuthis australis	southern reef squid	-	-
Veneridae largillierti *introduced	Venus clam	-	-
Venerupis sp.	Venus clam	-	-
Sharks and rays			
Bathytoshia brevicaudata	smooth stingray	-	-
Hemitrygon fluviorum	estuary stingray	-	-
Myliobatis australis	eagle ray	-	-
Trygonoptera testacea	common stingaree	-	-
Sponges			
-	sponges	-	-

Sources: Gillies et al. 2015; Gillies et al. 2017; Crawford et al. 2019; Dutka et al. 2022; Keane 2022; Martínez-Baena et al. 2023; Martin et al. 2025; McAfee et al. 2024; NSW DPIRD 2024 unpublished data; Strain et al. 2024; TNC 2024a

Consultation Questions on species lists

- Are any fauna or flora species incorrectly recorded? If so, please provide details.
- Please provide information on any other flora and fauna species that should be included, particularly commonly occurring species on remnant reefs.

Appendix B – Relationship to other habitat classification and mapping systems

Ecological communities are complex to classify. States and Territories apply their own systems to classify habitat communities. Reference to habitat and mapping units as equivalent to the ecological community, at the time of listing, should be taken as indicative rather than definitive. A unit that is generally equivalent may include elements that do not meet the key diagnostics and minimum condition thresholds. Conversely, areas mapped or described as other units may sometimes meet the key diagnostics for the ecological community. Judgement of whether the ecological community is present at a particular site should focus on how the site meets the description (section 1.2), the key diagnostic characteristics (section 2.1) and minimum condition thresholds (section 2.3).

State habitat mapping units are not the ecological community being listed. However, for some sites (but not all) certain habitat map units may correspond sufficiently to provide indicative mapping for the national ecological community, where the description matches. On-ground assessment is vital to finally determine if any patch is part of the ecological community.

For the native flat oyster reef ecological community, patches can occur in mosaics intergraded with other coastal or marine habitat or mapping classifications. As such, mapping and habitat classifications that may include the native flat oyster reef ecological community are outlined in Table 9.

Table 9. Mapping and habitat classifications that the native flat oyster reef ecological community may occur as an element

Name / Description	Habitat and Mapping Classification
National	
National Intertidal/Subtidal Benthic Habitat Classification Scheme (NISB)	NISB
Interim Australian National Aquatic Ecosystem Classification Framework as occurring in marine and estuary systems on unconsolidated substrate	SMB – Structural Macrobiota dominated by a filter feeding assemblage
Ramsar Classification System for Wetland Type	E7 – Bivalve (shellfish) reefs
Directory of Important Wetlands of Australia (DIWA) collates information about nationally and internationally important (Ramsar) wetlands in Australia.	DIWA
Marine waters – permanent shallow waters less than six metres deep at low tide; includes sea bays, straits	DIWA - A1
Subtidal aquatic beds; includes kelp beds, seagrasses, tropical marine meadows	DIWA – A2
Rocky marine shores; includes rocky offshore islands, sea cliffs, intertidal rock platforms	DIWA – A4
Estuarine waters; permanent waters of estuaries and estuarine systems of deltas	DIWA – A6
Tidal mud, sand or salt flats; intertidal or supratidal	DIWA – A7

Name / Description	**Habitat and Mapping Classification**
National Vegetation Information System (NVIS)	NVIS
Major Vegetation Group (MVG)	NVIS – MVG27 Naturally Bare, sand, rock, claypan, mudflat
Major Vegetation Group (MVG)	NVIS – MVG28 Sea and estuaries
Major Vegetation Subgroup (MVS)	NVIS – MVS42 Naturally bare, sand, rock, claypan, mudflat
Major Vegetation Subgroup (MVS)	NVIS – MVS46 Sea, estuaries (includes seagrass)
Australian Coastal Waterways geomorphic habitat mapping classification	Channel, Rocky Reef, Tidal Sand Banks
Geomorphic Features of Australia's margin	Reef, Tidal- sandwave/Sand-bank
Smartline 100K	Sediment bottom, Mixed sandy bottom, muddy bottom, Sloping rocky bottom, Sloping sandy bottom, Soft bedrock, Hard rocky reefs, Patchy hard rocky reefs /exposed rock, Rocky platform, Rock wall, Artificial substrate
Oz Estuaries 100K	Macroalgae, Filter feeders, Seagrass, Hard substrate, Soft substrate
SEAMAP AUSTRALIA National Benthic Habitat Layer	Invertebrates - Mixed Filter Feeder Community, Shelled Biota, Vegetation – Mixed Macrophytes, Macrophytes, Macroalgae, Seagrass, Hard Substrata – Mixed Hard Substrata, Consolidated Hard Substrata, Soft Substrata – Mixed Soft Substrata, Fine sediment – Silt, Mixed Fine Sediments, Coarse Sediment – Sand, Mixed Coarse Sediments, Mixed Hard/Soft Substrata
New South Wales	
BioNet Vegetation Classification	112 Seagrass Meadows
New South Wales Wetland Ecosystems	Estuarine wetland, Saline wetland, Coastal vegetation (subgroup), Estuarine water body (subgroup)
New South Wales Subtidal Marine Habitat Data	Seagrass, Reef, Exposed Reef/Outcrop
New South Wales Marine Habitats 2002	Seawall, Islands and rocks, Reef and shoal, Rocky intertidal, Subtidal sand, Seagrass
New South Wales Department of Primary Industries and Regional Development (DPIRD) – Oyster Reef Mapping	Clumping, Combination, Low profile 0.05-0.15 m, High profile 0.15-0.5 m, Shellbed
New South Wales Seabed Habitat State Waters	Reef 0-20 m, Reef 20-60 m

Name / Description	Habitat and Mapping Classification
New South Wales Estuary Ecosystems	Tide dominated estuary, Wave dominated estuary
New South Wales Estuarine Macrophytes	Seagrass, Saltmarsh, Mangrove
Victoria	
Ecological Vegetation Classes (EVCs)	EVC 10 Estuarine wetland
Combined Biotope Classification Scheme (CBICS)	CBICS habitats - Reef/rock Substratum – Sublittoral Zone, Seagrass on sediment – Sublittoral Zone, Sediment – Littoral Zone, Sediment – Sublittoral Zone, Sediment-Mud – Littoral Zone
South Australia	
State-wide benthic habitats	Seagrass, Macroalgae, High profile reef, Medium profile reef, Low profile reef, Invertebrate community, Unconsolidated bare substrate
Western Australia	
State-wide marine habitats	Macroalgae (intertidal), Macroalgae (subtidal), Seagrass, Filter Feeders, Bare reef (intertidal), Bare reef (subtidal), Mobile sand, Silt, Mudflat
Marine Futures Biota	Sessile invertebrates (SI), Kelp, Seagrass, Mixed kelp and SI, Mixed other algae and SI, Mixed vegetation and SI
Marine Futures Reef	Reef, Sand, Mixed reef and sand, Mixed reef, gravel and sand
Tasmania	
TASVEG – The Digital Vegetation Map of Tasmania	Other natural environments – Sand, mud (OSM), water, sea (OAQ)
Seamap Tasmania	Aquatic Macrophytes, Caulerpa, Reef, High profile reef, Medium profile reef, Low profile reef, Patchy reef, Sand, Hard Sand, Silty sand, Silt, Seagrass, Patchy seagrass, Sparse seagrass, Sparse patchy seagrass, Ruppia, Sponge, Vegetated unconsolidated

Consultation Questions on other habitat classification and mapping systems

- Are there additional habitat classification and mapping systems that may be relevant to the ecological community and should be documented in Table 9?

Appendix C – Additional information on survey techniques

Below are three example survey methods for subtidal oyster reefs. It is important to note, that both options 1 and 2 will require follow-up diver surveys to verify live oyster densities. These are example survey methods only and advances in technology may support the development of new techniques.

1. Multi-beam echo sounder (MBES)

Multi-beam echo sounder (MBES) surveys can be used to determine individual reef patch sizes, mosaic patch boundaries and percentage cover. This method is recommended for areas greater than 1 ha size. These surveys are undertaken in transects aligned with a grid pattern using multibeam sonar. The survey data is then exported to a GIS software platform to determine both the horizontal (reef footprint) and vertical (reef height) geospatial positioning. Generally, calmer ocean conditions are required to undertake these surveys and water visibility turbidity can impact on the results. To determine live oyster densities, diver oyster metric surveys will be required as a follow-up to MBES surveys.

2. Towed video and Remote Operated Underwater Video

Towed video or remotely operated vehicle (ROV) surveys can be used to determine individual reef patch sizes, mosaic patch boundaries and percentage cover. Before undertaking this survey, the target area could be determined by using a number of approaches, including for example, LIDAR imaging data, bathymetry rasters and the depth sounder approach outlined in the diver underwater survey method description (below). Towed video or ROV method is recommended for areas greater than 0.5 ha size but can be adapted to any survey area size. These methods can be used across all depth ranges where safe vessel navigation is permittable but is particularly useful in deeper waters when allowable safe diving times start to become limited. The surveys are undertaken by a vessel towing a video device or deploying a ROV in a parallel transect pattern (10 to 15 m apart) over the survey area. Images of the seafloor are recorded in intervals and the positioning tracked using GPS software. Generally, calmer ocean conditions are required to undertake these surveys and water visibility can greatly impact on the results. To determine live oyster densities, diver oyster metric surveys will be required as a follow-up to towed video and ROV surveys.

3. Diver underwater visual survey

Diver underwater visual surveys can be used to determine individual reef patch sizes, mosaic patch boundaries and percentage cover. This method is more labour intensive, depth limited (due to allowable safe bottom time) and potentially more suited to areas of smaller geographic size (i.e. < 0.5 ha).

First, the survey target area will be to be determined. This could be verified by a standard depth sounder on most vessels and the onboard GPS system. The vessel can be driven over the target area in a parallel transect pattern (20 to 30 m apart), observing for changes in seafloor profile (i.e. reef structure) and recording the GPS positions. The GPS locations marked can then be used to compile a target survey area using GIS software.

To prepare for the diver surveys, shot lines with floats can be deployed to mark the target survey area boundaries. The diver surveys will be in a parallel transect pattern (10 to 15 m apart) covering all of the survey area. Shot lines can then be deployed at the beginning and end of the transects. Divers will swim along that transect in a predetermined direction, recording underwater observations of reef patches at approximate metre intervals. A follow-up diver survey will be required to undertake a sub-sample of reef patches found to determine the approximate range of reef footprint sizes. This method does require water visibility of ideally at least 5 m. Oyster metric surveys to determine live oyster densities can also be undertaken during the diver-swum surveys.

Oyster metrics surveys

Oyster metrics is a universal method for determining the abundance of live and dead bivalves on oyster reefs.

Example oyster metric survey: On 50 m transects on native flat oyster reefs, 15 quadrats are sampled (typically 0.25 m^2 e.g. 50 x 50 cm but can cover a smaller area if shellfish densities are high) along each transect. Quadrat placement should be randomised using two independent random number sets using a random number generator. The first random number set identifies a distance along the 50 m base transect where a perpendicular transect is then laid. The length of the perpendicular transect should be the mean width of reef patches being surveyed. The second random number set identifies a distance on the perpendicular transect, such that quadrats are randomly sampled across the entire reef patch area. During sampling, divers can measure oyster and any other co-occurring shellfish species' densities *in-situ* within the surveyed quadrat. Alternatively, divers can also collect the oysters in catch bags to measure on a vessel or land, then returned back to reef, provided appropriate permits are in place.

Consultation Questions on survey techniques

- Is there any further information or survey approaches that should be noted within this section? Please providing supporting information.

Appendix D – Evidence of historical extent and decline

Table 10. Example historical accounts of the extent of likely native flat oyster reefs

Historical accounts of ecosystem size, extent and harvest	Reference
'I was engaged Oyster dredging myself at the time referred to and it was no uncommon thing for two men in one boat to raise 23 bags Oyster in one day... no less than 16,000 bags oysters were dredged during the years 1872, 1873 and 1874.'	Inspector of Oyster Fisheries (1886) cited in Alleway & Connell (2015)
'Records indicated that large quantities of oysters were caught within the St. Vincent Gulf, and in the early days of the colony (approximately 1836-1870) markets in Adelaide were supplied from extensive beds along the Yorke Peninsula and the north coast of Kangaroo Island.'	Randall (1911) and McIntosh (1913) cited in Alleway & Connell (2015)
Found that oyster reefs were present in the past across more than 1500 km of SA coastline. Extending along both sides of the Spencer Gulf, the eastern side of the St Vincent Gulf and the north coast of Kangaroo Island, also being found in bays on the western side of the Eyre Peninsula.	Alleway & Connell (2015)
Describes native flat oyster as being a feature of Victoria's major bays and estuaries for thousands of years. The native flat oyster, however, appears to have been very abundant in Western Port when Europeans arrived, forming large reef areas.	Ford & Hamer (2016)
In one of the peak years of the *O. angasi* oyster fishery in Tasmania in the 1860's, over 22 million oysters were recorded as being brought to market from five relatively small estuaries in south eastern Tasmania.	Gillies et al. 2015
Evidence given at the 1878 Select Committee hearings indicated that in the recent past there had been 16-17 doublehanded boats dredging in an area of 100-150 acres in Spring Bay (Tas), whereas now there were none.	Gillies et al. 2015
Over 350 coastal shell middens have been recorded for the Bellarine and Mornington Peninsula (Port Phillip Bay) and Phillip Island (Western Port) areas alone.	Sullivan (1981) and Presland (2010) cited in Ford & Hamer (2016)
Journals from these early explorations indicate the presence of abundant flat oysters, which were at that time popular European seafood. 'When Lieutenant John Murray brought the Lady Nelson into Western Port in 1801, he remarked in his journal that '…today gave the shore a strict search at low water and plainly perceived that a company of 6 or 8 men would not run any risk or hazard of being starved here for several months from the vast quantity of shell fish to be found at low water'. The shellfish he referred to were no doubt native flat oysters.'	Ford & Hamer (2016)
'In 1843 it was reported that 2900 dozen oysters were shipped from Port Albert to Melbourne, and sold for 2 shillings a dozen (Hannan & Bennett 2010), and during the 1850s '12,000 to 14,000 dozen were taken a week from twenty to twenty five boats' (from Hannan & Bennett 2010). The latter equates to on average 156,000 oysters per week during the 1850s, when at a conservative estimate of 65 g per oyster would equate to about 10 t per week. These types of weekly catch rates suggest the fishery would have been at least several hundred tonnes per year at its peak.'	Ford & Hamer (2016)
An account of oyster dredging offshore from Corner Inlet describes an oyster bank 'from Shallow Inlet towards Wilson Promontory for a distance of 12 miles' and another '3 miles long beginning at the (Corner) Inlet' (Illustrated Australian News, 7 November 1891).	Ford & Hamer (2016)

'The commissioner of Fisheries for Western Australia in 1893 described that 'many square miles' of oyster banks still existed in both Oyster Harbour and Princess Royal Harbour, even post significant depletion of the fishery reported 15 at least years earlier.'	Saville-Kent (1893) cited in Cook et al. (2021)
'Fisheries Victoria researchers working on oyster culture in the late 1980s reported dense oyster beds at Point Henry and Arthur the Great region of the Geelong Arm/ Geelong Outer Harbour, where these areas were used for brood stock collections, but heavy mortalities were recorded in these areas in 1991, thought to be the result of an outbreak of Bonamiosis.'	Hickman et al. (2000) cited in Hamer et al. (2013)
A survey in 1987 by the Department of Primary Industries and Fisheries reported that 'over 24 million native flat oysters were estimated to be present in a series of beds covering about 33 Ha throughout the bay. The highest quality oysters were found in and around the flood tide delta between Humbug Point and Lords Point, where a maximum density of 344 oysters m -2 with an average length of 85mm was found.'	Wilson (1991) cited in Mount et al. (2005)
'Two centuries ago, flat oyster reefs carpeted the seafloors of more than 5000 km of Australian Coastline.'	McAfee & Connell (2023)
'Originally the oysters extended from Darling Harbour to the Flats in more or less quantities, but a few years back they became almost extinct from over-dredging—I refer to the mud oysters. I have no doubt that the sewage matter together with the light soil continually washing from the cultivated lands has tended in a great measure to destroy many of the beds which at one time gave abundant yield —in places where old catchers informed me immense beds existed I found on dredging nothing but a soft slushy mud.'	Oyster Culture Commission (1877)
Describes the condition of oysters in the Wagonga River where 'Mud oysters are found in considerable numbers on the upper portion of the river, but are of no commercial value, owing to the difficulty in getting them to Sydney in marketable condition.'	Commissioners of Fisheries (1889)

Table 11. Published evidence of decline of native flat oyster reefs

Evidence of decline	Decline	Spatial extent	Temporal extent	Comments
National/general				
Gillies et al. (2018)	99%	Eastern and southern Australia, native flat oyster distribution	Relative to longer-term/1750 timeframe, primarily over a 150-year period from 1800 to 1950.	The measurement of ecosystem decline calculated by Gillies et al. (2018) was conducted at a locality-scale rather than a detailed spatial analysis of percentage area of decline, as very few historical accounts of native flat oyster reefs provide spatial information of actual ecosystem distribution and area of occupancy within or across localities. Gillies et al. (2018) estimate a locality-scale decline using a measurement of ecosystem decline based on the current presence and absence of native flat oyster reefs that encompass a single oyster reef of > 1 ha or a mosaic of oyster reefs of > 1 ha at recorded historical commercial fishery locations identified from primary and secondary literature sources (e.g. early explorer accounts, fisheries and government reports, commercial fishery surveys, first person accounts (published in newspaper articles), archaeological excavations (aboriginal living sites), sediment cores, place names and reviews of fisheries legislation). The minimum comparable unit of measurement for historical and existing oyster reef comparison used in Gillies et al. (2018) was set to > 1 ha based on: 1) the assumption that historical commercial fishing was unlikely to occur in areas where the ecosystem extent was less than 1 ha in size; 2) a review of the only commercially harvested

				natural native flat oyster reef remaining in Australia which includes oyster reef covering a similar spatial scale (Jones & Gardner 2016); and 3) a general consensus among consulted experts that 1 ha was a conservative yet comparable geographic unit of measure to assess historical and current shellfish ecosystem extent. Gillies et al. (2018) note that their estimate of geographic decline of native flat oyster reefs is likely a conservative estimate due to the threshold used for the minimum comparable unit of measurement and the assumption that historical sites identified in NSW were sites of *S. glomerata* oyster reefs instead of *O. angasi* oyster reefs, as these reefs were considered the primary reef-forming species in that region.
Gillies et al. (2020)	99%	Eastern and southern Australia, native flat oyster distribution	Relative to longer-term/1750 timeframe, primarily over a 150-year period from 1800 to 1950.	Published literature was used to provide information on present ecosystem distribution at a national (i.e. Gillies et al. 2015; Gillies et al. 2018) and a regional scale (i.e. Jones & Gardner 2016; McLeod et al. 2020) and historical ecosystem distributions at regional scales (i.e. Kirby 2004; Ogburn et al. 2007; Alleway & Connell 2015; Ford & Hamer 2016). Information used consisted of a mix of primary and secondary sources, including early explorer accounts, fisheries and government reports, commercial fishery surveys, first person accounts (published in newspaper articles), archaeological excavations (aboriginal living sites), sediment cores, place names and reviews of fisheries legislation. Most of the scientific studies used described the ecosystem in the context of wild oyster fisheries/oyster harvest and used a combination of fisheries harvest records, cultural histories, eyewitness accounts and parliamentary records attesting to and recording the decline of oyster populations and describing the collapse of the fishing and of oyster reefs. As few of the accounts and scientific papers provided information on ecosystem distribution within a location, Gillies et al. (2020) measured ecosystem decline as presence and absence of the oyster reef ecosystem at each recorded historical location. The only remnant native flat oyster reef included in this analysis was located in Georges Bay, Tas. This study was used to assess the Oyster Reef Ecosystem of Southern and Eastern Australia, comprised of Sydney rock oyster reefs and native flat oyster reefs, as Critically Endangered under the International Union for Conservation of Nature (IUCN) Red List of Ecosystems.
Beck et al. (2011)	99% reduction in native oyster reefs in bays in eastern and southern Australia and described as 'functionally extinct' or in 'poor condition'	Eastern and southern Australia	Present abundance as at date of publication relative to historical abundance (20-130 years before present)	Identified native oyster reef condition primarily as a function of oyster abundance and calculated condition using estimates of present abundances from the literature and past records of historical abundances from the past 20 – 130 years. Regional oyster reef condition was classified as functionally extinct and estimated to have more than 99% of habitat lost when sources indicated that it was difficult to find reefs, or that no reefs remained in bays where annual catch records were high (usually > 10,000 metric tons) but historical observations indicated that reefs had once been extensive. Regional oyster reef condition was classified as poor (90% to 99% habitat lost) when evidence indicated that fisheries were collapsing (or collapsed)

				but there was evidence that reefs remained, even if long-term viability was questionable.
Cook et al. (2021)	Mostly lost	Many estuaries along southern coastline of Australia	Between c. 1840 and 1870	-
Ogburn et al. (2007)	Died off	Many southern estuaries	During 1860s	References testimonies from the Oyster Culture Commission (1877) and historical reports.
New South Wales				
Ogburn et al. (2007)	Decimation / disappearance of sub-tidal oyster reefs	Major estuaries of NSW / east coast of Australia	Since European settlement (~1780s) and largely disappeared by the mid-1870s.	References testimonies from the Oyster Culture Commission (1877) and historical reports.
NSW DPI (2019b)	100% loss of subtidal native flat oyster reefs	Wapengo, NSW	40 or more years ago	NSW Oyster Industry Survey. The report references a comment from an oyster farmer in the Wapengo area 'The subtidal *Angasi* oyster reefs are all dead now... I used to dive the channel for live ones for my dad about 40 years ago'.
Oyster Culture Commission (1877)	Over-dredging leading to severe decline			Example excerpts from the report: 'Are you aware that those beds were worked out at that time by over-dredging? Yes, but as far as. I can see, these mud oysters can be dredged and annihilated much sooner than the rock oysters. I notice that in Victoria they are almost altogether annihilated from over-dredging'. 'Originally the oysters extended from Darling Harbour to the Flats in more or less quantities, but a few years back they became almost extinct from over-dredging—I refer to the mud oysters. I have no doubt that the sewage matter together with the light soil continually washing from the cultivated lands has tended in a great measure to destroy many of the beds which at one time gave abundant yield —in places where old catchers informed me immense beds existed I found on dredging nothing but a soft slushy mud.' 'the bed in the Clyde River was originally sand, but it was a great place for mud oysters until they all died off.' 'These mud oysters, which you get by dredging, of course are saleable? Yes; that is a sample (No. 7) of mud oysters of a rare species now nearly extinct.'
Victoria				
Ford & Hamer (2016)	Estimated as >95% and considered to be functionally extinct with no notable areas of continuous oyster reef	Estuarine and coastal waters in Victoria, with a detailed analysis of Port Phillip Bay, Western Port, Corner Inlet–Nooramunga	Since European settlement. Largely decimated by 1860, although oyster fisheries	Documented the decline of native flat oyster reefs in Vic using information from a variety of sources, including historical and contemporary literature, interviews with Victorian coastal fisherman, fisheries catch data, documented Indigenous use, and the authors' first-hand knowledge and observations, to establish a baseline of the likely major areas of native flat oyster systems at the time of European arrival and reconstruct a timeline of decline. Historical locations and periods where oysters

		and the Gippsland Lakes.	were able to continue at a much lower biomass until 1970.	were fished were documented, along with information on commercial catch, relative abundance and the extent of beds or size of the fishery.
South Australia				
Alleway & Connell (2015)	~100%	At least 1,500 km of coastline in SA	By 1946	Used historical records to quantify commercial catch of *O. angasi* in southern Australia from early colonization (around 1836) to some of the last recorded catches in 1944. Estimates of catch and effort were used to map past distribution and assess oyster abundance of *O. angasi* over approximately 180 years in South Australia. Historical catch quantities may be underrepresented because returns were made voluntarily and represent what was reported to the inspector.
Inspector of Oyster Fisheries (1892)	Extensive decline	SA	1892	Alleway & Connell (2015) reproduce a quote from the Inspector of Oyster Fisheries in 1892 that describes the state of oyster beds in SA: '...our once prolific oyster beds are every year becoming less reproductive and it is my firm conviction that nothing but decisive measures can cope with the difficulty under which our oyster beds and cutters at present labour, the continual dredging and redredging by large number of boats... if we are to conserve existing oyster beds and extend the industry, all further dredging on known deposits must be suspended to enable the beds to be restocked by spawn from properly matured oysters.'
Inspector of Oyster Fisheries (1886)	Completely depopulated of reproduction capacity	Yorke Peninsula, SA	1886	Alleway & Connell (2015) reproduce a quote from the Inspector of Oyster Fisheries in 1886 that describes the state of oyster beds in Yorke Peninsula, SA: 'In the early days of the colony the Oyster supply was obtained from the Eastern Shores of Yorke Peninsula and the dredging there was continued for years, crossing and recrossing over the same beds constantly without hinderance, protection or regulation of any king, so much so that the beds were never allowed to rest, and the result was that Oyster beds were completely depopulated of all power of reproduction to such an extent that for nearly 20 years there were hardly any oysters to be obtained, where previously there was abundance....'
Inspector of Oyster Fisheries (1892)	Destruction by dredging	SA	1892	Alleway & Connell (2015) reproduce a quote from the Inspector of Fisheries (1892) on the destruction of oyster beds by dredging: 'I would point out that dredging is always accompanied by a large amount of unavoidable destruction to young oysters and oyster brood, and taking more than the market requirements from the natural beds simply means ruin...'
Western Australia				
Warnock & Cook (2015) cited in Gillies et al. (2020)	Loss of oyster beds	Estuaries in southwest WA	By 1940	-

Gillies pers obs. (2017)	~100%	Oyster Harbour, WA	-	-
Tasmania				
Edgar & Samson (2004)	~100%	Derwent Estuary, Tas	Steep decline after 1910 and no oyster shell after 1930	Used historical patterns of deposition of mollusc shells to infer changes to inshore benthic assemblages across a 100 km extent in southeastern Tasmania.
Edgar & Samson (2004)	~100%	D'entrecasteaux Channel, Tas	Steep decline after 1910 and no oyster shell after 1930	Used historical patterns of deposition of mollusc shells to infer changes to inshore benthic assemblages across a 100 km extent in southeastern Tasmania.

Consultation Questions on historical extent and decline

- Are there any additional examples of historical extent and/or decline that should be represented above? Please provide supporting information.

Appendix E – Historical location list

This includes all historical locations identified in scenarios 1 and 2 from section 6.2.2 noting that it also includes existing reefs that are assumed to have been present historically.

New South Wales

Bedlam Bay
Bermagui River
Botany Bay
Brisbane Water
Clyde River
Darling Harbour
Durras Lake
Five Dock Bay
Georges River (Jewfish Point)
Hawkesbury River
Hen and Chicken Bay
Jervis Bay (Currumbene Creek)
Jervis Bay (Hole in the Wall) Lane Cove River
Merimbula Lake
Middle Harbour
Moruya River
Narrabeen Lagoon
Nelson Lagoon
Pambula Lake
Port Jackson
Port Stephens
Tuross Lake
Wagonga Inlet
Wallaga Lake
Wapengo Lagoon
Wonboyn Lake

Victoria

9ft Bank (Port Phillip Bay)
Anderson Inlet
Corner Inlet
Limeburners Bay (near Avalon)
Limeburners Point (near Geelong)
Oyster Bed Channel (Nooramunga)
Point Wilson / Wilson Spit (Port Phillip Bay)
Shallow Inlet
Western Port

South Australia

American River
American Beach
Anxious Bay
Backy Bay/Point
Ballast Head
Bay of Shoals (Kangaroo Island)
Bickers Island
Bird Rock
Black Point (Port Alfred)
Blanche Harbour
Boston Bay
Boston Island
Cape Donington
Coffin Bay (General)
Corey Point (Hardwicke Bay)
Cygnet River
Davenport Creek (Denial Bay)
Denial Bay
Dutton Bay
Eastern Cove (Kangaroo Island)
Edithburgh
Entrance Island (Franklin Harbour)
False Bay
Fowlers Bay
Franklin Harbour
Grange
Grantham Island
Hardwicke Bay
Head of the Gulf (Port Arthur)
Head of the Gulf (Port Augusta)
Hervey Bay
Hindmarsh River (Encounter Bay)
Holdfast Bay
Kellidie Bay (Coffin Bay)
Kingscote
Leven Beach (Hardwicke Bay)
Long Beach (Coffin Bay)
Louth Bay
Louth Island
Mangrove Point (near Blanche Harbour)
Marion Reef
Middle Bank

Middleton (Encounter Bay)
Mt Dutton Bay (Coffin Bay)
Mt Young
Murininie Beach
North Coast Kangaroo Island
North Shields (Boston Bay)
NW Coast (N of Franklin Harbour)
Orontes Bank
Oyster Bay (near Stansbury)
Parara Point/Ardrossan
Peters Island (Denial Bay)
Pine Point
Point Bolingbroke
Point Boston
Point Fanny
Point Longnose (Coffin Bay)
Point Lowly
Point Morrison (Kangaroo Island)
Point Pearce
Point Riley
Point Souttar (Hardwicke Bay)
Port Adelaide – Inner bar
Port Adelaide – North Arm
Port Broughton
Port Clinton
Port Clinton (North)
Port Douglas (Coffin Bay)
Port Elliot (Encounter Bay)
Port Julia
Port Lincoln
Port Pirie
Port Price (Wills Creek)
Port River and Barker Inlet
Port Victoria (South)
Port Vincent
Port Wakefield
Porter Bay
Proper Bay (far west)
Proper Bay (general)
Proper Bay (south)
Rabbit Island 1
Rabbit Island 2
Red Cliff
Rocky Point
Rogues Point
Salt Creek
Semaphore
Shallow Water Point (Franklin Harbour)
Sheaoak Flat
Sir Joseph Banks Group
Smoky Bay
Spalding Cove
Stamford Hill
Stansbury
Stansbury Point
Streaky Bay (Central)
Streaky Bay (Habour)
Streaky Bay (South)
Surveyor Point (Port Vincent)
The Brothers Islands
Tourville Bay
Tumby Bay
Victor Harbor
Wallaroo
Western Cove (Kangaroo Island)
Wool Bay
Yangie Bay (Coffin Bay)

Western Australia

King George Sound
Nornalup Inlet
Oyster Harbour
Princess Royal Harbour
Swan-Canning Estuary
Taylor Inlet
Wilsons Inlet

Tasmania

Ansons Bay
Barnes Bay
Bicheno
Blackman Bays
Boomer Bay
Bridport
Carlton River
Cloudy Bay
Coles Bay
Deception Bay
D'Encasteaux Channel
Derwent Estuary
Duck Bay
Dunalley
Eaglehawk Bay
Georges Bay
Great Oyster Bay
Greater Swanport (Swansea)
Hastings Bay

Huon Estuary
Kenneth Bay
Little Oyster Cove (Kettering)
Little Oyster Cove Creek (near Kettering)
Little Swanport
Macquarie Harbour
Maria Island
Mawson Bay
Mercury Passage
Montagu bay
Musselroe Bay
Norfolk Bay
North-West Bay
Oyster Bay (Maria Island)
Oyster Cove
Oyster Cove Rivulet (near Kettering)
Oyster Patch (Georges Bay)
Oyster Rocks Conservation Area
Pipeclay Lagoon
Pittwater
Port Arthur
Port Cygnet
Port Davey
Port Esperance
Port Sorell
Prosser bay
Ralphs Bay
Recherche Bay
Rocky Cape
Scamander
Southport
Spring Bay/Triabunna
Swanwick
Tamar Estuary
Tasman River
Wedge Bay

Consultation Questions on historical locations

- Are there any additional historical locations of native flat oyster reefs that should be included in the list above? Please provide details of location, including likely size and latitude and longitude points if available.

Consultation Questions on any other information

- Do you have comments on any other matters relevant to the assessment of this ecological community?

References

Adelaide Times (1857) *The Glenelg Jetty*. The Adelaide Times, Saturday 28 March 1857.

AFD (Australian Faunal Directory) (2024) *Species Ostrea stentina Payraudeau, 1826*. Accessed: 5 December 2024 Available at: https://biodiversity.org.au/afd/taxa/e098afd6-4991-42e4-bba7-f8b087e65db7

Allen RJ & Webb BM (2011) Determination of wave transmission coefficients for oyster shell bag breakwaters. *Proceedings of the Coastal Engineering Practice*, 684-697.

Alleway HK & Connell SD (2015) Loss of an ecological baseline through the eradication of oyster reefs from coastal ecosystems and human memory. *Conservation Biology* 29(3), 795-804.

Alsaffar Z, Pearman JK, Curdia J, Ellis J, Calleja ML, Ruiz-Compean P, Roth F, Villalobos R, Jones BH, Morán XAG & Carvalho S (2020) The role of seagrass vegetation and local environmental conditions in shaping benthic bacterial and macroinvertebrate communities in a tropical coastal lagoon. *Scientific Reports* 10, 13550. doi: 10.1038/s41598-020-70318-1.

Amaral V, Cabral HN & Bishop MJ (2012) Moderate acidification affects growth but not survival of 6-month-old oysters

Attenbrow V (2002) *Sydney's Aboriginal past: investigating the archaeological and historical records*. University of New South Wales Press, Sydney. Australia, 226 p.

Baggett LP, Powers SP, Brumbaugh R, Coen LD, DeAngelis B, Greene J, Hancock B & Morlock S (2014) *Oyster habitat restoration monitoring and assessment handbook.* The Nature Conservancy, Arlington, VA, United States of America.

Baggett LP, Powers SP, Brumbaugh RD, et al. (2015) Guidelines for evaluating performance of oyster habitat restoration. *Restoration Ecology* 23(6), 737-745. doi: 10.1111/rec.12262.

Barnes TK, Volety AK, Chartier K, Mazzotti FJ & Pearlstine L (2007) A habitat suitability index model for the eastern oyster (Crassostrea virginica), a tool for restoration of the Caloosahatchee Estuary, Florida. *Journal of Shellfish Research*, 26(4), 949-959.

Bartlett J, Maher W, Ubrihien R, Krikowa F, Edge K, Potts J & Taylor A (2020) Fitness of two bivalves Saccostrea glomerata and Ostrea angasi exposed to a metal contamination gradient in Lake Macquarie, NSW Australia: Integrating subcellular, energy metabolism and embryo development responses. *Ecological indicators*, *110*, 105869.

Beck MW, Brumbaugh RD, Airoldi L, et al. (2009) *Shellfish Reefs at Risk: A Global Analysis of Problems and Solutions*. The Nature Conservancy, Arlington VA. 52 p.

Beck MW, Brumbaugh RD, Airoldi L, et al. (2011) Oyster reefs at risk and recommendations for conservation, restoration, and management. *Bioscience*, 61(2), 107-116.

Bishop MJ, Carnegie RB, Stokes NA, Peterson CH & Burreson EM (2006) Complications of a non-native oyster introduction: facilitation of a local parasite. *Marine Ecology Progress Series*, *325*, 145-152.

Bishop MJ, Swearer SE, Porter SN, Altieri AH & Keith DA (2020) M1.4 Shellfish beds and reefs, in Keith DA, Ferrer-Paris JR, Nicholson E & Kingsford RT (Eds) (2020) *The IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups*. IUCN, Gland, Switzerland.

Bleaney A, Hickey CW, Stewart M, Scammell M & Senjen R (2015) Preliminary investigations of toxicity in the Georges Bay catchment, Tasmania, Australia. *International Journal of Environmental Studies, 72*(1), 1-23.

Bowen AM (2012) Archaeology of the Chinese fishing industry in colonial Victoria. *Studies in Australian Historical Archaeology*. Australasian Society for Historical Archaeology, Sydney, xiv, 177 p. ISBN 781920899813

Bradley TL, Mercer JA, Humphrey JD, et al. (2019) Bonamiosis in farmed native oysters (Ostrea angasi). *Fisheries Research and Development Corporation*, 52 p.

Bradley TL, Mercer JA, Humphrey JD, Moody NJG & Hunnam JC (2020) Bonamia exitiosa in farmed native oysters Ostrea angasi in Australia: optimal epidemiological qPCR cut-point and clinical disease risk factors. *Diseases of Aquatic Organisms*, *140*, 151-165.

Brand SC, Jeffs AG, von Ammon U & Zaiko A (2022) Assessing the presence, settlement and growth of the invasive Mediterranean fanworm, Sabella spallanzanii, on mussel farms. *Journal of Experimental Marine Biology and Ecology*, *554*, 151767.

Bray DJ (2020) *Chrysophrys auratus* in Fishes of Australia. Accessed: 26 April 2022 Available at: https://fishesofaustralia.net.au/home/species/678.

Break O'Day Council, SGS Economics & Planning & Tasmanian Climate Change Office (2012) *Tasmanian Coastal Adaptation Pathways Project - Georges Bay*. SGS Economics and Planning Pty Ltd., Hobart.

Brown E (2000) *Cooloola Coast: Noosa to Fraser Island. The Aboriginal and settler histories of a unique environment.* University of Queensland Press, Brisbane, Australia.

Bursill L & Jacobs M (2001) *Dharawal: the story of the Dharawal speaking people of Southern*. Kurranulla Aboriginal Corporation, Sydney.

Buss JJ, Harris JO, Elliot Tanner J, Helen Wiltshire K & Deveney MR (2020a) Rapid transmission of Bonamia exitiosa by cohabitation causes mortality in Ostrea angasi. *Journal of fish diseases*, *43*(2), 227-237.

Buss JJ, Wiltshire KH, Harris JO, Tanner JE & Deveney MR (2020b) Infection dynamics of Bonamia exitiosa on intertidal Ostrea angasi farms. *Journal of fish diseases*, 43(3), 359-369.

Buss JJ, Wiltshire KH, Prowse TA, Harris JO & Deveney MR (2019) Bonamia in Ostrea angasi: diagnostic performance, field prevalence and intensity. *Journal of fish diseases*, *42*(1), 63-74.

Calder JE (1886) *Oyster Culture. A compendium of facts*. James Barnard Government Printer, Hobart, Tasmania.

Campbell D (2015) *Quantifying the effects of boat wakes on intertidal oyster reefs in a shallow estuary* (Masters thesis, University of Central Florida Orlando, Florida).

Chan CY & Wang WX (2019) Biomarker responses in oysters Crassostrea hongkongensis in relation to metal contamination patterns in the Pearl River Estuary, southern China. *Environmental pollution*, *251*, 264-276

Charifi M, Sow M, Ciret P, Benomar S & Massabuau JC (2017) The sense of hearing in the Pacific oyster, Magallana gigas. *PLoS One*, 12(10), e0185353.

Clarence City Council (2024) *takara limuna (Sheoak Walk)*. Accessed: 2 December 2024 Available at: https://www.ccc.tas.gov.au/explore/the-outdoors/takara-limuna-sheoak-walk/

Clark GF & Johnston EL (2017) *Australia state of the environment 2016: coasts*, independent report to the Australian Government Minister for Environment and Energy, Australian Government Department of the Environment and Energy, Canberra.

Coen LD & Bishop MJ (2015) The ecology, evolution, impacts and management of host–parasite interactions of marine molluscs. *Journal of Invertebrate Pathology*, *131*, 177-211.

Coen LD, Brumbaugh RD, Bushek D, Grizzle R, Luckenbach MW, Posey MH, Powers SP & Tolley, SG (2007) Ecosystem services related to oyster restoration. *Marine Ecology Progress Series*, *341*, 303-307.

Colella D, Miller D, Hicks J & Brock D (2017) *Baseline survey of fishes and large mobile invertebrate assemblages at the Rogues Point native shellfish reef restoration site and nearby areas, South Australia – April 2017, DEWNR Technical Note* 2017/27*.* Government of South Australia, Department of Environment, Water and Natural Resources, Adelaide, Australia.

Cole VJ, Chapman MG & Underwood AJ (2007) Landscapes and life-histories influence colonisation of polychaetes to intertidal biogenic habitats. *Journal of Experimental Marine Biology and Ecology*, *348*(1-2), 191-199.

Cole VJ, Harasti D, Lines R & Stat M (2021) Estuarine fishes associated with intertidal oyster reefs characterized using environmental DNA and baited remote underwater video. *Environmental DNA*, *4*(1), 50-62.

Cole VJ, Parker LM, O'Connor SJ, O'Connor WA, Scanes E, Byrne M & Ross PM (2016) Effects of multiple climate change stressors: ocean acidification interacts with warming, hyposalinity, and low food supply on the larvae of the brooding flat oyster Ostrea angasi. *Marine Biology*, 163, 1-17.

Connolly RM, Herrera C, Rasmussen J, et al. (2024) Estimating enhanced fish production on restored shellfish reefs using automated data collection from underwater videos. *Journal of Applied Ecology*, *61*(4), 633-646.

Cook PA, Warnock B, Gillies CL & Hams AB (2021) Historical abundance and distribution of the native flat oyster (*Ostrea angasi*) in estuaries of the Great Southern region of Western Australia help to prioritise potential sites for contemporary oyster reef restoration. *Marine and Freshwater Research* 73(1), 48-56.

Corbeil S, Handlinger J & Crane MSJ (2009) Bonamiasis in Australian Ostrea angasi. *Australian and New Zealand standard diagnostic procedure*, 22 p.

Crawford C (2016) *National review of Ostrea angasi aquaculture: historical culture, current methods and future priorities.* University of Tasmania Institute for Marine and Antarctic Studies, Hobart, Tasmania, Australia.

Crawford C & Cahill K (2008) *State of Estuary Report for Georges Bay, April 2007 – March 2008*. Tasmania Aquaculture and Fisheries Institute and Natural Resource Management of Northern Tasmania. Tasmania, Australia. Accessed: 2 February 2022 Available at: https://researchdata.edu.au/state-estuary-report-georges-bay/685431?fl

Crawford C, Edgar G, Gillies CL & Heller-Wagner G (2019) Relationship of biological communities to habitat structure on the largest remnant flat oyster reef (*Ostrea angasi)* in Australia. *Marine and Freshwater Research* 71(8), 972-983.

Crooks JA (2001) Assessing invader effects within changing ecosystems: A historical and experimental evaluation of the role of an exotic mussel in an urbanized lagoon, *Biological Invasions*, 1, 23-36.

CSIRO (2021a) *Regional Projection for Eastern Australia*. Accessed on the Internet at: https://research.csiro.au/cor/wp-content/uploads/sites/282/2021/07/Summary-of-Regional-projections-E-Australia-v3.pdf

CSIRO (2021b) *Regional Projection for Southern Australia*. Accessed on the Internet at: https://research.csiro.au/cor/wp-content/uploads/sites/282/2021/07/Summary-of-Regional-projections-S-Australia-v3.pdf

CSIRO & Bureau of Meteorology (2015a) *Regional Climate Change Explorer – Clusters – Southern and South-Western Flatlands*. Accessed: 28 February 2024 Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/regional-climate-change-explorer/clusters/?current=SSWS&popup=true&tooltip=true

CSIRO & Bureau of Meteorology (2015b) *Regional Climate Change Explorer – Super Clusters – Eastern Australia*. Accessed: 28 February 2024 Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/regional-climate-change-explorer/clusters/?current=SSWS&popup=true&tooltip=true

CSIRO & Bureau of Meteorology (2020) *Coastal and marine projections*. Accessed: 23 February 2024 Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/coastal-marine-projections/

CSIRO & Bureau of Meteorology (2021) *Marine Explorer*. Accessed: 23 February 2024 Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/coastal-marine-projections/marine-explorer/

CSIRO & Bureau of Meteorology (2022) *State of the Climate 2022*, © Government of Australia.

CSIRO & Bureau of Meteorology (2024) *State of the Climate 2024*, © Government of Australia.

DAFF (Department of Agriculture, Fisheries and Forestry) (2020) *Infection with Bonamia exitosa*. Accessed on the Internet at: https://www.agriculture.gov.au/agriculture-land/animal/aquatic/aquatic_animal_diseases_significant_to_australia_identification_field_guide#parasitic-diseases-of-molluscs

Danic-Tchaleu G, Heurtebise S, Morga B & Lapègue S (2011) Complete mitochondrial DNA sequence of the European flat oyster Ostrea edulis confirms Ostreidae classification. *BMC research notes*, *4*, 1-10.

DAWE (Department of Agriculture, Water and Environment) (2022d) *Species – Arcuatula senhousia*. Accessed: 27 May 2024 Available at: https://nimpis.marinepests.gov.au/species/species/7

DAWE (Department of Agriculture, Water and Environment) (2022c) *Species – Asterias amurensis*. Accessed: 2 May 2024 Available at: https://nimpis.marinepests.gov.au/species/species/105

DAWE (Department of Agriculture, Water and Environment) (2022a) *Species – Magallana (Crassostrea) gigas*. Accessed: 24 June 2024 Available at: https://nimpis.marinepests.gov.au/species/species/133

DAWE (Department of Agriculture, Water and Environment) (2022e) *Species – Maoricolpus roseus*. Accessed: 27 May 2024 Available at: https://nimpis.marinepests.gov.au/species/species/33

DAWE (Department of Agriculture, Water and Environment) (2022f) *Species – Sabella spallanzanii*. Accessed: 17 May 2024 Available at: https://nimpis.marinepests.gov.au/species/species/70

DAWE (Department of Agriculture, Water and Environment) (2022b) *Species – Undaria pinnatifida*. Accessed: 31 May 2024 Available at: https://nimpis.marinepests.gov.au/species/species/50

DAWE (Department of Agriculture, Water and Environment) (2023a) *Species – Carcinus maenas*. Accessed: 2 May 2024 Available at: https://nimpis.marinepests.gov.au/species/species/84

DAWE (Department of Agriculture, Water and Environment) (2023b) *Species – Varicorbula gibba*. Accessed: 20 May 2024 Available at: https://nimpis.marinepests.gov.au/species/species/51

DAWE (Department of Agriculture, Water and Environment) (2024) *Species – Mya arenaria*. Accessed: 7 May 2024 Available at: https://nimpis.marinepests.gov.au/species/species/9

Deadly Story (2024) *Wadawurrung Language*. Accessed 2 December 2024 Available at: https://deadlystory.com/page/aboriginal-country-map/Aboriginal_Country_Completed/Wadawurrung/Wadawurrung_Language

Diggles BK, Porter R, Vardon J, Hawthorne S & Veary E (2019) *Pumicestone Passage Shellfish Reef Habitat Restoration Project—December 2018 deployment. 12 Month invertebrate monitoring*. OzFish, Brisbane, Australia.

Dinamani P & Beu AG (1981) Description of a new species of incubatory oyster from northern New Zealand, with notes on its ecology and reproduction. *New Zealand Journal of Marine and Freshwater Research*, *15*(2), 109-119.

Dove MC & Sammut J (2007a) Impacts of estuarine acidification on survival and growth of Sydney rock oysters *Saccostrea glomerata (Gould 1850)*. *Journal of Shellfish Research 26(6)*, 519-527.

Dove MC & Sammut J (2007b) Histological and feeding response of Sydney rock oysters, Saccostrea glomerata, to acid sulfate soil outflows. *Journal of Shellfish Research*, *26*(2), 509-518.

Dortch CE, Kendrick GW & Morse K (1984) Aboriginal mollusc exploitation in southwestern Australia. *Archaeology in Oceania* 19, 81-104.

Department of Primary Industries and Water (2007) *Shellfish Fishery Policy Document - Information Supporting the Shellfish Management Plan for the Fisheries (Shellfish) Rules 2007*. Accessed on the Internet at: https://fishing.tas.gov.au/commercial-fishing/commercial-fisheries/shellfish-fishery

Dutka TL, Fejer AJ, Williams T, Donnelly DM & Flynn AJ (2022) Extent and characteristics of a newly discovered unique bryozoan biogenic reef complex. *Frontiers in Marine Science* 9, 841131.

DWER (Department of Water and Environmental Regulation) (2019) *Oyster Harbour - Miaritch (Miyaritj) - Condition of the Estuary 2016-2019*. Government of Western Australia.

Edgar GJ & Samson CR (2004) Catastrophic decline in mollusc diversity in eastern Tasmania and its concurrence with shellfish fisheries. *Conservation Biology*, 18, 1579–1588.

Engelsma MY, Culloty SC, Lynch SA, Arzul I & Carnegie RB (2014) Bonamia parasites: a rapidly changing perspective on a genus of important mollusc pathogens. *Diseases of Aquatic Organisms, 110*(1-2), 5-23.

EPA Victoria (2024) *Report Card 2022-23 – Port Phillip, Western Port and Gippsland Lakes*. EPA Victoria State Government of Victoria, Melbourne.

Eymann C, Götze S, Bock C, Guderley H, Knoll AH, Lannig G, Sokolova IM, Aberhan M & Pörtner, HO (2020) Thermal performance of the European flat oyster, Ostrea edulis (Linnaeus, 1758)—explaining ecological findings under climate change. *Marine biology*, 167, 1-15.

Fabris GJ, Monahan CA & Batley GE (1999) Heavy metals in waters and sediments of Port Phillip Bay, Australia. *Marine and freshwater research*, 50(6), 503-513.

Filgueira R & Grant J (2009) A box model for ecosystem-level management of mussel culture carrying capacity in a coastal bay. *Ecosystems*, *12*, 1222-1233.

Filgueira R, Grant J, Stuart R & Brown MS (2013) Ecosystem modelling for ecosystem-based management of bivalve aquaculture sites in data-poor environments. *Aquaculture Environment Interactions*, *4*(2), 117-133.

Filgueira R, Guyondet T, Comeau LA & Grant J (2014) A fully-spatial ecosystem-DEB model of oyster (Crassostrea virginica) carrying capacity in the Richibucto Estuary, Eastern Canada. *Journal of Marine Systems*, *136*, 42-54.

Fitzsimons J, Branigan S, Brumbaugh RD, McDonald T & Zu Ermgassen PSE (Eds) (2019) *Restoration Guidelines for Shellfish Reefs*. The Nature Conservancy, Arlington, VA, United States of America.

Fuentes HR, Williams RJ, Diver LP & Smith AK (1990) *Commercial molluscs of Jervis Bay*. Fisheries research institute.

Ford JR & Hamer P (2016) The forgotten shellfish reefs of coastal Victoria: documenting the loss of a marine ecosystem over 200 years since European settlement. *Proceedings of the Royal Society of Victoria* 128(1), 87-105.

Forrest BM, Keeley NB, Hopkins GA, Webb SC & Clement DM (2009) Bivalve aquaculture in estuaries: review and synthesis of oyster cultivation effects. *Aquaculture*, *298*(1-2), 1-15.

Galtsoff PS & Merrill AS (1962) Notes on shell morphology, growth, and distribution of Ostrea equestris Say. *Bulletin of Marine Science*, *12*(2), 234-244.

Gara T (2017) *Colonialism and its aftermath: a history of Aboriginal South Australia*. Adelaide: Wakefield Press.

Gibbs MC, Parker LM, Scanes E and Ross PM (2024) Recognising the importance of shellfish to First Nations peoples, Indigenous and Traditional Ecological Knowledge in aquaculture and coastal management in Australia. *Marine and Freshwater Research*, *75*(4).

Gibbs MT (2007) Sustainability performance indicators for suspended bivalve aquaculture activities. *Ecological indicators*, *7*(1), 94-107.

Gillanders BM, Elsdon TS, Halliday IA, Jenkins GP, Robins JB & Valesini FJ (2011) Potential effects of climate change on Australian estuaries and fish utilising estuaries: a review. *Marine and Freshwater Research*, 62(9), 1115-1131.

Gilby BL, Olds AD, Peterson CH, Connolly RM, Voss CM, Bishop MJ, Elliott M, Grabowski JH, Ortodossi NL & Schlacher TA (2018) Maximizing the benefits of oyster reef restoration for finfish and their fisheries. *Fish and Fisheries* 19(5), 931-947.

Gilby BL, Schlacher T, Olds AD, Connolly R, Henderson CJ, Duncan CK, Ortodossi NL, Brook TW, Hardcastle F & Rummell A (2020) *Bringing fish life back to Noosa: restoring lost oyster reef habitats in the Noosa Biosphere. Final Report*. University of the Sunshine Coast

Gillies CL, Castine SA, Alleway HK, Crawford C, Fitzsimons JA, Hancock B, Koch P, McAfee D, McLeod I & Zu Ermgassen PSE (2020) Conservation status of oyster reef ecosystem of Southern and Eastern Australia. *Global Ecology and Conservation* 22, e00988.

Gillies CL, Crawford C & Hancock B (2017) Restoring Angasi oyster reefs: What is the endpoint ecosystem we are aiming for and how do we get there? *Ecological Management and Restoration* 18(3), 214-222.

Gillies CL, Creighton C & McLeod IM (Eds) (2015) *Shellfish reef habitats: A synopsis to underpin the repair and conservation of Australia's environmentally, socially and economically* *important bays and estuaries*. Report to the National Environmental Science Programme, Marine Biodiversity Hub. Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) Publication, James Cook University, Townsville, Australia.

Gillies CL, McLeod IM, Alleway HK, et al. (2018) Australian shellfish ecosystems: Past distribution, current status and future direction. *PLoS One* 13, e0190914.

Godfrey M (1989) Shell midden chronology in southwestern Victoria: reflections of change in prehistoric population and subsistence? *Archaeology in Oceania* 24(2), 65-69.

Grabowski JH, Brumbaugh RD, Conrad RF, Keeler AG, Opaluch JJ, Peterson CH, Piehler MF, Powers SP & Smyth AR (2012) Economic valuation of ecosystem services provided by oyster reefs. *Bioscience* 62(10), 900-909.

Grabowski JH & Peterson CH (2007) Restoring oyster reefs to recover ecosystem services. *Ecosystem Engineers: Plants to Protists* 4, 281-289.

Grabowski JH, Powers SP, Roman H & Rouhani S (2017) Potential impacts of the 2010 Deepwater Horizon oil spill on subtidal oysters in the Gulf of Mexico. *Marine Ecology Progress Series*, 576, 163-174.

Grannum RK, Murfet NB, Ritz DA & Turner E (1996) *The distribution and impact of the exotic seastar, Asterias amurensis (Lutken) in Tasmania*. University of Tasmania: Hobart, Australia.

Grant J, Bacher C, Cranford PJ, Guyondet T & Carreau M (2008) A spatially explicit ecosystem model of seston depletion in dense mussel culture. *Journal of Marine Systems*, *73*(1-2), 155-168.

Grant J, Curran KJ, Guyondet TL, Tita G, Bacher C, Koutitonsky V & Dowd M (2007) A box model of carrying capacity for suspended mussel aquaculture in Lagune de la Grande-Entrée, Iles-de-la-Madeleine, Québec. *Ecological modelling*, *200*(1-2), 193-206.

Griffitt J, Posey M & Alphin T (1999) Effects of edge fragmentation on oyster reef utilization by transient nekton. *Journal of Elisha Mitchell Scientific Society* 115, 98-103.

Guo X, Li C, Wang H & Xu Z (2018) Diversity and evolution of living oysters. *Journal of Shellfish Research*, *37*(4), 755-771.

Hamer P, Pearce B & Winstanley R (2013) *Towards reconstruction of the lost shellfish reefs of Port Phillip*. *Recreational Fishing Grants Program Research Report.* Project SG/117. 34pp.

Hanke MH, Posey MH & Alphin TD (2017) The influence of habitat characteristics on intertidal oyster *Crassostrea virginica* populations. *Marine Ecology Progress Series* 571, 121-138. doi: 10.3354/meps12094.

Hannan H & Bennett B (2010). *Western Port Fishermen*. Hannan and Bennett, Melbourne Victoria.

Harwell HD, Posey MH & Alphin TD (2011) Landscape aspects of oyster reefs: effects of fragmentation and habitat utilization. *Journal of Experimental Marine Biology and Ecology* 409, 30-41. doi: 10.1016/j.jembe.2011.07.036.

Hayes K, Sliwa C, Migus S, McEnnulty F & Dunstan P (2005) National priority pests: Part II Ranking of Australian marine pests. *An independent report undertaken for the Department of Environment and Heritage by CSIRO Marine Research*, 1-106.

Heasman M, Diggles BK, Hurwood D, Mather P, Pirozzi I & Dworjanyn S (2004) *Paving the way for continued rapid development of the flat (angasi) oyster (Ostrea angasi) farming industry in New South Wales*. New South Wales Fisheries, Nelson Bay, New South Wales, Australia.

Heasman M & Lyall I (2000) Proceedings of the workshop held on 3 March 2000 at the Sydney Fish Markets: problems of producing and marketing flat oysters *Ostrea angasi* in NSW. *NSW Fisheries Research Institute* June 2000: 56 pp. ISSN 1442-0147.

Heller-Wagner GJ (2017) *Naturally Occurring Ostrea angasi reefs in Tasmania: Associated biological communities and their relationship with habitat structure*. University of Tasmania. 56 p.

Hemraj DA, Bishop MJ, Hancock B, Minuti JJ, Thurstan RH, Zu Ermgassen PS & Russell BD (2022) Oyster reef restoration fails to recoup global historic ecosystem losses despite substantial biodiversity gain. *Science Advances* 8(47), eabp8747.

Herbert-Read JE, Thornton A, Amon DJ, et al. (2022) A global horizon scan of issues impacting marine and coastal biodiversity conservation. *Nature Ecology & Evolution,* 6(9), 1262-1270.

Hercus LA (1992) *A Nukunu dictionary*

Hewitt CL, Campbell ML, Thresher RE, et al. (2004) Introduced and cryptogenic species in port Phillip Bay, Victoria, Australia. *Marine biology*, *144*, 183-202.

Hickman NJ, Mantzaris S & Rawlinson P (2000) Native flat oyster investigation. *Marine and Freshwater Resources Institute*, Queenscliff. Report No. 26, 31 p

Hine PM & Jones JB (1994) Bonamia and other aquatic parasites of importance to New Zealand. *New Zealand Journal of Zoology*, *21*(1), 49-56.

Hobday AJ & Pecl GT (2014) Identification of global marine hotspots: sentinels for change and vanguards for adaptation action. *Reviews in Fish Biology and Fisheries* 24(2):415–425.

Howie AH & Bishop MJ (2021) Contemporary oyster reef restoration: responding to a changing world. Frontiers in Ecology and Evolution 9, 1-15. doi: [10.3389/fevo.2021.689915.](https://doi.org/10.3389/fevo.2021.689915)

Howie AH, Hanns C, Theuerkauf S, Reeves SE, Gillies CL & Longley-Wood K (2023) Shellfish Reef Restoration Suitability Modelling: Technical Manual. *The Nature Conservancy*, Arlington VA, USA

Howie AH, Reeves SE, Gillies CL & Bishop MJ (2024) Integration of social data into restoration suitability modelling for oyster reefs. *Ecological Indicators*, 158, 111531.

Hu L, Wang H, Zhang Z, Li C & Guo X (2019) Classification of small flat oysters of Ostrea stentina species complex and a new species Ostrea neostentina sp. nov.(Bivalvia: Ostreidae). *Journal of Shellfish Research*, *38*(2), 295-308.

Huang CH, Lin HJ, Huang TC, Su HM & Hung JJ (2008). Responses of phytoplankton and periphyton to system-scale removal of oyster-culture racks from a eutrophic tropical lagoon. *Marine Ecology Progress Series*, *358*, 1-12.

Hurwood DA, Heasman MP & Mather PB (2005) Gene flow, colonisation and demographic history of the flat oyster Ostrea angasi. *Marine and freshwater research*, *56*(8), 1099-1106.

IMAS (2024a) *Oysters – Native Flat*. Accessed: 17 June 2024 Available at: https://tasfisheriesresearch.org/nfo/

IMAS (2024b) *Oysters – Native Flat – Fisheries Management*. Accessed: 17 June 2024 Available at: https://tasfisheriesresearch.org/nfo/management/

Inspector of Oyster Fisheries (1886) *Diary and letter book*. Department of Marine and Harbors, Adelaide.

Jamal E, Reichelt-Brushett A & Benkendorff K (2022) Exposure to multiple elements reduces the health of Saccostrea glomerata: An assessment of the Richmond River estuary, NSW, Australia. *Marine Pollution Bulletin*, *184*, 114177.

Jones H & Gardner C (2016) *Small bivalve survey, assessment and stock status update.* Institute for Marine and Antarctic Studies Report. University of Tasmania, Hobart, Australia.

Kasoar T, Zu Ermgassen PS, Carranza A, Hancock B & Spalding M (2015) New opportunities for conservation of a threatened biogenic habitat: a worldwide assessment of knowledge on bivalve-reef representation in marine and coastal Ramsar Sites. *Marine and Freshwater Research* 66, 981-988.

Keane JP (2021) *2021 Small Bivalve Fishery Assessment, Ostrea angasi - Georges Bay. Institute for Marine and Antarctic Studies Report*. University of Tasmania, Hobart. 17 p.

Keane JP (2022) *2022 Small Bivalve Fishery Assessment. Institute for Marine and Antarctic Studies Report*. University of Tasmania, Hobart. 17 p.

Keane JP (2024) 2024 *Small Bivalve Fishery Assessment, Ostrea angasi – Georges Bay. Institute of Marine and Antarctic Studies Report.* University of Tasmania, Hobart. 16 p.

Keith DA, Ferrer-Paris JR, Nicholson E & Kingsford RT (eds) (2020) *The IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups*. IUCN, Gland, Switzerland.

Kellogg ML, Cornwell JC, Owens MS & Paynter KT (2013) Denitrification and nutrient assimilation on a restored oyster reef. *Marine Ecology Progress Series* 480, 1-19.

Kellogg ML, Smyth AR, Luckenbach MW, Carmichael RH, Brown BL, Cornwell JC, Piehler MF, Owens MS, Dalrymple DJ & Higgins CB (2014) Use of oysters to mitigate eutrophication in coastal waters. *Estuarine, Coastal and Shelf Science* 151, 156-168.

Kibria G, Nugegoda D, Rose G & Haroon AY (2021) Climate change impacts on pollutants mobilization and interactive effects of climate change and pollutants on toxicity and bioaccumulation of pollutants in estuarine and marine biota and linkage to seafood security. *Marine Pollution Bulletin*, 167, 112364.

La Peyre M, Humphries AT, Casas SM & La Peyre JF (2014) Temporal variation in development of ecosystem services from oyster reef restoration. *Ecological Engineering* 63, 34-44.

La Peyre MK, Marshall DA, Buie SCL, Hijuelos A & Steyer GD (2022) Are we falling short on restoring oysters at a regional scale?. *Environmental Management*, *70*(4), 581-592.

Lee K, Krassoi FR & Bishop MJ (2012) Effects of tidal elevation and substrate type on settlement and post settlement mortality of the Sydney Rock Oyster, *Saccostrea glomerata,* in a mangrove forest and on a rocky shore. *Journal of Shellfish Research* 31 (4), 1043-1050.

Lenihan HS & Peterson CH (1998) How habitat degradation through fishery disturbance enhances impacts of hypoxia on oyster reefs. *Ecological applications*, 8(1), 128-140.

Leong R (2022) *Spatial-ecological relationships of a threatened foundation species across multiple spatial scales* (Doctoral thesis dissertation, UNSW Sydney).

Leong R, Bugnot A, Marzinelli E, Figueira W, Erickson K, Poore A & Gribben P (2022) Variation in the density and body size of a threatened foundation species across multiple spatial scales. *Restoration Ecology*, e13670.

Li C, Kou Q, Zhang Z, Hu L, Huang W, Cui Z, Liu Y, Ma P & Wang, H. (2021) Reconstruction of the evolutionary biogeography reveal the origins and diversification of oysters (Bivalvia: Ostreidae). *Molecular Phylogenetics and Evolution*, *164*, 107268.

Lin HJ, Shao KT, Hsieh HL, Lo WT & Dai XX (2009) The effects of system-scale removal of oyster-culture racks from Tapong Bay, southwestern Taiwan: model exploration and comparison with field observations. *ICES Journal of Marine Science*, *66*(5), 797-810.

Lipcius RN, Zhang Y, Zhou J, Shaw LB & Shi J (2021) Modeling oyster reef restoration: Larval supply and reef geometry jointly determine population resilience and performance. *Frontiers in Marine Science*, 8, 677640.

Liu GX, Shu MA, Chai XL, Shao YQ, Wu HX, Sun CS & Yang SB (2014) Effect of chronic sublethal exposure of major heavy metals on filtration rate, sex ratio, and gonad development of a bivalve species. *Bulletin of environmental contamination and toxicology*, *92*, 71-74.

Lourandos H (1968) Dispersal of activities: the east Tasmanian Aboriginal sites. *Papers and proceedings of the Royal Society of Tasmania* 102(2), 40-46.

Luebbers RA (1978) *Meals and menus: a study of change in prehistoric coastal settlements in South Australia.* PhD Thesis, Australian National University, Canberra, Australia.

Luo L, Zhang Q, Kong X, Huang H & Ke C (2017) Differential effects of bisphenol A toxicity on oyster (Crassostrea angulata) gonads as revealed by label-free quantitative proteomics. *Chemosphere*, *176*, 305-314.

MacKenzie CL (Ed.) (1997) *The history, present condition, and future of the molluscan fisheries of North and Central America and Europe* (Vol. 127). US Department of Commerce.

Macleod C & Coughanowr C (2019) Heavy metal pollution in the derwent estuary: history, science and management. *Regional Studies in Marine Science*, 32, 100866.

Markwith AL (2010) Distribution patterns and select life history characteristics of Ostrea equestris (Say 1834) in southeastern North Carolina. University of North Carolina Wilmington.

Martin B, Huveneers C, Reeves S & Baring R (2025) Reviving shellfish reef socio-ecological histories for modern management and restoration. *Ocean & Coastal Management*, *261*, 107540.

McAfee D, Alleway HK & Connell SD (2020b) Environmental solutions sparked by environmental history. *Conservation Biology* 34(2), 386-39

McAfee D & Connell SD (2020) Cuing oyster recruitment with shell and rock: Implications for timing reef restoration. *Restoration Ecology*, 28(3), 506-511.

McAfee D & Connell SD (2023) Rapid reversal of ecological extinction. *Science*, 381(6658), 613-613.

McAfee D, McLeod IM, Boström-Einarsson L & Gillies CL (2020a) The value and opportunity of restoring Australia's lost rock oyster reefs. *Restoration Ecology* 28, 304-14.

McAfee D, McLeod LD, Carruthers S & Connell SD (2024) Reversing functional extinction: successful restoration of eradicated oyster reefs. *Restoration Ecology*, e14169.

McAfee D, Larkin C & Connell SD (2021) Multi-species restoration accelerates recovery of extinguished oyster reefs. *Journal of Applied Ecology* 58(2), 286-294.

McAfee D, Reis-Santos P, Jones AR et al. (2022) Multi-habitat seascape restoration: optimising marine restoration for coastal repair and social benefit. *Frontiers in Marine Science*, *9*, 910467.

McAfee D, Williams BR, McLeod L, Reuter A, Wheaton Z & Connell SD (2023) Soundscape enrichment enhances recruitment and habitat building on new oyster reef restorations. *Journal of Applied Ecology*, *60*(1), 111-120.

McIntosh S (1913) *Fisheries—Report of Chief Inspector for 1912–13*. House of Assembly, South Australia

McLeod IM, Boström-Einarsson L, Creighton C, et al. (2020) Habitat value of Sydney rock oyster (*Saccostrea glomerata*) reefs on soft sediments. *Marine and Freshwater Research* 71, 771-81.

McLeod IM, Zu Ermgassen PS, Gillies CL, Hancock B & Humphries A (2019) Can bivalve habitat restoration improve degraded estuaries?. In *Coasts and Estuaries* (pp. 427-442). Elsevier.

Morris RL, Bishop MJ, Boon P, et al. (2021) *The Australian Guide to Nature-Based Methods for Reducing Risk from Coastal Hazards. Earth Systems and Climate Change Hub Report No. 26.* NESP Earth Systems and Climate Change Hub, Australia.

Morton B, Lam K & Slack-Smith S (2003) First report of the European flat oyster Ostrea edulis, identified genetically, from Oyster Harbour, Albany, south-western Western Australia. *Molluscan Research*, *23*(3), 199-208.

Mount RE, Crawford C, Veal CJ & White C (2005) *Bringing back the bay: marine habitats and water quality in Georges Bay*. Break O'Day Council, Hobart.

Museums Victoria (2022) *Ostrea angasi*. Accessed: 3 May 2022 Available at: https://collections.museumsvictoria.com.au/species/8638

NACA (Network of Aquaculture Centres in Asia-Pacific) (2024) *Quarterly Aquatic Animal Disease Report*. Accessed: 19 December 2024 Available at: https://enaca.org/?id=8

Nell, JA (2007) *Controlling mudworm in oysters*. NSW Department of Primary Industries. Accessed on the internet at: https://www.dpi.nsw.gov.au/dpi/bfs/aquatic-biosecurity/aquaculture/oysters/other-oyster-health-issues

Nell JA (2001) The history of oyster farming in Australia. *Marine fisheries review*, *63*(3), 14-25.

Nell JA, Gibbs PJ (1986) Salinity tolerance and absorption of L-methionine by some Australian bivalves. *Australian Journal of Marine and Freshwater Research*, *37*(6), 721-727

Nelson KA, Leonard LA, Posey MH, Alphin TD & Mallin MA (2004) Using transplanted oyster (*Crassostrea virginica*) beds to improve water quality in small tidal creeks: a pilot study. *Journal of Experimental Marine Biology and Ecology* 298, 347-368. doi: 10.1016/s0022-0981(03)00367-8.

Newell RI & Koch EW (2004) Modelling seagrass density and distribution in response to changes in turbidity stemming from bivalve filtration and seagrass sediment stabilization. *Estuaries* 27, 793-806.

Newell RI & Mann R (2012) *Shellfish aquaculture: ecosystem effects, benthic pelagic coupling and potential for nutrient trading.* Report to the Secretary of Natural Resources, Commonwealth of Virginia.

Newton G (2012) Buffer zones for aquatic biodiversity conservation. *Australasian Plant Conservation: Journal of the Australian Network for Plant Conservation*, *21*(2), 18-22.

Nind S (1831) Description of the Natives of King George's Sound (Swan River Colony) and adjoining Country. *Journal of the Royal Geographical Society* 6, 21-51.

North EW, Schlag Z, Hood RR, Li M, Zhong L, Gross T & Kennedy VS (2008) Vertical swimming behavior influences the dispersal of simulated oyster larvae in a coupled particle-tracking and hydrodynamic model of Chesapeake Bay. *Marine Ecology Progress Series*, 359, 99-115.

NRE Tas (Department of Natural Resources and Environment Tasmania) (2024a) *Shellfish fishery*. Accessed: 7 March 2024 Available at: https://fishing.tas.gov.au/commercial-fishing/commercial-fisheries/shellfish-fishery

NRE Tas (Department of Natural Resources and Environment Tasmania) (2024b) *Shellfish and Shell collecting*. Accessed: 7 March 2024 Available at: https://fishing.tas.gov.au/recreational-fishing/fishing-by-species/shellfish-and-shell-collecting

NRM South (2022) *Reef Builder South Coast Tasmania Project: Native Oyster Reef Restoration – Environmental Effects Report*. Accessed on the Internet at: https://epa.tas.gov.au/Documents/NRM%20South%20Reef%20Builder%20EER_Main%20document.pdf

NSW DPI (Department of Primary Industries) (2018) *NSW Marine Estate Management Strategy 2018-2028*. Accessed on the Internet at: https://www.marine.nsw.gov.au/marine-estate-programs/marine-estate-management-strategy

NSW DPI (Department of Primary Industries) (2019a) *Oyster Reef Restoration: A guide to help government embed Oyster Reef Restoration into a Coastal Management Program*. New South Wales Department of Primary Industries, New South Wales. Accessed on the internet at: https://www.marine.nsw.gov.au/projects/oyster-reef-restoration-research

NSW DPI (Department of Primary Industries) (2019b) *Oyster Reef Restoration: NSW Oyster Industry Survey – Survey Results July 2019*. New South Wales Department of Primary Industries, New South Wales. Accessed on the internet at: https://www.marine.nsw.gov.au/__data/assets/pdf_file/0020/1149131/Summary-report-Oyster-reef-restoration-industry-survey.pdf

NSW DPI (Department of Primary Industries) (2020) *Oyster Reef Restoration: Oyster Reef Mapping Criteria – Definitions and guidelines for practitioners undertaking field-based mapping of NSW's oyster reefs*. New South Wales Department of Primary Industries, New South Wales. Accessed on the internet at: https://www.marine.nsw.gov.au/projects/oyster-reef-restoration-research

NSW DPI (Department of Primary Industries) (2021) *NSW Shellfish Reef Restoration Project Planning and Implementation Guidelines* New South Wales Department of Primary Industries, New South Wales. Accessed on the internet at: https://www.marine.nsw.gov.au/news-and-more/newsroom/news/pre-2023/nsw-shellfish-reef-restoration-guidelines-available

NSW DPI (Department of Primary Industries) (2023a) *Northern Pacific Seastar*. Accessed: 2 May 2024 Available at: https://www.dpi.nsw.gov.au/dpi/bfs/aquatic-biosecurity/aquatic-pests-and-diseases/marine-pests/other-marine-pests/northern-pacific-seastar

NSW DPI (Department of Primary Industries) (2023b) *European green crab (Carcinus maenas)*. Accessed: 3 May 2024 Available at: https://www.dpi.nsw.gov.au/dpi/bfs/aquatic-biosecurity/aquatic-pests-and-diseases/marine-pests/crustaceans/european-green-crab-carcinus-maenas

NSW DPIRD (Department of Primary Industries and Regional Development) (2021) *How to get involved*. Accessed: 6 December 2024 Available at: https://www.marine.nsw.gov.au/statewide-projects/water-quality-and-litter/oyster-reef-restoration/how-to-get-involved

NSW DPIRD (Department of Primary Industries and Regional Development) (2024a) *The health of our estuaries*. Accessed: 26 September 2024 Available at: https://www2.environment.nsw.gov.au/topics/water/estuaries/estuaries-of-nsw

NSW DPIRD (Department of Primary Industries) (2024b) *Saltwater bag and size limits*. Accessed: 7 March 2024 Available at: https://www.dpi.nsw.gov.au/fishing/recreational/fishing-rules-and-regs/saltwater-bag-and-size-limits

O'Connor SJ, Moltschaniwskyj N, Bolch C & O'Connor WA (2015) Assessment of temperature or salinity effects on larval development by cateholamine-induced metamorphosis of hatchery reared flat oyster, *Ostrea angasi* (Sowerby 1871) larvae. *Aquaculture Research* 46, 2501-2511.46, 2501-2511.

Ogburn DM, White I & McPhee DM (2007) The disappearance of oyster reefs from eastern Australian estuaries – Impact of colonial settlement or mudworm invasion? *Coastal Management* 35, 271-287.

Ogburn DM (2011) *The NSW oyster industry: A risk indicator of sustainable coastal policy and practice*. Australian National University.

Olsen AM (1994) The history of development for the Pacific Oyster, *Crassostreas gigas* (Thunberg) industry in South Australia. *Trans Roya Soc. South Australia*, 118(4), 157-163.

O'Sullivan, B. W. (1980). The fertility of the Port Lincoln oyster (Ostrea angasi Sowerby) from West Lakes, South Australia. *Aquaculture*, *19*(1), 1-11.

Overton K, Dempster T, Swearer SE, Morris RL & Barrett LT (2024) Aerial exposure tolerance of juvenile flat oysters (Ostrea angasi) depends on shell length and air temperature. *Restoration Ecology*, 32(1), e14047.

Oyster Culture Commission (1877) *Report of the Royal Commission*. New South Wales, Sydney. 101 pp.

Parliamentary Report (1885) *Fisheries Inspectors: reports for 1884; 1885, No 90*.

Parry GD (2017) Potential for biocontrol of the exotic starfish, Asterias amurensis, using a native starfish. *Biological Invasions*, *19*, 2185-2196.

Parry GD & Cohen BF (2001) *The Distribution, Abundance and population dynamics of the exotic seastar Asterias Amurensis during the first three years of its invasion of Port Phillip Bay,(incorporating a Report on the Bay Pest Day, 2 April 2000)*. Marine and Freshwater Resources Institute.

Peck L (2019) *Feasibility of shellfish reef restoration in a south-western Australian estuary* (Doctoral dissertation, Murdoch University).

Pereira RR, Scanes E, Parker LM, Byrne M, Cole VJ & Ross PM (2019) Restoring the flat oyster Ostrea angasi in the face of a changing climate. *Marine Ecology Progress Series*, 625, 27-39.

Peterson BJ & Heck Jr KL (2001a) An experimental test of the mechanism by which suspension feeding bivalves elevate seagrass productivity. *Marine Ecology Progress Series* 218, 115-125.

Peterson BJ & Heck Jr KL (2001b) Positive interactions between suspension-feeding bivalves and seagrass a facultative mutualism. *Marine Ecology Progress Series* 213, 143-155.

Pine C (2021) *Oyster Reef Design Rules: Understanding the influence of Reef Characteristics on Fish Assemblages to increase the effectiveness of current and future restoration efforts.* Honours Thesis, The University of Sydney, New South Wales, Australia.

PIRSA (Department of Primary Industries and Regions South Australia) (2017) *Pearl Oyster*. Accessed: 18 November 2024 Available at:

https://www.pir.sa.gov.au/recreational_fishing/rules/species_limits/pest_profile/pearl_oyster

PIRSA (Department of Primary Industries and Regions South Australia) (2024a) *Wakame (Japanese seaweed)*. Accessed: 20 October 2024 Available at: https://pir.sa.gov.au/recreational_fishing/rules/species_limits/pest_profile/wakame

PIRSA (Department of Primary Industries and Regions South Australia) (2024) *Fishing Limits Search*. Accessed: 13 March 2024 Available at: https://pir.sa.gov.au/recreational_fishing/rules/species_limits

Powers SP, Roman H, Meixner J, Wirasaet D, Brus S, Fricano G & Westerink J (2023) Establishing connectivity patterns of eastern oysters (Crassostrea virginica) on regional oceanographic scales. *Ecosphere*, 14(1), e4337.

Powers SP, Rouhani S, Baker MC, Roman H, Murray J, Grabowski JH, Scyphers SB, Willis JM & Hester MW (2015) *Loss of oysters as a result of the Deepwater Horizon oil spill degrades nearshore ecosystems and disrupts facilitation between oysters and marshes*. DWH Oyster NRDA Technical Working Group Report.

Presland G (2010) *The First People: The eastern Kulin of Melbourne, Port Phillip and Central Victoria*. Museum Victoria, Melbourne, Victoria

Prins TC, Smaal AC & Dame RF (1997) A review of the feedbacks between bivalve grazing and ecosystem processes. *Aquatic Ecology*, *31*, 349-359.

Prum P, Harris L & Gardner J (2024) Widespread warming of Earth's estuaries. *Limnology and Oceanography Letters*.

Radford R & Campbell V (1982) Archaeology of the southern Adelaide region. *Anthropological Society of South Australia,* 20, 1–8.

Randall WG (1911) *Report of the chief inspector of oyster fisheries on oyster-fishing*. House of Assembly, South Australia.

Reber G (1965) Aboriginal carbon dates from Tasmania. *Mankind*, 6, 264-268. https://doi.org/10.1111/j.1835-9310.1965.tb00359.x

Reeves S, Nedosyko A & Gillies C (2019) *The Nature Conservancy Windara Reef Technical Report 2019*. The Nature Conservancy, Australia.

Richardson MF, Sherman CDH, Lee RS, Bott NJ & Hirst AJ (2016) Multiple dispersal vectors drive range expansion in an invasive marine species, *Molecular Ecology 25* 5001–5014. doi: 10.1111/mec.13817

Rodriguez AB, Fodrie FJ, Ridge JT, et al. (2014) Oyster reefs can outpace sea-level rise. *Nature climate change*, *4*(6), 493-497.

Rodriguez-Perez A, Sanderson WG, Møller LF, Henry TB & James M (2020) Return to sender: The influence of larval behaviour on the distribution and settlement of the European oyster Ostrea edulis. Aquatic Conservation: *Marine and Freshwater Ecosystems*, 30(11), 2116-2132.

Royal Commission of the Fisheries of Tasmania (1883) Government Printer, Hobart, Tas., p. 8–11.

Salatin R, Wang H, Chen Q & Zhu L (2022) Assessing wave attenuation with rising sea levels for sustainable oyster reef-based living shorelines. *Frontiers in Built Environment*, 8, 884849.

Salvi D, Macal A & Mariottini P (2014) Molecular phylogenetics and systematics of the bivalve family Ostreidae based on rRNA sequence-structure models and multilocus species tree. *PloS one*, *9*(9), e108696

Salvi D, Al-Kandari M, Oliver PG, Berrilli E & Garzia M (2022) Cryptic marine diversity in the northern Arabian Gulf: an integrative approach uncovers a new species of oyster (Bivalvia: Ostreidae), Ostrea oleomargarita. *Journal of Zoological Systematics and Evolutionary Research*, *2022*(1), 7058975.

Sandoval-Gil J, Alexandre A, Santos R & Camacho-Ibar VF (2016) Nitrogen uptake and internal recycling in *Zostrea marina* exposed to oyster farming: eelgrass potential as a natural biofilter. *Estuaries and Coasts* 39(6), 1694-1708.

Santori C, Rowe, S & Smyth C (2023) The impacts of the 2019-2020 wildfires on marine species and ecosystems. *Australia's Megafires: Biodiversity Impacts and Lessons from 2019-2020:* 78.

Sas H, Deden, B, Kamermans P, et al. (2020) Bonamia infection in native oysters (Ostrea edulis) in relation to European restoration projects. *Aquatic Conservation-marine And Freshwater Ecosystems, 30*(11), 2150-2162.

Saville-Kent W (1891a) Oysters and oyster culture in Australasia. *Australasian Assoc. Advance. Sci*. 3, 550–573

Saville-Kent W (1891b) *Oysters and oyster fisheries of Queensland*. Department of Fisheries, Brisbane. Available at: https://www.biodiversitylibrary.org/item/47011#page/3/mode/1up

Saville-Kent W (1893) *Albany oysters. Mr Saville-Kent's report*. In The West Australian, 21 June 2024, p. 7. Available at: https://trove.nla.gov.au/newspaper/article/3056333

Scammell M (2004) *Environmental Problems Georges Bay, Tasmania*. Accessed on the Internet at: https://www.sourcewatch.org/images/7/7c/Tasmanian_Seafood_Industry_Council_Report_to_DPIPWE_-_Environmemtal_Problems_Georges_Bay_Tasmania_Feb-Jun_2004.pdf

Scyphers SB, Powers SP, Heck Jr HL & Byron D (2011) Oyster reefs as natural breakwaters mitigate shoreline loss and facilitate fisheries. *PLoS ONE* 6, e22396.

Sharma S, Goff J, Moody RM, Byron D, Heck KL, Powers SP, Ferraro C & Cebrian J (2016) Do restored oyster reefs benefit seagrasses? An experimental study in the Northern Gulf of Mexico. *Restoration Ecology* 24, 306-313.

Shervette VR & Gelwick F (2008) Relative nursery function of oyster, vegetated marsh edge, and nonvegetated bottom habitats for juvenile white shrimp *Litopenaeus setiferus*. *Wetlands Ecology and Management* 16(5), 405-419.

Smaal AC & Van Duren LA (2019) Bivalve aquaculture carrying capacity: concepts and assessment tools. *Goods and services of marine bivalves*, 451-483.

Souchu P, Vaquer A, Collos Y, Landrein S, Deslous-Paoli JM & Bibent B (2001) Influence of shellfish farming activities on the biogeochemical composition of the water column in Thau lagoon. *Marine Ecology Progress Series*, *218*, 141-152.

Stewart BD, Jenkins SR, Boig C, Sinfield C, Kennington K, Brand AR, Lart W & Kröger R (2021) Metal pollution as a potential threat to shell strength and survival in marine bivalves. *Science of the Total Environment*, *755*, 143019.

Stockton ED (1977) Middens of the Central Coast, New South Wales. *Australian Archaeology* 7(1), 20-31. doi: 10.1080/03122417.1977.12093326.

Stokes S, Wunderink S, Lowe M & Gereffi G (2012) *Restoring gulf oyster reefs*. Accessed on the Internet at: https://www.researchgate.net/publication/294579963_Restoring_Gulf_Oyster_Reefs

Stonehouse Research (2022a) Historic shellfish reefs/beds along the NSW coast

Stonehouse Research (2022b) Historic shellfish reefs - other estuaries

Strain E, Bugnot AB, Hancock B, Fulweiler RW, Ross DJ & Reeves S (2024) Assessing the Ecological Functioning and Biodiversity of Remnant Native Flat Oyster (Ostrea angasi) Reefs in Temperate Southeast Australia. *Marine Environmental Research*, *202*, 106782.

Sumner ME (1972) Oysters and Tasmania. *Tasmanian fisheries research*, 6(2):1-18.

Sullivan ME (1981) Ninety years later: a re-survey of shell middens on Wagonga Inlet and Pambula Lake, NSW. *Archaeology in Oceania*, *16*(2), 81-86.

Sullivan ME (1982) *Aboriginal shell middens in the coastal landscape of New South Wales*. The Australian National University (Australia).

Sullivan ME (1984) A shell midden excavation at Pambula Lake on the far south coast of New South Wales. *Archaeology in Oceania*, *19*(1), 1-15.

Sussan TT & Charpentier CL (2024) Conditions that promote oyster settlement coincide with areas of high boating activity in a developed coastal habitat. Journal of Experimental *Marine Biology and Ecology*, 572, 151989.

Sutton JT, Nishimoto J, Schrader J, Agonias K, et al. (2020) Genetic analysis identifies the Ostrea stentina/aupouria/equestris oyster species complex in Hawai ʻi, and resolves its lineage as the western Pacific O. equestris. *bioRxiv*, 2020-03.

Tamburri MN, Luckenbach MW, Breitburg DL & Bonniwell SM (2008) Settlement of Crassostrea ariakensis larvae: effects of substrate, biofilms, sediment and adult chemical cues. *Journal of Shellfish Research*, *27*(3), 601-608.

Talman, SG & Keough, MJ (2001) Impact of an exotic clam, *Corbula giba*, on the commercial scallop *Pecten fumatus* in Port Phillip Bay, south-east Australia: evidence of resource-restricted growth in a subtidal environment, *Marine Ecology Progress Series*, 221, 135-143.

TasTAFE (2024) *Meaningful new artwork takes shape at taypani Clarence*. Accessed: 2 December 2024 Available at: https://www.tastafe.tas.edu.au/news-folder/meaningful-new-artwork-takes-shape-at-taypani-clarence

Tilbrook B & Lenton A (2021) *SoE 2021 marine expert assessments: pressure assessment – ocean acidification*, Australian Ocean Data Network, Hobart

TNC (The Nature Conservancy Australia) (2022) *Rebuilding Australia's shellfish reefs*. Accessed: 1 February 2022 Available at: https://www.natureaustralia.org.au/what-we-do/our-priorities/oceans/ocean-stories/restoring-shellfish-reefs/

TNC (The Nature Conservancy Australia) (2024a) *Reef Builder Monitoring and Evaluation Report*. A report prepared for the Department of Climate Change, Energy, the Environment and Water by Bayraktarov E, Rullens V, Valesini F, Branigan S, Martínez-Baena F, and Reeves S. The Nature Conservancy Australia, Melbourne, 73p.

TNC (The Nature Conservancy Australia) (2024b) *Rebuilding Australia's Lost Shellfish Reefs. 2024 Reef Builder Final Summary Report.* The Nature Conservancy Australia, Melbourne, 34p.

Theuerkauf SJ, Puckett BJ & Eggleston DB (2021) Metapopulation dynamics of oysters: sources, sinks, and implications for conservation and restoration. *Ecosphere* 12(7), e03573.

Thomson JM (1954) The genera of oysters and the Australian species. *Marine and Freshwater Research, 5*(1), 132-168.

Thresher R, Proctor C, Ruiz G, Gurney R, MacKinnon C, Walton W, Rodriguez L & Bax N (2003) Invasion dynamics of the European shore crab, *Carcinus maenas*, in Australia, *Marine Biology*, 142, 867-876.

Thurstan RH, Diggles BK, Gillies CL, et al. (2020) Charting two centuries of transformation in a coastal social-ecological system: A mixed methods approach. *Global Environmental Change* 61, 102058.

TSSC [Threatened Species Scientific Committee] (2017). *Guidelines for nominating and assessing the eligibility for listing of ecological communities as threatened according to the Environment Protection and Biodiversity Conservation Act 1999 and the EPBC Regulations 2000.* Department of the Environment and Energy. Available from http://www.environment.gov.au/biodiversity/threatened/nominations/forms-and-guidelines

VFA (Victorian Fisheries Authority) (2022) *Recreational Fishing Guide – Snapper*. Accessed: 26 April 2022 Available at: https://vfa.vic.gov.au/recreational-fishing/recreational-fishing-guide/catch-limits-and-closed-seasons/types-of-fish/marine-and-estuarine-scale-fish/snapper

VFA (Victorian Fisheries Authority) (2024a) *Anglers tune in to find out why Port Phillip Bay is so important to snapper*. Accessed: 18 October 2024 Available at: https://vfa.vic.gov.au/recreational-fishing/recreational-fishing-grants-program/licence-fees-at-work/your-licence-fees-at-work-research-reports/your-licence-fees-at-work-reports/2017/anglers-tune-in-to-find-out-why-port-phillip-bay-is-so-important-to-snapper

VFA (Victorian Fisheries Authority) (2024b) *Tracking Snapper in Port Phillip Bay*. Accessed: 18 October 2024 Available at: https://vfa.vic.gov.au/science-in-fisheries/fisheries-research-findings/science-supporting-key-species/tracking-snapper-in-port-phillip-bay

VFA (Victorian Fisheries Authority) (2024c) *Recreational Fishing Guide – Oysters (all species)*. Accessed: 13 March 2024 Available at: https://vfa.vic.gov.au/recreational-fishing/recreational-fishing-guide/catch-limits-and-closed-seasons/types-of-fish/shellfish/oysters-all-species

Vic DSE (Department of Sustainability and Environment) (2002) *Controlling the Northern Pacific Seastar (Asterias amurensis) in Australia*. 52 p.

WA DPIRD (Department of Primary Industries and Regional Development) (2024) *Western Australian recreational fishing rules – Oysters (group)*. Accessed: 7 March 2024 Available at: http://rules.fish.wa.gov.au/Species/Index/110

Wall CC, Peterson BJ & Gobler CJ (2008) Facilitation of seagrass *Zostrea marina* productivity by suspension-feeding bivalves. *Marine Ecology Progress Series* 357, 165-174.

Wallace-Carter E (1987) *For they were fishers: the history of the fishing industry in South Australia.* Amphitrite Publishing House.

Walles B, Troost K, van den Ende D, Nieuwhof S, Smaal AC & Ysebaert T (2016) From artificial structures to self-sustaining oyster reefs. *Journal of Sea Research* 108, 1-9. doi:10.1016/j.seares.2015.11.007.

Walters LJ, Sacks PE & Campbell DE (2021) Boating impacts and boat-wake resilient restoration of the eastern oyster Crassostrea virginica in Mosquito Lagoon, Florida, USA. *Florida Scientist*, 84(2/3), 173-199.

Warnock B & Cook PA (2015) *Historical Abundance and Distribution of the Native Flat Oyster, Ostrea angasi, in the Great Southern Region of Western Australia*. Centre of Excellence in Natural Resource Management, University of Western Australia, Albany, WA, Australia.

Wells FE, McDonald JI & Huisman JM (2009) *Introduced Marine Species in Western Australia*. Perth, Australia: Department of Fisheries, 2009. Available at: https://www.fish.wa.gov.au/Documents/occasional_publications/fop057.pdf

Weng N & Wang WX (2014) Improved tolerance of metals in contaminated oyster larvae. *Aquatic toxicology*, *146*, 61-69.

Wilberg PL, Taube SR, Ferguson AE, Kremer MR & Reidenbach MA (2019) Wave attenuation by Oyster Reefs in Shallow Coastal Bays. *Estuaries and Coasts* 42, 331-347.

Williams BR, McAfee D & Connell SD (2022) Oyster larvae swim along gradients of sound. *Journal of Applied Ecology*, 59, 1815–1824. https://doi.org/10.1111/1365-2664.14188

Williams BR, McAfee D & Connell SD (2024) Anthropogenic noise disrupts acoustic cues for recruitment. *Proceedings B*, *291*(2027), 20240741.

Wilson JP (1991) *Survey of the Flat Oyster Stocks in Georges Bay*. Taroona, Sea Fisheries Division, Department of Primary Industries, 9p.

WoRMS (World Register of Marine Species) (2024) *Ostrea stentina Payraudeau, 1826*. Accessed: 5 December 2024 Available at: https://www.marinespecies.org/aphia.php?p=taxdetails&id=489077#distributions

Young C (1997) Southern Abundance. Western Fisheries, Autumn, Department of Fisheries, Western Australia, 35-39.

Ysebaert T, Walles B, Haner J & Hancock B (2019) *Habitat Modification and Coastal Protection by Ecosystem-Engineering Reef-Building Bivalves*, in Smaal A, Ferreira J, Grant J, Petersen J & Strand Ø (Eds) Goods and Services of Marine Bivalves. Springer, Cham. doi: 10.1007/978-3-319-96776-9_13.

Zarwood Education & Wallaby Walkabout Tours (2023) *Living sites.* Accessed: 27 November 2024 Available at: https://aboriginallaunceston.com.au/living-sites-3/

Other Sources

Gillies C (2017) Personal observation noted in nomination. Ecological Communities Nomination Form 2018 Assessment Period.

McAfee D (2024) Personal communication by telephone and email, 1 July, The University of Adeliade.

NRE Tas (2024) Personal communication by email, 17 October, Department of Natural Resources and Environment Tasmania.

NRM South (2024) Personal communication by email, 15 February, Natural Resource Management South Tasmania.

NSW DPIRD (2024) Unpublished BRUV data from 2021-2024 provided by email 29 October, New South Wales Department of Primary Industries.

NSW DPIRD (2024) Personal communication by email, 4 June, New South Wales Department of Primary Industries.

NSW DPIRD Fisheries (2024) Unpublished data from Marine Estate Management Strategy projects, contributing to Reef Builder projects, New South Wales Department of Primary Industries and Regional Development. Provided to The Nature Conservancy for monitoring and evaluation of Reef Builder and associated partners restoration sites.

TNC (2024) Personal communication by email, 11 April, The Nature Conservancy Australia.

TNC (2024) Unpublished data from Reef Builder projects provided by email, 28 June. The Nature Conservancy Australia.

Keating (2024). Personal communication by email, 27 September, New South Wales Department of Primary Industries and Regional Development.

Gillies (2017) Personal observation noted in the ecological community nomination. The Nature Conservancy, Australia.

Cataloguing data

This publication (and any material sourced from it) should be attributed as: Department of Climate Change, Energy, the Environment and Water 2024, Draft *Conservation advice for Ostrea angasi* oyster reefs of southern Australia, Canberra.

Department of Climate Change, Energy, the Environment and Water
GPO Box 858, Canberra ACT 2601
Telephone 1800 900 090
Web dcceew.gov.au

Document type	Title	Date
Published Consultation draft	Draft Conservation Advice for *Ostrea angasi* oyster reefs of southern Australia	20-01-2025
–	–	–