

Local extinction of golden sandfish at Ashmore Reef, northwestern Australia

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Abstract

Once common and heavily exploited at Ashmore Reef Marine Park off northwestern Australia, the golden sandfish *Holothuria lessoni* has not been observed there since 1987, despite 13 surveys of sea cucumber populations since then up until 2023, covering more than 107 ha of total search area. Based on the extensive nature of these surveys, and with no observations of *H. lessoni* at Ashmore Reef in over three decades, we argue that it meets the definition of extirpation or local extinction. We discuss overfishing as the mostly likely cause of this extinction and why it is unlikely the species will reestablish in this area. We also clarify the status of *Holothuria scabra* at Ashmore Reef, which while also absent in recent and most historical surveys, was probably never common there. There has been only two verified individual sightings of *H. scabra* at Ashmore Reef (1978 and 2013) and there have been none since.

Key words: extirpation, extinction, sea cucumber, *Holothuria lessoni*, *Holothuria scabra*

Introduction

Golden sandfish, *Holothuria lessoni* Massin, Uthicke, Purcell, Rowe and Samyn, 2009, is polyonymous in the literature, having been referred to as *Holothuria scabra* var. *versicolor*, *H. timana*, *H. timama* and *H. aculeata*. *Holothuria timama* Lesson, 1830 and *H. scabra* var. *versicolor* Conand, 1986 were found to be either invalid or synonyms of *Holothuria lessoni* by Massin et al. (2009) who also determined that *H. aculeata* Semper, 1867 was a separate valid species. *Holothuria timana* is a spelling mistake dating back to 1931 (see Massin et al. 2009) and has been widely repeated since.

Holothuria lessoni is widely distributed in the tropical Indian and western Pacific oceans between Africa and Tonga, and is fished in multiple places over that geographic range, including Australia and Indonesia (Purcell et al. 2023). Aspects of its biology, contrasted with that of *Holothuria scabra*, were reported by Conand (1986). It was recorded from Ashmore Reef (situated between Australia and Indonesia) in 1986 (Marsh et al. 1993) and in 1987 (Russell and Vail 1988).

Ashmore Reef, which is part of the Australian Territory of Ashmore and Cartier Islands, is 25 km long and 217 km² in area. It is 340 km from the nearest point of the Australian mainland but just 140 km from the Indonesian island of Rote. Indonesian fishermen are known to have visited Ashmore Reef from at least the mid-18th century to collect fish, shark fins, clams, sea cucumbers, turtles and trochus (Fox 2009). Ashmore Reef was annexed by Britain in 1878 and the territory was ceded to Australia in 1933 (Fox 2009). Indonesian fishermen continued to access resources at the reef and a memorandum of understanding,

reached in 1974 between Australia and Indonesia, provided continued but limited access by Indonesian fishers to an area referred to as the MOU74 Box of Australia's exclusive economic zone, which includes Ashmore Reef. The arrangement precluded the taking of turtles but allowed continued fishing of clams and sea cucumbers. Ashmore Reef was gazetted as a nature reserve in 1983, and there was growing concern over the levels of fishing. Very heavy rates of exploitation of holothurians and clams were reported in 1986 and 1987 (Berry 1993; Marsh et al. 1993; Russell and Vail 1988). Berry (1993) records an observation of 15 fishers from two vessels harvesting an estimated 1300 giant clams in a single, low tide event. As a result of these concerns, bilateral arrangements were reviewed in 1988 (Fox 2009). The taking of giant clams and sea cucumbers was prohibited, and access to Ashmore Reef was greatly restricted to just a small area (within the current Recreational Use Zone), comprising mostly the safe anchorage in the deep lagoon near West Island (Commonwealth of Australia 2002).

Despite these formal conservation measures, pressure from (what was by then) illegal fishing continued. Field et al. (2009) point to a significant rise in reports and detection of illegal fishing in late 2005 and 2006. The reported increase in illegal fishing at Ashmore Reef prompted the surveys conducted by Ceccarelli et al. (2007, 2011), and to which those authors attributed significant declines in trochus abundance at Ashmore Reef between 2005 and 2006. Another dramatic increase in illegal fishing off northwestern Australia in 2021 (Keesing et al. 2025) prompted further surveys of sea cucumbers at Ashmore Reef and other Australian marine parks in 2022 (Keesing et al. 2023).

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Since 2008, an almost continuous surveillance presence has been maintained at Ashmore Reef by Australian Customs and Naval vessels. (Speed et al. 2018). While this has been done to principally deter illegal immigration, it has also kept illegal fishing at Ashmore Reef at low levels. Prior to this, there has also been an intermittent enforcement and surveillance presence at Ashmore Reef since 1985 (Guinea 2020) and especially between 2000 and 2002 (Commonwealth of Australia 2002). Lapses in surveillance and enforcement in 2005 and 2006 may have contributed to high levels of illegal fishing (Field et al. 2009; Ceccarelli et al. 2007; Vince et al. 2021). Although the level of illegal fishing and the effectiveness of enforcement between 1989 and 2008 is debated (Guinea 2020; Meekan et al. 2020) there have clearly been steps taken to enforce the regulations in place at Ashmore Reef since 1988 when fishing for sea cucumbers was completely prohibited.

Despite the formal conservation, surveillance and enforcement measures applied at Ashmore Reef Marine Park, a comprehensive survey in 1998 (Skewes et al. 1999, 2005) failed to find any specimens of *Holothuria lessoni*. The purpose of this study was to determine the status of *H. lessoni* and another economically valuable sea cucumber, *H. scabra*, at Ashmore Reef based on a review of all surveys to date, and including two comprehensive surveys of sea cucumbers at Ashmore Reef in 2019 and 2022.

Methodology

We conducted extensive surveys for sea cucumbers and other invertebrates (mainly corals, giant clams, other large molluscs and echinoderms) at Ashmore reef in 2019 (Keesing et al. 2021) and 2022 (Keesing et al. 2023). The survey design was the same statistically rigorous, reef-wide generalized random tessellation stratified (GRTS) base survey proposed by Hosack and Lawrence (2013) and used by Ceccarelli et al. (2013). This design provided balanced sampling across all the five benthic habitat facies at Ashmore Reef, established in the first comprehensive survey of Ashmore Reef by Skewes et al (1999, 2005) in 1998. These facies were shallow, intertidal reef flat; shallow, intertidal sand flat; shallow, subtidal lagoon; deep lagoon; and reef slope sites on the windward and leeward sides of the reef. While Ceccarelli et al. (2013) surveyed 95 sites (each 80 m²) in 2013, our surveys were much more extensive with 224 sites surveyed in 2019 and 128 sites surveyed in 2022, with an area of 200 m² searched at each site. The survey method was the standard and widely used method established by Reef Life Survey (Edgar et al. 2017). Briefly, in our surveys, two scuba divers descended the anchor line at each site, each running out a 50-m tape and then counting and identifying all sea cucumbers to a width of 1 m on each side of the tape. Each diver surveyed 100 m² and at each site had a total area of 200 m² searched.

Using our survey data from 2019 and 2022, and a review of data from all previous and subsequent surveys that we could

locate, we sought to draw conclusions about the status of *Holothuria lessoni* and *H. scabra* at Ashmore Reef.

Results and discussion

Ashmore Reef is regarded as having a diverse population of echinoderms (Marsh et al. 1993) and this is in part attributed to a wide variety of habitat types, as well as the closeness of the Indonesian archipelago and connections to the Australian and Papuan continental shelves. This is in contrast to the more isolated Scott Reef and Rowley Shoals, located approximately 230 km and 680 km southwest of Ashmore Reef, respectively, which have less diverse fauna (Marsh et al. 1993). The first survey of Ashmore Reef, which included sea cucumbers, was conducted by the Soviets in 1978 (reported in Marsh et al. 1993). This was followed with surveys by the Northern Territory Museum and the Western Australian Museum between 1986 and 1987 (Berry 1993; Marsh et al. 1993). Marsh et al. (1993) recorded 178 species of echinoderms and compared these to the lower numbers found at Scott and Seringapatam Reefs (119) and Rowley Shoals (90). Of the 178 echinoderm species recorded at Ashmore Reef by Marsh et al. (1993), 47 were holothurians. Berry (1993) and Marsh et al. (1993) commented on the intensity of fishing at Ashmore Reef and the rarity of the highly valued *Microthele* spp. (now *Holothuria whitmaei* and *H. fuscogilva*) and *Theleota ananas* in 1986 compared with Rowley Shoals.

With the exception of additional biodiversity-focused museum expeditions to Ashmore Reef (e.g. Keesing et al. 2024), subsequent marine surveys at Ashmore Reef Marine Park have been much more quantitative and have concentrated on exploited species of holothurians, giant clams and trochus. Many of these surveys were prompted by concerns about overexploitation of giant clams and sea cucumbers. Including our surveys in 2019 and 2022, there have been 14 surveys between 1987 and 2023 using a variety of survey methods (Table 1), but all have made detailed quantitative records of the sea cucumbers present. A summary of the level of search effort from each of these studies indicates more than 107 ha were searched at 968 sites (Table 1). The only survey to record *H. lessoni* was that of Russell and Vail (1988). All but two of the surveys recorded between 11 and 19 species of sea cucumbers. This is much less than the species list of 47 by Marsh et al. (1993), although that survey used different methods that included a search for small and cryptic species under coral rubble. These species would not be encountered by the large-scale quantitative surveys summarised in Table 1.

Holothuria lessoni was common at Ashmore Reef during, and prior to, the last time it was observed in 1987 as evidenced with photographic documentation and by catch composition (Figs. 1 and 2). Russell and Vail (1988) found 110 *H. lessoni* (17% of catch) among the catches of holothurians on five Indonesian *prabus* (small sail boats) and another 94 (11% of catch) taken by seven Indonesian fishermen in dugout canoes.



Figure 1. Indonesian fisherman processing a large catch of *Holothuria lessoni* on one of the islands at Ashmore Reef in 1987. Plate 12 reproduced from Russell and Vail (1988) with permission. Image: Lyle Vail.



Figure 2. Indonesian fishermen with a catch of sea cucumbers laid out for drying on a sand cay at Ashmore Reef in 1987. The catch shown is mainly *Actinopyga* spp. and *Holothuria lessoni*. Plate 12A reproduced from Russell and Vail (1988) with permission. Image: Lyle Vail.

At least the latter was known to be from a single day of fishing. Russell and Vail (1988), however, recorded very few individuals of *H. lessoni* in their own surveys. The Indonesian fishers interviewed by Russell and Vail (1988) stated that *H. lessoni* was the most valuable of all holothurian species they harvested from Ashmore Reef. Its absence in the extensive surveys undertaken between 1998 and 2023 indicate that

H. lessoni is locally extinct at Ashmore Reef, and is most likely the result of overfishing. The consequence of depletion from overfishing leads to an absence of reproductive effectiveness from an anthropogenically induced Allee effect (Purcell et al. 2014), whereby the distance between remaining individuals is so great that dilution of gametes exceeds the threshold necessary for egg fertilisation.

Holothuria scabra was recorded by the Soviet survey of Ashmore Reef in 1978 (Marsh et al. 1993) and again in 2013 (Keesing et al. 2024) but has not been observed in any of the quantitative surveys undertaken between 1998 and 2023 (Table 1). *Holothuria scabra* is perhaps one of the most heavily exploited species of holothurian throughout the Indo-Pacific (Kinch et al. 2008; Friedman et al. 2011). Both *H. scabra* and *H. lessoni* were regarded as being locally extinct by 1998 (Skewes et al. 1999; Smith et al. 2001) although there is no evidence *H. scabra* was ever common at Ashmore Reef.

Russell and Vail (1988) included photographs of both *H. scabra* and *H. rubrofusca* in their report as part of a set used to aid interviews with Indonesian fisherman, but these species were not observed at Ashmore Reef (Lyle Vail, pers. comm.). Smith et al. (2001, 2005) stated that *H. scabra* was

not found during the 2000 survey, but it is listed in a table in both reports. We were unable to resolve this inconsistency and so have treated this report of *H. scabra* as being unverified. The record of *H. scabra* at Ashmore Reef by Marsh et al. (1993) is verified by a specimen (registration number 58776) in the Western Australian Museum (WAM), collected in 1978. The specimen from 2013 recorded by Keesing et al. (2024) is also in the WAM (registration number 68148). Both preserved specimens are very small (less than 6 cm long), and are probably juveniles.

Holothuria scabra is a widespread Indo-Pacific species but is predominantly an inshore species inhabiting generally more muddy or silty habitats (Hamel et al. 2022) than those that occur at Ashmore Reef. It is likely that *H. scabra* was never common at Ashmore Reef and that its possible absence now cannot be primarily attributed to overfishing.

Table 1. Summary of all quantitative surveys for sea cucumbers at Ashmore Reef from 1987 to 2023.

Survey	Years	No. of sites	Transect size	Transect replication	Area surveyed (m ²)	Area surveyed (ha)	No. of species
Russell and Vail (1988)	1987 ^a	5	20 m x 50 m	10-24	134000	13.40	17
Skewes et al. (1999, 2005)	1998	240	4 m x 20-100 m ^b		25140	2.51	13 ^c
Smith et al. (2001, 2005)	2000	96	various ^d		106000	10.60	19 ^d
Rees et al. (2003)	2003	38	5 m x 500 m	3	285000	28.50	17 ^e
Kospartov et al. (2006)	2005	45	5 m x 500 m	3 ^f	172500	17.25	16
Ceccarelli et al. (2007, 2011)	2006	55	5 m x 500 m	3 ^f	217500	21.75	18
Richards et al. (2009)	2009	8	10 m x 100 m	10 ^g	80000	8.00	11
Ceccarelli et al. (2013)	2013	95	2 m x 40 m		7600	0.76	11 ^c
Edgar et al. (2017)	2013	12	2 m x 50 m	1-2 ⁱ	2400	0.24	2
Edgar et al. (2020) ^h	2018	20	2 m x 50 m	1-2 ⁱ	4000	0.40	10
Keesing et al. (2021)	2019	224	2 m x 50 m	2	44800	4.48	18
Reef Life Survey ^h	2021	16	2 m x 50 m	1-2 ⁱ	3200	0.32	10
Keesing et al. (2023)	2022	128	2 m x 50 m	2	25600	2.56	17
Reef Life Survey ^h	2023	12	2 m x 50 m	1-2 ⁱ	2400	0.24	4
Total		968				107.01	

^a Russell and Vail (1988) surveyed the same sites in both April and September 1987. Photographs of both *H. scabra* and *H. rubrofusca* are shown in the report as part of a set used to aid interviews with Indonesian fisherman, but these species were not observed at Ashmore Reef (Lyle Vail, pers. comm.).

^b Transect length varied with habitat type.

^c Skewes et al. (1999) and Ceccarelli et al. (2013) identified 13 and 11 taxa respectively but grouped *Actinopyga* spp. as one taxa.

^d Smith et al. (2001, 2005) used three methods and transect sizes (4 m x 500 m reef walks [n=10], 2 m x 500 m manta tow [n=59], 4 x 250 m scuba or snorkel swims [=27]), they found 19 species but only record the names of 15 species and one unidentified *Holothuria* species. The text of both these references indicates that *H. scabra* was not found on the 2000 survey, but it is listed in Tables in both references. This inconsistency has not been able to be resolved so *H. scabra* is not included in the right-hand column total. This has been clarified with the senior author Luke Smith who confirmed that *H. scabra* was not found at Ashmore Reef in 2000.

^e Rees et al. (2003) identified 17 taxa but grouped *Actinopyga* spp. other than *A. lecanora* and *A. mauritiana* as one taxa.

^f Kospartov et al. (2006) and Ceccarelli (2007) used three replicate transects totalling 7500m² at some sites, while others had a single 2500 m² transect.

^g transects per site, replicated at 2 depths.

^h RLS data downloaded from <https://portal.aodn.org.au/search> on 10 January 2025, note 2018 includes sites surveyed early new year of 2019.

ⁱ Total area calculation assumes 2 replicates per site, which was almost always the case, only occasionally 1.

In the absence of adult immigration, which for an isolated reef such as Ashmore Reef can be ruled out for *H. lessoni* and other shallow water holothurians, any future recruitment to Ashmore Reef will rely on larval supply from distant reefs. The absence of *H. lessoni* at Ashmore Reef since at least 1998 suggests that this has not occurred and, therefore, unlikely to change. The species is one of several sea cucumbers threatened by overexploitation (Purcell et al. 2014) and its extirpation at Ashmore Reef suggests that it may be vulnerable to local extinction elsewhere across its range.

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