Fisheries Scientific Committee

Final determination

Lord Howe Abalone
Haliotis rubiginosa

Assessment outcome: CRITICALLY ENDANGERED
Category: B1ab(iii)

The Fisheries Scientific Committee, established under Part 7A of the *Fisheries Management Act 1994* (FM Act), has assessed *Haliotis rubiginosa* **(Lord Howe Abalone)** under the Common Assessment Method and has determined that it is eligible to be listed as a **CRITICALLY ENDANGERED SPECIES** Part 1 of Schedule 4 of the Act.

The determination is based on the assessment prepared by Dr Howard Peters (Department of Environment & Geography, University of York) and Caitlin Woods (University of Wollongong) for consideration by the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. This assessment led to *Haliotis rubiginosa* (Lord Howe Abalone) being listed as CRITICALLY ENDANGERED on the IUCN Red List of Threatened Species in 2021. Peters and Woods (2022) have provided support for this information to be used as the basis for this determination under the Act.

The Fisheries Scientific Committee, with reference to the criteria relevant to this species, prescribed by Part 16 of the Fisheries Management (General) Regulation 2019 (the Regulation) has assessed and determined that:

- The listing of CRITICALLY ENDANGERED is provided for by Part 7A, Division 2 of the FM Act.
- The assessment has been determined in accordance with the national Common Assessment Method (CAM), which provides a nationally consistent approach to the assessing and listing of threatened species in Australia.
- The assessment documentation below indicates the eligibility of the species for listing under both FM Act requirements and IUCN criteria as prescribed by the CAM.
- For more information about the CAM, visit https://www.dcceew.gov.au/environment/biodiversity/threatened/cam

Species information and status

a) Taxonomy

Scientific Name: Haliotis rubiginosa Reeve, 1846. Family: Haliotidae

Synonym(s):

• *Haliotis howensis Iredale,* 1929

• *Sanhaliotis howensis Iredale*, 1929

Taxonomic Source(s):

WoRMS Editorial Board. 2015. World Register of Marine Species. Available at:

http://www.marinespecies.org. (Accessed: 16 April 2015).

b) Cultural and community significance

This species occurs only in the waters of Lord Howe Island where it is protected by the Lord Howe Island Marine Park (Edgar et al. 2010). It has not been recorded as being fished for human consumption, due to its small size. Harvesting of live animals has previously occurred for the ornamental and collection value of their shells (H. Morrison pers. comm. 2022). However, shells of the species only appear in the shell trade periodically where they are considered scarce. Due to its small size, cryptic nature and low population size, this species has received limited attention socially or culturally until it's 2021 listing as CRITICALLY ENDANGERED on the IUCN Red List, which has raised its profile resulting in it being celebrated in local news reports (e.g. Lord Howe Island Marine Park news and the Australian Rural & Regional News) and various publications (e.g. 'Extraordinary & Endangered' by Australian Geographic).

The significance of the ecological community, particular species, spiritual and other cultural values are diverse and varied for the many Indigenous peoples that live in the area and care for Country. This section describes some examples of this significance but is not intended to be comprehensive or applicable to, or speak for, all Indigenous people. Such knowledge may be only held by Indigenous groups and individuals who are the custodians of this knowledge.

c) Current conservation status

Jurisdiction	Date listed or assessed	Listing category
Global (IUCN Red List)	2021	Critically Endangered
National (EPBC Act)	Under assessment	Proposed Critically Endangered
National (Australian Society for Fish Biology)	N/A	N/A
New South Wales (FM Act)	Listed	Critically Endangered

d) Description of species

The size of *H. rubiginosa* shells varies between 30 mm and 56 mm. The spiralling, ovate shell is convex, wrinkled and spirally ridged. The ridges are obtusely scaled. The six open perforations (respiratory pores, called 'tremata') are imperfectly formed. The shell's exterior surface is rusty orange, spirally streaked with white and can be covered with epibionts (Figure 1). The shell interior is nacreous (pearlescent) and smoothly wrinkled. "Besides the peculiarity of its sculpture, it is fairly characterized by its rusty orange painting and silvery interior" (Figure 2) (Pilsbry, 1890).

As with all members of the genus, *H. rubiginosa* has a large muscular foot for attachment to the substrate. The foot is circled by the mantle and epipodium which bears sensory tentacles and projects beyond the shell edge when the animal is active. Sensory tentacles may also project through the tremata when active. The animal has a lobed head with a pair of light receptors on the end of well-developed eye stalks and a pair of long sensory cephalic tentacles (Hickman, 1998).

Observations of live *H. rubiginosa* indicate that the foot of this species is cream coloured, the mantle, head and cephalic tentacles are lime green, and the end of the eye stalks are red. The epipodium is frilled with brown, white and pale pink banding (Woods, pers. comm. 2023). Further examination of live and museum specimens may be necessary to confirm whether these characteristics are typical of the species. No specific information on the internal anatomy of *H. rubiginosa* is available.

Figure 1: *Haliotis rubiginosa* (Lord Howe Abalone) in the Lord Howe Island Marine Park © Copyright, Justin Gilligan

Figure 2: *Haliotis rubiginosa* (Lord Howe Abalone) shells found in the Lord Howe Island Marine Park. Photo credit NSW DPI.

e) Distribution and abundance

Haliotis rubiginosa (Lord Howe abalone) is endemic to Lord Howe Island, New South Wales, Australia (Geiger and Owen 2012), where it has been observed between the inter-tidal and 10 m, with the latter depth recorded at Ned's Beach (H. Morrison pers. comm. 2020). Lord Howe Island is a hotspot for endemic species and its high conservation significance has been formally recognised by its inclusion on the UNESCO World Heritage List (1982), as well as the declaration of Marine Parks in State and Commonwealth waters surrounding the island. The Lord Howe Island Marine Park (LHIMP) was declared in 1999 and extends to the edge of state waters from the mean high-water mark, covering an area of approximately 48 000 ha. See Figure 3.

There are no published comprehensive population data for *H. rubiginosa*. There are reports of moderate numbers of *H. rubiginosa* being previously observed in intertidal and shallow subtidal habitats. Up to 10 large individuals were observed at Neds Beach in one survey in 1999, and aggregations of juveniles were seen in ledges and overhangs 2-3 m deep on reef edges near North Passage (H. Morrison pers. comm. 2022). However, during 2019, visual surveys of inter-tidal reef habitats around the island were undertaken at ten locations across 15,600 m^2 in which only six individuals were found. Furthermore, the individuals observed in 2019 occurred at only three sites beneath calcium carbonate boulders (Woods, 2022). Biennial surveys of shallow, subtidal reefs have been conducted at over 40 sites throughout the marine park since 2006, including visual searches for macro-invertebrates (adult size > 2.5 cm). During these surveys, only one individual *H. rubiginosa* has been recorded, observed at 8 m depth in 2020 (RLS et al. 2022; Edgar et al. 2020; Edgar & Barrett, 2012). There are no other data from subtidal reefs (Peters & Woods, 2022).

There are single observation records for this species in the Atlas of Living Australia from other locations including Middleton Reef, Balls Pyramid, Malekula Island (Vanuatu) and Gilbert Islands (Kiribati). Following further investigation, these records are either single shells only or have ambiguous location data, and do not confirm extant subpopulations (Peters, pers comm 2022).

Figure 3: Based on published records, the geographic range of Lord Howe Abalone is restricted to the shallow waters surrounding Lord Howe Island.

f) Relevant biology/ecology of the species

Abalone species are herbivorous with preference for red or brown algae, which they graze on using a rhipidoglossate radula (a toothed, chitinous ribbon). They are primarily nocturnal feeders (Hickman, 1998). The specific diet of *H. rubiginosa* is unknown, but may include species of coralline and turfing algae on intertidal and shallow subtidal reefs within the Lord Howe Island Marine Park (Woods, pers. comm. 2023).

The specific reproductive biology of *H. rubiginosa* has not been documented, however abalone are dioecious broadcast spawners, meaning individuals are female or male and release eggs or sperm into the water where they are fertilised. In some species of abalone successful fertilization occurs only when individuals are in close proximity (i.e. a few metres apart at most), and therefore if population densities decline below a critical threshold it may impact reproductive success, known as the Allee effect (Gascoigne & Lipicus, 2004). Fertilized larvae do not feed during the larval planktonic stage but rely on yolk within the egg for nutrition during development before settling on to suitable habitat. In other species of abalone, larvae have been found to be negatively buoyant and remain close to the benthos during early development and therefore have limited dispersal ability (Prince at al., 1987). A combination of the Allee effect and limited dispersal ability may hinder natural population recovery of abalone species including *H. rubiginosa* following any impact.

Abalone are severe haemophiliacs meaning their blood does not clot and any tissue damage can result in death from blood loss. This aspect of their biology makes them vulnerable to direct physical disturbance. When physically disturbed, *H. rubiginosa* releases white mucous from exhalant shell pores (Woods, pers. comm. 2023). Similar mucous secretions have been documented in other abalone species to have repellent properties to deter predators, and may also act as an intraspecific alarm. As noted previously, abalone are capable of short bursts of relatively rapid locomotion so the mucous secretions may also visually obscure the direction of escape from predators (Ponder et al. 2019, pp. 546).

Data on the biology and ecology and other ecological considerations for this species are not reported in the literature (Peters & Woods, 2022). Research on the species is required to gain an understanding of the species biology and also its ecological requirements.

g) Habitat requirements of the species

The species is restricted to carbonate reefs around Lord Howe Island, and its abundance is considered to be low (Woods, 2022). It occurs at depths to 10 m where it lives under rocks, in rubble and in aggregations on ledges (H. Morrison pers. comm. 2020) and beneath calcium carbonate boulders (Woods, 2022).

h) Threats and level of risk to the species
Assessment of threatening processes (under clause 238 of the Fisheries Management (General) Regulation 2019)

The principal threats to this species are marine heatwaves driven by climate change. As the species has a highly restricted range (1 location), the population is susceptible to marine heatwaves that are becoming more frequent and of greater intensity. Although considered scarce in the specimen shell trade owing to the economic cost of visiting the island, coupled with difficult access to some habitats, shallow subtidal reef surveys undertaken biennially since 2006 and inter-tidal reef surveys in 2019 have documented few individuals (see 'populations') indicating a possible collapse in populations.

<u>Climate change</u>

Unprecedented marine heatwaves in the waters of Lord Howe Island caused by El Nino and La Nina (Dalton et al. 2020) will have a significant effect on marine life, including this species (Peters & Woods, 2022). Persistent thermal stress from elevated sea-surface temperatures can result in disparate immune responses in abalone, with antiviral activity tending to increase and

antibacterial activity becoming compromised (Dang et al. 2012). Coral bleaching has been documented around Lord Howe Island in 1998, 2010, 2011, and 2019 (Harasti et al. 2022). In 2010 and 2011, Lord Howe Island experienced two large coral bleaching events during a fast phase transition from El Nino to La Nina (Dalton et al. 2020) with a more recent bleaching event in early 2019 (Davis et al. 2020). Research on the effects of projected global changes in sea-surface temperature and ocean acidification caused by the uptake of carbon dioxide (CO2) from the atmosphere has shown that abalone larvae exposed to such a scenario would be unable to accrete aragonite onto the larval surface, thus inhibiting survival to the juvenile stage (Byrne et al. 2011). It has also been shown that increased water temperatures can impact on the reproductive output of other abalone species such as *Haliotis rufescens* (Rogers-Bennett et al. 2010). Furthermore, earlier research suggests *Haliotis* spp. require active metamorphic inducer molecules uniquely available on the surface of coralline red algae for larval settlement and metamorphosis (Roberts 2001, Morse and Morse 1984). These coralline algae, essential for larval development, are similarly susceptible to projected changes to ocean acidification (Ragazzola et al. 2012). Absence of suitable settlement surface will further reduce opportunities for juvenile recruitment.
Increased occurrences of storm surge associated with climate change will have a direct impact on calcium carbonate boulder reefs and their inhabitants exposed to ocean swell (Woods, 2022). These threats in turn can result in the individual abalone becoming dispersed. However, as with other Haliotids, close proximity of mature individuals of both sexes is necessary for successful broadcast spawning. Where individuals become too widely dispersed (> 2 m), recruitment failure may follow (Babcock and Keesing 1999), leading to population decline. Prince et al. (1987) determined that the larvae of Haliotids rapidly sink and become immediately benthic with limited dispersal ability, severely limiting opportunities for recovery in the event of stock depletion. The extent to which this species has suffered through overdispersal through fragmentation of habitat, over-fishing, heatwave, disease or any other cause is unknown.

Climate change is an observed threat that is expected to increase further in the near future. Human caused climate change has been listed as a key threatening process under the NSW *FM Act 1994* and has the ability to adversely affect threatened species populations or ecological communities. Furthermore, the loss of climatic habitat caused by anthropogenic emissions of greenhouse gases is also listed as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999*.

Pollution and Habitat Disturbance

Due to its restricted geographic range, and only inhabiting intertidal and shallow subtidal reefs, direct impact from localised pollution or habitat disturbance on these reefs threaten *H. rubiginosa*. This includes pollution from vessel discharge and maritime disasters such as oil/chemical spills that may occur close to navigation channels and maritime infrastructure (jetties and moorings) (Woods, 2022); pollution from terrestrial anthropogenic sources including runoff, discharge into creeks and rivers, and groundwater seepage (Davis, 2022a, 2022b); and habitat disturbance from human activity such as trampling anchoring or development (Woods, 2022).

Unregulated harvest

Although considered scarce in the specimen shell trade – owing to the economic cost of visiting the island, coupled with difficult access to some habitats – declines in *H. rubiginosa* could be contributed to by over-exploitation from unregulated harvest for the ornamental and collection

value of its shells previously known to occur (H. Morrison pers. comm. 2022). However, shells of the species only appear in the shell trade periodically where they are considered scarce. Specimen shells for sale on the specialist website, Australian Seashells (http://www.seashells.net.au/), indicate a few specimens typically 30 mm at a medium price of USD 35. The threat from illegal harvest is considered to be low as there is no evidence to suggest the species is currently being collected within the Lord Howe island Marine Park.

Invasive Species and Disease

Threats to this species also include marine pest or exotic marine disease incursions (Aquenal Pty Ltd, 2006). Further research is required to determine what invasive pests and diseases may impact on this species, but in other abalone species they include spionid polychaete worms, the bacterial pathogens *Xenohaliotis californienses* responsible for a fatal 'withering syndrome', and abalone herpesvirus (abHV) which has been found in wild Australian abalone populations in Victoria (Ponder et al. 2019, pp. 628).

i) Eligibility against criteria

Reason for assessment

The reason for the assessment is outlined in the IUCN REDLIST assessment by Peters & Woods (2022) below:

This small/medium-sized species of abalone is endemic to Lord Howe Island, Australia, where it occurs between the inter-tidal and 10 m depth. There are no data on populations of this species in the literature, or fragmentation within its habitat, or other ecological data. However, recent visual surveys of intertidal reefs (Woods, 2022) at ten locations recorded just six individuals, possibly indicating a collapse in population size, although the surveys did not include the subtidal areas. In the waters of Lord Howe Island, it is afforded some protection by the Lord Howe Island Marine Park. It appears in the specimen shell trade periodically where it is reported rare, however, this is considered to be more a reflection of access and availability.

The principal threats to this species result from its highly restricted range, making the population particularly susceptible to marine heatwaves that are becoming more frequent and of greater intensity as a result of climate change, as well as the increasing regularity of El Nino, such as occurred during 2010–2011. *Haliotis roei*, as an example, experienced 99% mortality in some populations across Western Australia during the following year as a result of a marine heatwave. Persistent thermal stress from elevated sea-surface temperatures can result in disparate immune responses in abalone, with antiviral activity tending to increase and antibacterial activity becoming compromised. Furthermore, research on the effects of projected changes in sea-surface temperature and ocean acidification caused by the uptake of carbon dioxide (CO2) from the atmosphere from the combustion of fossil fuels, has shown that abalone larvae, exposed to such a scenario, would be unable to accrete aragonite onto the larval surface, thus inhibiting survival to the juvenile stage. Further comprehensive field research is required to determine distribution, population levels and trends, degree of fragmentation, habitat, diet and threats.

Further to the above, there is information to suggest subtidal populations of *H. rubiginosa* may also be very low or in decline. There are reports of moderate numbers being observed in shallow subtidal habitats in 1999 and earlier (H. Morrison pers. Comm. 2022). However, biennial surveys of shallow, subtidal reefs conducted at over 40 sites throughout the marine

park since 2006, including visual searches for macro-invertebrates (adult size greater than 2.5cm), have recorded only one individual (RLS et al. 2022; Edgar et al. 2020; Edgar & Barrett, 2012).

Assessment of the species reduction in abundance, geographic distribution or genetic diversity (under clause 271 of the Fisheries Management (General) Regulation 2019)

In 2015 the NSW Government signed an Intergovernmental Memorandum of Understanding on the Agreement on a Common Assessment Method for listing of threatened species and threatened ecological communities (the CAM). The CAM provides a nationally consistent approach to assessing and listing threatened species in Australia, using the IUCN Redlist Categories and Criteria (Version 3.1). To ensure that this Determination meets the requirements under the CAM, an assessment against the IUCN Redlist Categories and Criteria (Version 3.1) has been included. This assessment also reflects the requirements for listing species provided under clause 271 of the Fisheries Management (General) Regulation 2019. For more information on the CAM please visit http://www.environment.gov.au/biodiversity/threatened/cam

This assessment uses the criteria set out in the EPBC Regulations. The thresholds used correspond with those in the IUCN Red List criteria except where noted in criterion 4, sub-criterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

Table 3 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria. The definition of each of the parameters follows the Guidelines for Using the IUCN Red List Categories and Criteria.

Table 1 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	-	-	-	Unknown
Trend	Likely decreasing due to climate impacts.			The IUCN assessment identified a continuing decline in area, extent and quality of habitat for this species (Peters & Woods, 2022)
Generation time (years)	-	-	-	Unknown but estimated to be between 3 to 10years for other species of abalone
Extent of occurrence	48.0 km2			Based on that used in the IUCN assessment (Peters & Woods, 2022).
Trend	Contracting (most likely due to climate impacts).			The IUCN assessment identified a continuing decline in area, extent and quality of habitat for this species (Peters & Woods, 2022)
Area of Occupancy	48.0 km2			Based on that used in the IUCN assessment (Peters & Woods, 2022).

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Likely contracting due to climate impacts. The IUCN assessment identified a continuing decline in area, extent and quality of habitat for this species.			This information was provided in the IUCN assessment (Peters & Woods, 2022).
Number of subpopulations	1			Only one population is known to occur in the waters surrounding Lord Howe Island to a depth of 10 m.
Trend	Only 1 population, however the number of individuals is likely decreasing due to a decline in area, extent and quality of habitat.			This information was provided in the IUCN assessment (Peters & Woods, 2022).
Basis of assessment of subpopulation number	This information was provided in the IUCN assessment (Peters & Woods, 2022).			
No. locations	1			Lord Howe Island to a depth of 10 m (Peters & Woods, 2022).
Trend	Number of individuals in the population is likely contracting.			As provided by Peters & Woods (2022).
Basis of assessment of location number	The IUCN assessment published in 2021 was used to inform this assessment. Only 1 location was identified to cover the distribution of this species which is the water surrounding Lord Howe Island to a depth of 10 m (Peters & Woods, 2022), which could all be affected by a single marine heatwave event.			
Fragmentation	Only found at 1 location, and only recorded from intertidal and shallow subtidal calcium carbonate reefs (Peters & Woods, 2022) which occur around the coastline of Lord Howe island but are fragmented by basalt coastline, soft sediment, deep nearshore waters, and other habitat types. There is no evidence to suggest that fragmentation is occurring for the species around Lord Howe Island.			
Fluctuations	No fluctuations in species abundance have been observed.			

Criterion 1 Population size reduction

Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
	Critically Endangered **Very severe reduction**	**Endangered** **Severe reduction**	**Vulnerable** **Substantial reduction**
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [*(a) cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

Based on any of the following

(a) direct observation [except A3]
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
(d) actual or potential levels of exploitation
(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

Criterion 1 evidence

There is insufficient data on population abundance of *Haliotis rubiginosa* to determine eligibility, therefore the outcome is data deficient.

Criterion 2 Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy

		Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1.	Extent of occurrence (EOO)	**< 100 km²**	**< 5,000 km²**	**< 20,000 km²**
B2.	Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**
AND at least 2 of the following 3 conditions:				
(a)	Severely fragmented OR Number of locations	**= 1**	**≤ 5**	**≤ 10**
(b)	Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c)	Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Criterion 2 evidence

Eligible under Criterion 2 B1ab(iii) for listing as Critically Endangered.

Based on its restricted geographic range *Haliotis rubiginosa* has been listed as Critically Endangered by the IUCN under B1ab(iii) in 2020, published in 2021. Using GeoCAT, the Extent of occurrence (EOO) was determined to be 48 km² and the area of occupancy (AOO) was determined to be 48 km². This means the EOO is less than the <100 km² EOO required to be considered as Critically Endangered under B1. In addition, (a) the number of locations that this species occurs is one as it only occurs in the waters surrounding Lord Howe Island to a depth of 10 m. The location for the species in the assessment is considered to be the single location of Lord Howe Island as any potential threat to the species such as ocean warming is likely to have the same impact across the entire location. Finally, (b)(iii) it was determined that there has been a continuing decline in area, extent and/or quality of habitat (Peters & Woods, 2022).

There are no data on populations of this species in the literature, or fragmentation within its habitat, or other ecological data. However, recent visual surveys of intertidal reefs (Woods, 2022) at ten locations recorded just six individuals, possibly indicating a collapse in populations, although the surveys did not include the subtidal environment. In the waters of Lord Howe Island, it is afforded some protection by the Lord Howe Island Marine Park. This species occasionally appears in the specimen shell trade where it is reported rare, however, this is considered to be more a reflection of access and availability.

Decline in the area, extent and quality of habitat is projected for the species: The principal threats to this species result from its highly restricted range, making the population particularly susceptible to marine heatwaves that are becoming more frequent and of greater intensity as a result of climate change, as well as the increasing regularity of El Nino, such as occurred during 2010–2011. *Haliotis roei*, as an example, experienced 99% mortality in some populations across Western Australia during the following year as a result of a marine heatwave. Persistent

thermal stress from elevated sea-surface temperatures can result in disparate immune responses in abalone, with antiviral activity tending to increase and antibacterial activity becoming compromised. Furthermore, research on the effects of projected changes in sea-surface temperature and ocean acidification caused by the uptake of carbon dioxide (CO2) from the atmosphere from the combustion of fossil fuels, has shown that abalone larvae, exposed to such a scenario, would be unable to accrete aragonite onto the larval surface, thus inhibiting survival to the juvenile stage. Further comprehensive field research is required to determine distribution, population levels and trends, degree of fragmentation, habitat, mortality and threats. Owing to this species' sparse populations, vulnerability and highly restricted range, it is assessed as Critically Endangered.

The Committee considers that the species' Extent Of Occurrence (EOO) and Area Of Occupancy (AOO) is very restricted, the number of locations (n=1) is very restricted and a continuing decline is inferred for area, extent and quality of habitat. Therefore, the species has met the relevant elements of Criterion 2 to make it eligible for listing as Critically Endangered (CR) B1ab(iii).

Criterion 3 Population size and decline

		Critically Endangered **Very low**	**Endangered** **Low**	**Vulnerable** **Limited**
Estimated number of mature individuals		**< 250**	**< 2,500**	**< 10,000**
AND either (C1) or (C2) is true				
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)		**Very high rate** **25% in 3 years or 1 generation** **(whichever is longer)**	**High rate** **20% in 5 years or 2 generation** **(whichever is longer)**	**Substantial rate** **10% in 10 years or 3 generations** **(whichever is longer)**
C2. An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:				
(a)	(i) Number of mature individuals in each subpopulation	**≤ 50**	**≤ 250**	**≤ 1,000**
	(ii) % of mature individuals in one subpopulation =	**90 – 100%**	**95 – 100%**	**100%**
(b) Extreme fluctuations in the number of mature individuals				

Criterion 3 evidence

There is insufficient data on numbers of mature *Haliotis rubiginosa* to determine eligibility.

Criterion 4 Number of mature individuals

	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
D. Number of mature individuals	< 50	< 250	< 1,000
D2.[1] *Only applies to the Vulnerable category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to Critically Endangered or Extinct in a very short time			D2. Typically: area of occupancy < 20 km² or number of locations ≤ 5

[1] The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the *common assessment method*.

Criterion 4 evidence

The Committee considers that as the number of locations is ≤5 (only 1 location), and there is a plausible future threat (i.e. ocean warming, marine heatwaves) that could drive the species to Critically Endangered or Extinct in a very short time. Therefore, the species has met the relevant elements of Criterion 4 to make it eligible for listing as Vulnerable D2.

Criterion 5 Quantitative analysis

	Critically Endangered Immediate future	Endangered Near future	Vulnerable Medium-term future
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Criterion 5 evidence

Population viability analysis has not been undertaken for *Haliotis rubiginosa*. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

j) Fisheries Scientific Committee conclusion pursuant to Section 220F of the NSW Fisheries Management Act 1994:

It is the opinion of the NSW Fisheries Scientific Committee that *Haliotis rubignosa* is facing an extremely high extinction risk in New South Wales in the immediate future, as determined in accordance with criteria prescribed by the regulations.

As provided in the abovementioned evidence, and in accordance with Fisheries Management Regulation 237 Criteria—reduction in abundance, geographic distribution or genetic diversity

(1) It is observed, estimated, inferred or reasonably suspected that the species has undergone, or is likely to undergo, within a time frame appropriate to the life cycle and habitat characteristics of the taxon—

(a) for critically endangered species—an extremely large reduction in 1 or more of the following—

(i) an index of abundance appropriate to the taxon,

(ii) geographic distribution,

(iii) genetic diversity

The species is eligible to be listed as a CRITICALLY ENDANGERED SPECIES

k) Additional information

i) Fisheries Scientific Committee Management Recommendations for Lord Howe Abalone

Current and recommended management actions and research priorities that will benefit the conservation of the species:

Management actions:

- Targeted education and advisory initiatives to increase public appreciation and awareness of the conservation status of the Lord Howe abalone.
- The continued implementation of comprehensive and adequate no-take areas incorporating Lord Howe abalone habitat to ensure effective ecosystem function and resilience against climate change.
- Continued implementation of management actions to address the threat of anchoring impacts on remaining habitat.
- Continued emergency response implementation to reduce the threat of oil and chemical spill impacts on Lord Howe abalone.
- Local management actions should be implemented to help mitigate impacts from anthropogenic changes in hydrology/ water/sediment flow in nearshore environments, particularly the Lord Howe Island lagoon, that may result in unfavourable conditions for Lord Howe abalone.
- Any disturbance that may result in abalone mortality, such as localised water pollution from diffuse source runoff or maritime source pollution, eutrophication resulting from groundwater contamination which can exacerbate the impacts of climate change should be identified and addressed through local management actions.
- Lord Howe Island Marine Park management plan actions should consider increased protection measures to conserve habitats of the Lord Howe Island abalone.
- Effective compliance and enforcement activities in relation to management actions for this species.
- Develop emergency response actions for the Lord Howe abalone and incorporate this information into local marine heat wave response plans.

Research priorities:

- Targeted surveys should be undertaken to assess and map the distribution and population status of Lord Howe abalone to establish critical monitoring baselines.
- Future mapping of all intertidal and shallow subtidal reef types throughout the distribution of Lord Howe abalone is also recommended for marine spatial planning.
- Ongoing monitoring of Lord Howe Island abalone abundance to identify population trends to further clarify projections.

- Monitoring of impacted and reference sites to assess recovery and changes over time.
- Investigate potential for a captive breeding program to help restock the population and to safeguard this species from extinction.
- Future monitoring should use methods which allow adequate scope and representation of reef types to document Lord Howe abalone.
- Assess adaptability and resilience of Lord Howe abalone to increasing water temperatures and acidity using aquaria experiments.
- Initiate research to assess the biology of the species, including diet and other ecological considerations.

ii) Priorities Action Statement

The NSW Department of Primary Industries Priorities Action Statement (PAS) is a statutory, non-regulatory document addressing each threatened species, population, ecological community and key threatening process (KTP) listed on the schedules of the *FM Act 1994*. The PAS provides an agreed list of strategies and actions that will assist to down-grade or de-list species, populations and ecological communities from the threatened species schedules of the *FM Act 1994*, as well as actions that will assist to abate or eliminate the impacts of KTPs.

l) Statement on the standard of scientific evidence and adequacy of survey:

This assessment has been prepared by the Fisheries Scientific Committee in good faith using the highest possible standard of scientific evidence and adequacy of survey. This assessment is based on the information contained within the IUCN Redlist assessment for the species (Peters & Woods, 2022).

As prescribed under Section 4 of the Intergovernmental MOU on the CAM, in preparing this documentation the Committee gave consideration to:

(i) the nature of the data, including adequacy of survey (occurrences) and monitoring (to detect change), including factors such as sampling design, effort applied, number of variables considered, proportion of a species' range covered, time period covered etc.;

(ii) the number of data sets relevant to the conclusion;

(iii) the range of uncertainty in the data and degree of consistency between different data sets;

(iv) the source of the data and its credibility; and

(v) the relevance of the data to the particular assessment criterion.

m) References

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