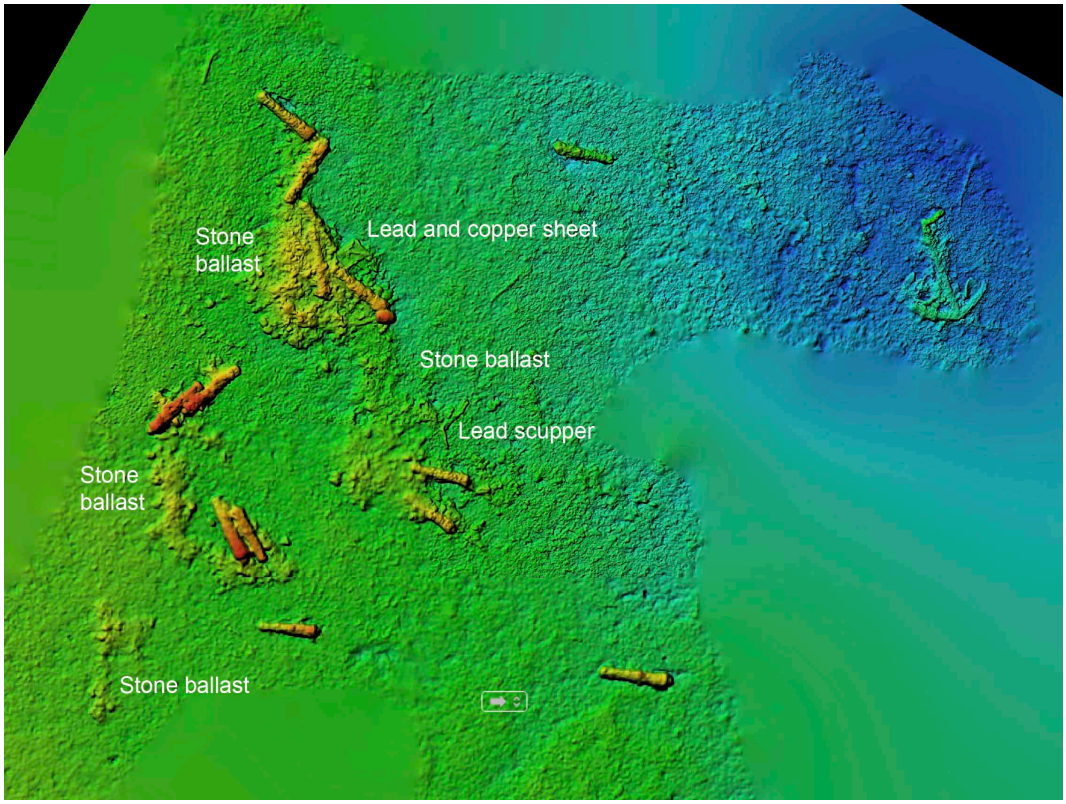
REPORT ON 'MAPPING THE OLD WITH THE NEW: RE-IMAGING THE 1727 *ZEEWIJK* SHIPWRECK SITE WITH NEW RECORDING TECHNOLOGY' PROJECT

(Grant Number: GCE-2019-03)



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Report—Western Australian Museum, Department of Maritime Archaeology, No. 339

Cover photo. Orthophoto taken from 3D model showing ’12-cannon area’ with mounds of stone ballast and an anchor nearby, the final resting place of the *Zeewijk* shipwreck (Western Australian Museum, 2022).

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EXECUTIVE SUMMARY

In 1727 the Dutch United East India Company (*Verenigde Oostindische Compagnie*, or VOC) ship *Zeewijk* wrecked in the Pelsaert Group of the Houtman Abrolhos Islands.

This report details the methodology, outputs and conclusions of a 2022 field survey conducted between 11 and 17 March 2022. The primary aim was to create a 3D record of the *Zeewijk* (1727) shipwreck site using photogrammetry. The work would allow for a critical assessment of Mr Hugh Edwards' claim of finding the wreck of *Aagtekerke* (1726) on the same site as *Zeewijk*. It would also better visualise the site for research, management, and public interpretation purposes.

The fieldwork successfully mapped the widely dispersed *Zeewijk* shipwreck site on the inner (inside lagoon) and outer reef (in the surf zone) using digital cameras and GPS positioning. It resulted in significant new findings allowing a re-evaluation of the total count of all iron cannon and anchors in the offshore reef, and inshore lagoon areas.

This work, when combined with findings of the earlier 'Roaring Forties Project' (Paterson et al. 2019), and more recent research undertaken by the Western Australian (WA) Museum, provides convincing evidence that there is only one shipwreck on the *Zeewijk* site, and negates the hypothesis of two VOC shipwrecks present within the Pelsaert Group. The resulting updated corpus of high-resolution digital imagery, 3D models and site data will greatly facilitate future studies, public interpretation outputs and on-going site monitoring and management of this highly significant Dutch-Australian mutual heritage site.

It is gratefully acknowledged that the field work was primarily funded by a grant from the Embassy of the Kingdom of the Netherlands (GCE-2019-03), with additional funding support provided through the WA Museum/Australian Government's Underwater Cultural Heritage Program and Flinders University's Maritime Archaeology Program. Transport, logistics and local knowledge to enable safe access to the *Zeewijk* site were provided by the Liddon family.

ZEEWIJK 2022 FIELDWORK

Background

In 1727 the Dutch United East India Company (*Verenigde Oostindische Compagnie*, or VOC) ship *Zeewijk* wrecked on the northern end of Half Moon Reef in the Pelsaert Group of the Houtman Abrolhos Archipelago (Fig. 1). Survivors lived for nine months on Gun Island, 5 km east of the wreck site. During this time, they foraged around the Pelsaert Group of islands, salvaged the wreck, found possible evidence of wreckage from another ship in the area, and obtained food, water, and timber supplies to build an 8-ton sloop, in which they sailed to the town of Batavia in the Dutch East Indies.

The ship was newly built and sank on its maiden voyage to Southeast Asia—it was constructed by and for the VOC chamber of Zeeland in 1725 (Bruijn et al. 1979:2680.1; NL-HaNA 1725). The 850-ton ship measured 145 Amsterdam feet (about 41 metres) in length and according to VOC instructions was to be armed with 36 iron cannon plus six breech-loading, bronze swivel guns (NL-HaNA 1725; Van Dam 1927:511). The ship indeed arrived at the Cape of Good Hope in South Africa with the aforementioned armament (NL-HaNA 1727) (Fig. 2). However, when *Zeewijk* departed from the Cape of Good Hope, Skipper Jan Steijns and Second Mate Adriaan van der Graaf both commence their journals with the statement that it carried ten 12-pounder cannon, 20 six-pounders, six three-pounders and eight swivel guns—two extra swivel guns were then likely loaded onto the ship while at the Cape (NL-HaNA 1729; Steijns 1727:1) (Figs 3–4).

Today, *Zeewijk* is among Australia's earliest and most significant historic shipwrecks of the pre-colonial era, with mutual heritage values shared between Australia and the Netherlands. It is protected by the Commonwealth *Underwater Cultural Heritage Act 2018* and lies within the Commonwealth Abrolhos Marine Park area. The survivors' camp on Gun Island is part of the Houtman Abrolhos Islands National Park, and protected by the *Maritime Archaeology Act 1973*.

Prior to the 2022 fieldwork, the 1978 WA Museum site plan was the most accurate plan of the site. The techniques and technology available to the 1970s WA Museum team consisted of using underwater tape measurements in the strong waves and currents, buoying of major features on the site to allow aerial photography using a helicopter, and using a land-based theodolite to obtain bearing fixes on marker buoys (Ingelman-Sundberg 1977a, 1977b, 1977c, 1977d, 1977e, 1978a, 1978b, 1979).

Until GPS positions could be obtained, the georeferenced 1978 WA Museum site plan was the most accurate plan of the outer reef site. Obtaining GPS positions in 2022 not only allowed accurate positions to be obtained, but georeferencing of individual features made it possible to compare the site today with the 1978 WA Museum site plan. The 1978 WA Museum team led by Catherine Ingelman-Sundberg managed an extraordinary job to map the outer reef areas scattered over some 700m in detail, in an energy-sapping surf zone with strong currents, without the advantages of modern GPS, jetboat or jetski to enable efficient and safe access. Nevertheless, both the 1978 and 2022 teams faced the same conditions in the water with breaking waves, strong currents and occasional whiteouts caused by breaking surf.

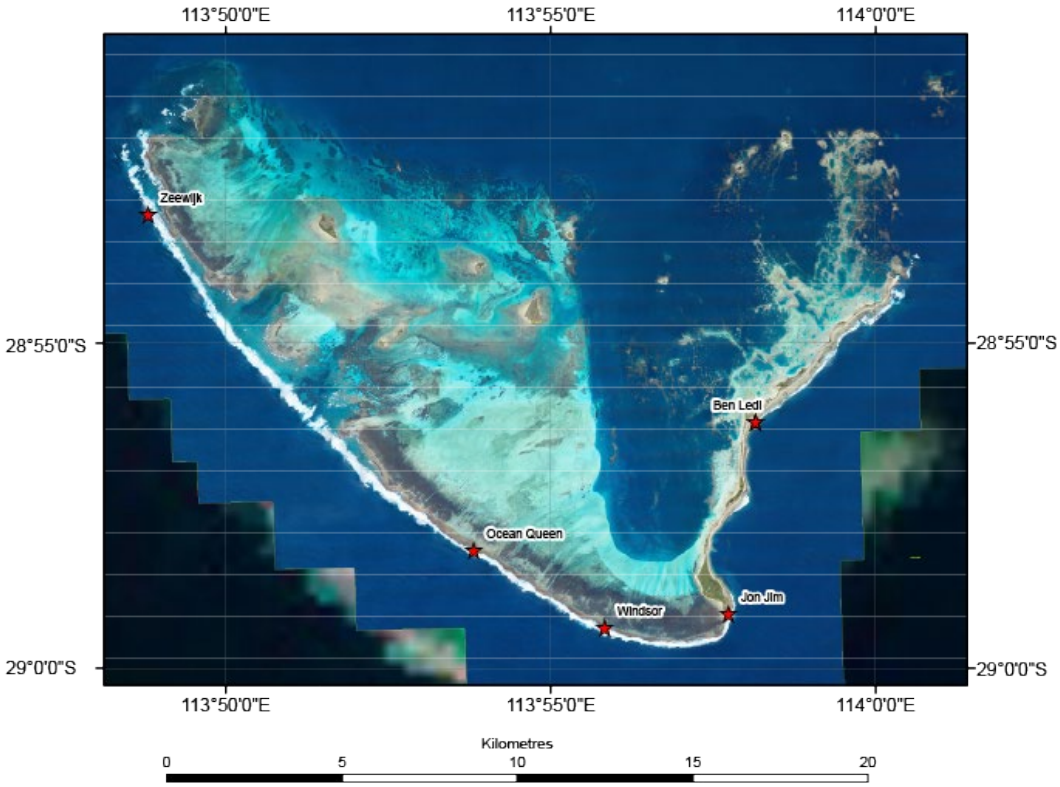


Fig. 1. The *Zeewijk* shipwreck site on the outer reef (red star), in the northern end of Half Moon Reef in the Pelsaert Group of the Houtman Abrolhos Archipelago. Other shipwrecks along this reef all date to the 19th century (J. Green, WA Museum; Landgate, 2015).

This report details the outputs of a 2022 field survey that set out to create a 3D-record of the *Zeewijk* shipwreck site, including the production of 3D models, orthophotos and a Digital Elevation Model (DEM) to acquire better visualisation for both site management and public interpretation. This report also enables interrogation of Hugh Edwards' claim to have discovered a second VOC shipwreck *Aagtekerke* (built in 1724, lost in 1726) (Bruijn et al. 1979:2622.1) in the same location as *Zeewijk* (1727), which has received significant public and media interest since 2012 (Christian 2016; *Fremantle Herald* 2012; Noble 2016; Quekett 2017; Victoria 2016). The exact number of cannon on the archaeological site is thus important as it became the basis of Edwards' 'Two VOC Wrecks' theory.

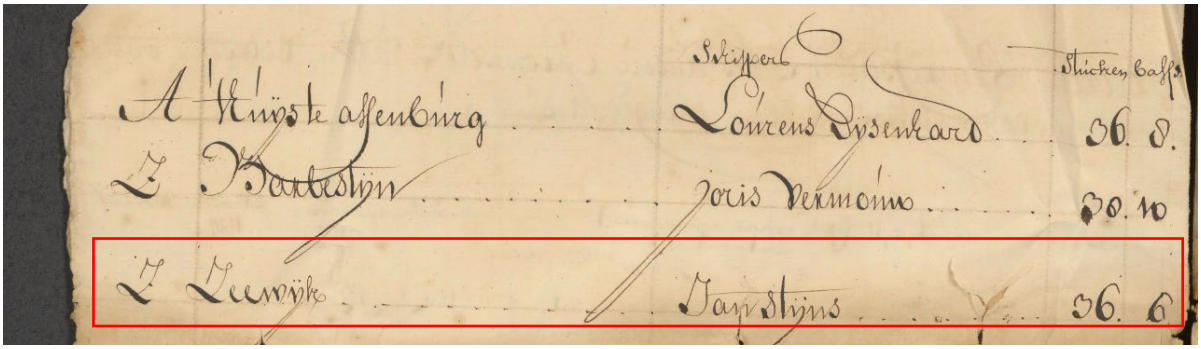
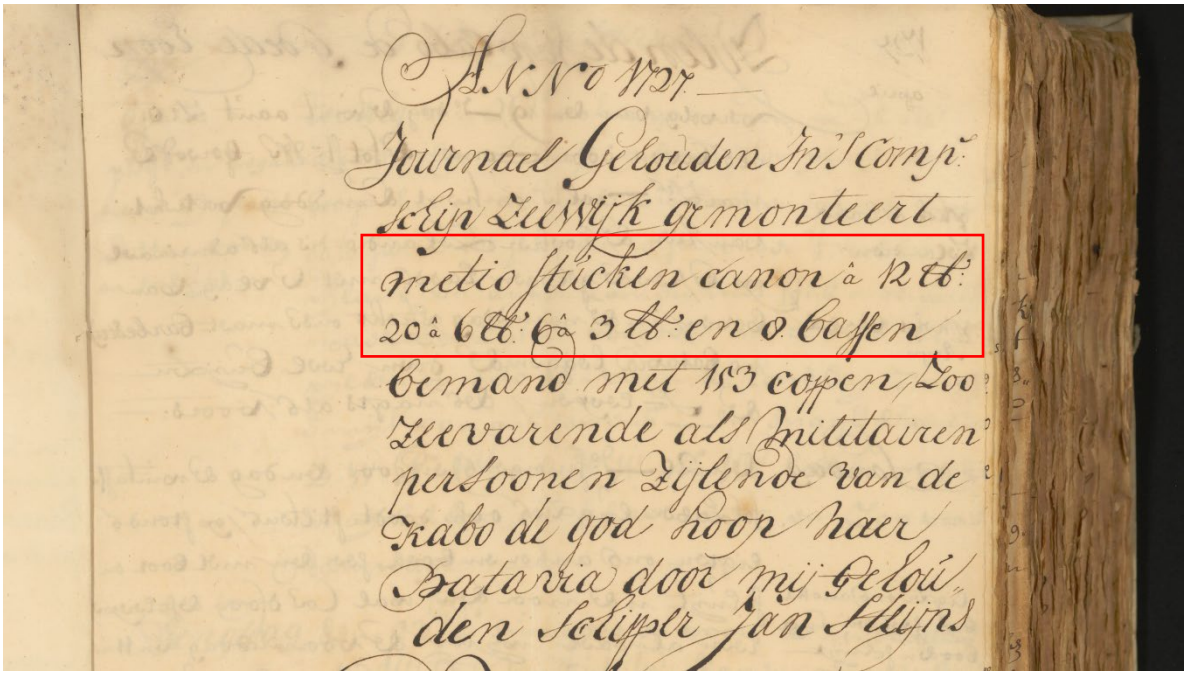


Fig. 2. List of ships arrived at the Cape of Good Hope in South Africa, showing that *Zeewijk* carried 36 cannon and 6 swivel guns upon arrival (NL-HaNA 1727 [scan 165]).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persoonen Zijlende van de
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den Schipper Jan Steijns

Fig. 3. First paragraph of Jan Steijn's journal detailing the number of cannon and swivel guns aboard when *Zeewijk* is departing the Cape of Good Hope. Transcription: Metio stucken canon â 12 lb: 20 â 6lb: 6 â 3lb: en 8 bassen. Translation: Ten pieces of cannon à 12 Lb: 20 à 6 Lb: 6 à 3 Lb: and 8 swivels (NL-HaNA 1729 [scan 587]).

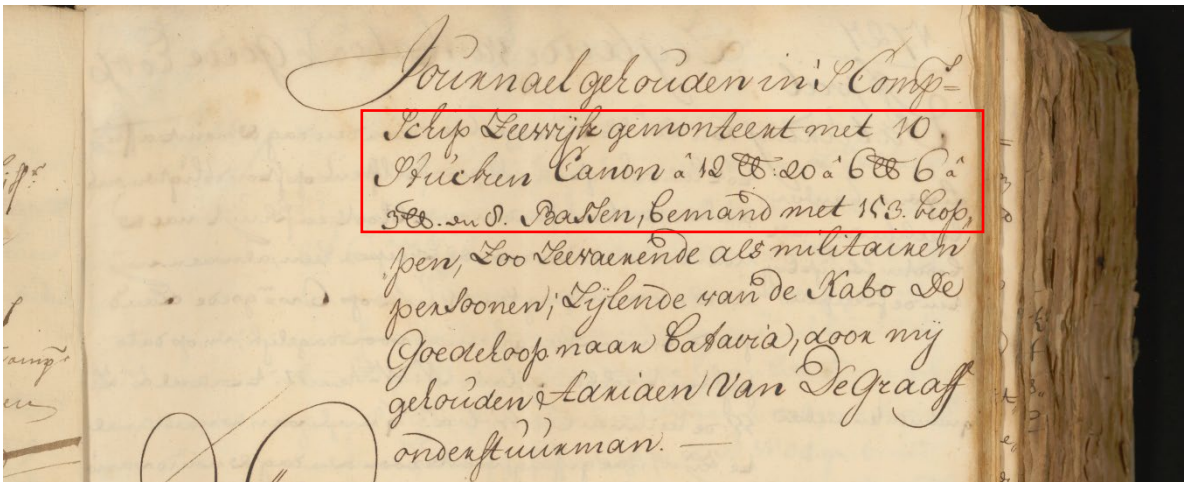
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Fig. 4. First paragraph of Adriaan van der Graaf's journal detailing the number of cannon and swivel guns aboard *Zeewijk* when it sailed from the Cape.Transcription: […] 10 stucken canon â 12 lb: 20 â 6lb: 6 â 3lb: en 8 bassen. Translation: Ten pieces of cannon à 12 Lb: 20 à 6 Lb: 6 à 3 Lb: and 8 swivels, […] (NL-HaNA 1729 [scan 547]).

Previous studies

WA Museum expeditions (1976–1978)

Between 1976 and 1978, Swedish maritime archaeologist Catharina Ingelman-Sundberg led three major expeditions to the Pelsaert Group with a team of Western Australian (WA) Museum maritime archaeologists to map the *Zeewijk* site (Ingelman-Sundberg 1977a, 1977b, 1977c, 1977d, 1977e, 1978a, 1978b, 1979) (Fig. 5). The team recorded the distribution of all major features such as cannon, anchors, timbers and other artefacts over a wide area of about 700m x 2,000m, extending from the outer reef into the sheltered lagoon. The count of large iron objects known to have come from the *Zeewijk* site included

the guns raised by the Royal Australian Navy team, as well as the artefacts recorded on the seabed in both the inner lagoon and outer reef site. The 1970s team tallied a total of 38 iron cannon, and six or seven anchors (Ingelman-Sundberg 1977d:277; 1978, 1979). The outer reef site requires very low swell conditions to access it safely, which only occur once or twice a month, and rarely for periods longer than a day or two. In the outer reef area, the 1970s team mapped two main concentrations of wreckage material, since known as the '8-cannon area' and '12-cannon area' (Fig. 5).

The main wreckage area of *Zeewijk* (Fig. 5) is difficult to access as it is located on the outside of a shallow reef over which large waves break. The force of heavy swell and pounding breakers of the Indian Ocean inhibit site access. At best there are only a few days in the summer months for divers to access the site. In 1978, Catharina Ingelman-Sundberg, who led the WA Museum fieldwork, advised:

> To improve the access to the *Zeewijk* main site divers could be dropped directly onto the site by jetboat. This can save some time as regards swimming to and from to the wreck as well as increasing the amount of days one has access to the wreck.

The best strategy to access the *Zeewijk* site is thus to have a small team of diving archaeologists standing by and ready to go and work on the site for a few days in a summer weather window.

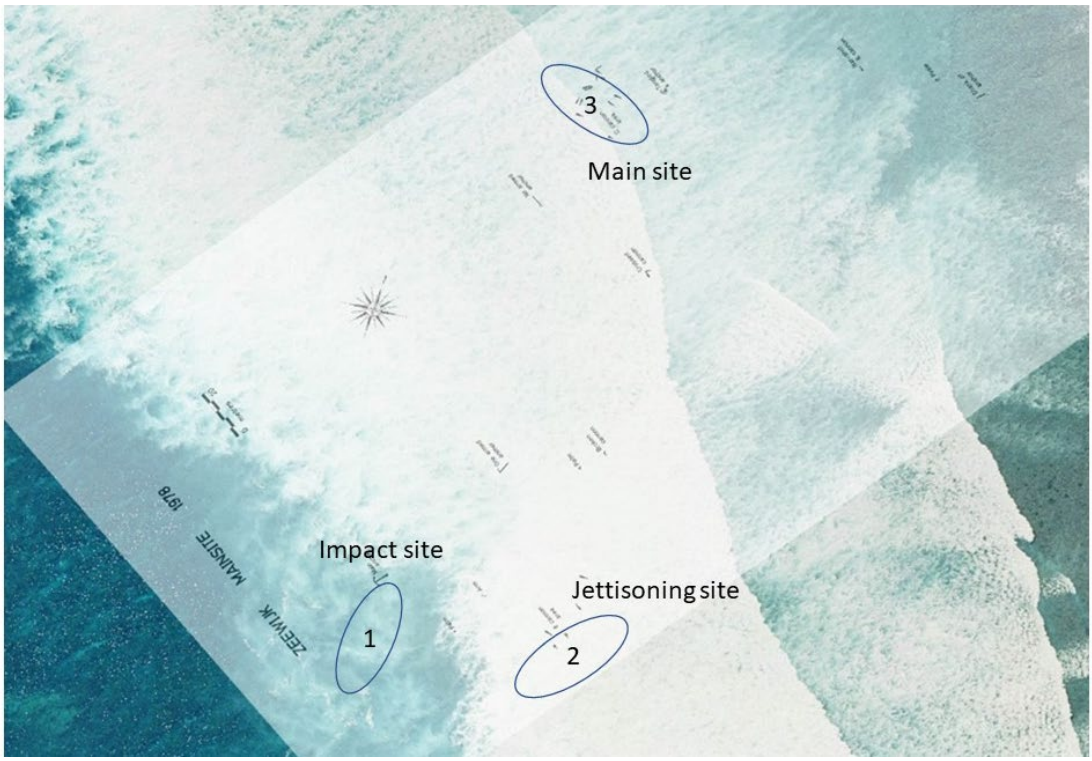

Fig. 5. GIS map with 1970s site plan overlayed on the modern aerial photo, showing the impact, jetsam (=8-cannon area) and main (=12-cannon area) sites (R. Anderson, WA Museum; Landgate, 2019).

Roaring 40s Project (2016–2019)

Three recent fieldwork campaigns to survey the Pelsaert Group of Islands in the Abrolhos were carried out under the auspices of the Australian Research Council-funded project 'Shipwrecks of the Roaring 40s' (LP130100137), and they are described in detail by

Jeremy Green, Kevin Edwards and Alistair Paterson in the book *Shipwrecks of the Roaring 40s* (Green and Paterson 2020:92–102, 127–151; see also Paterson et al. 2019).

In 2016 an aerial magnetometer survey of the Pelsaert Group was privately funded by Mr John Rothwell AO on behalf of the WA Museum (Fig. 6). Thomson Aviation flew the survey and in three fieldwork campaigns in 2016, 2017 and 2019, magnetic targets from this survey were investigated, both on land and under water.

In 2019 a team of archaeologists set out to inspect and record the main features of the *Zeewijk* site using 3D photogrammetry and to reinvestigate two major wreckage concentrations, namely the '8-cannon' and 12-cannon' areas. The team also planned to inspect outstanding magnetic anomaly ZW002 500m north of the *Zeewijk* site, and locate, record and geolocate cannon and anchors recorded during 1970s.

A diving reconnaissance in 2019 indicated that the outer reef, where the 8-cannon and 12-cannon areas are located, was inaccessible due to unfavourable swell and surf conditions. In a narrow weather window, the team did get the opportunity to inspect the magnetic anomaly Z002 (Figs 7 and 8), situated in the gutter 500m north of the wreck site. Inspection confirmed a large iron cannon measuring 3m in length, 75 cm in width across the trunnions and with a bore diameter of 10cm. This cannon is probably a 12-pounder and was found together with lead sheathing (Green and Paterson 2020:137; Paterson et al. 2019).

This gun corresponds to one observed in the 1978 WA Museum survey, but its position was not mapped at the time (Ingelman-Sundberg 1978b:13). The size, weight and distance of the gun north of the main site indicates the significance of the northern wreck plume in the site formation process of wreck disintegration.

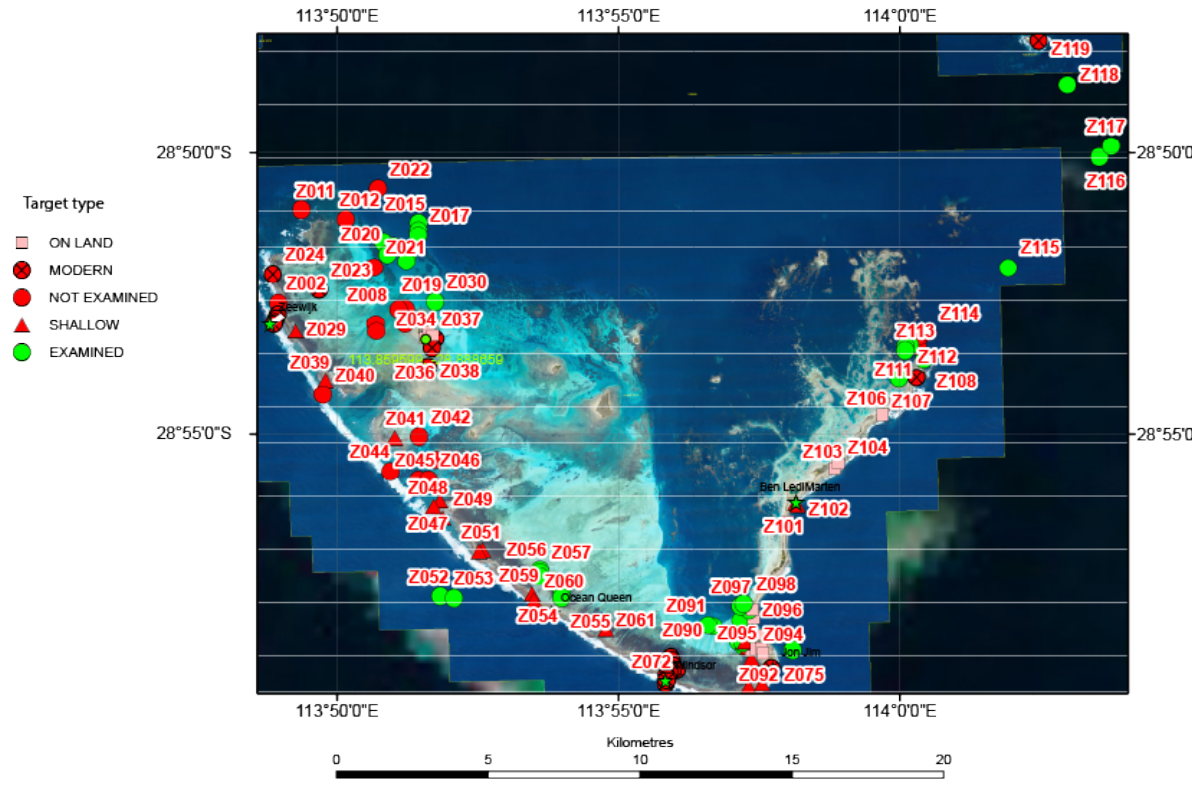

Fig. 6. Targets of the 2016 aerial magnetometer survey (J. Green, WA Museum; Landgate, 2015).

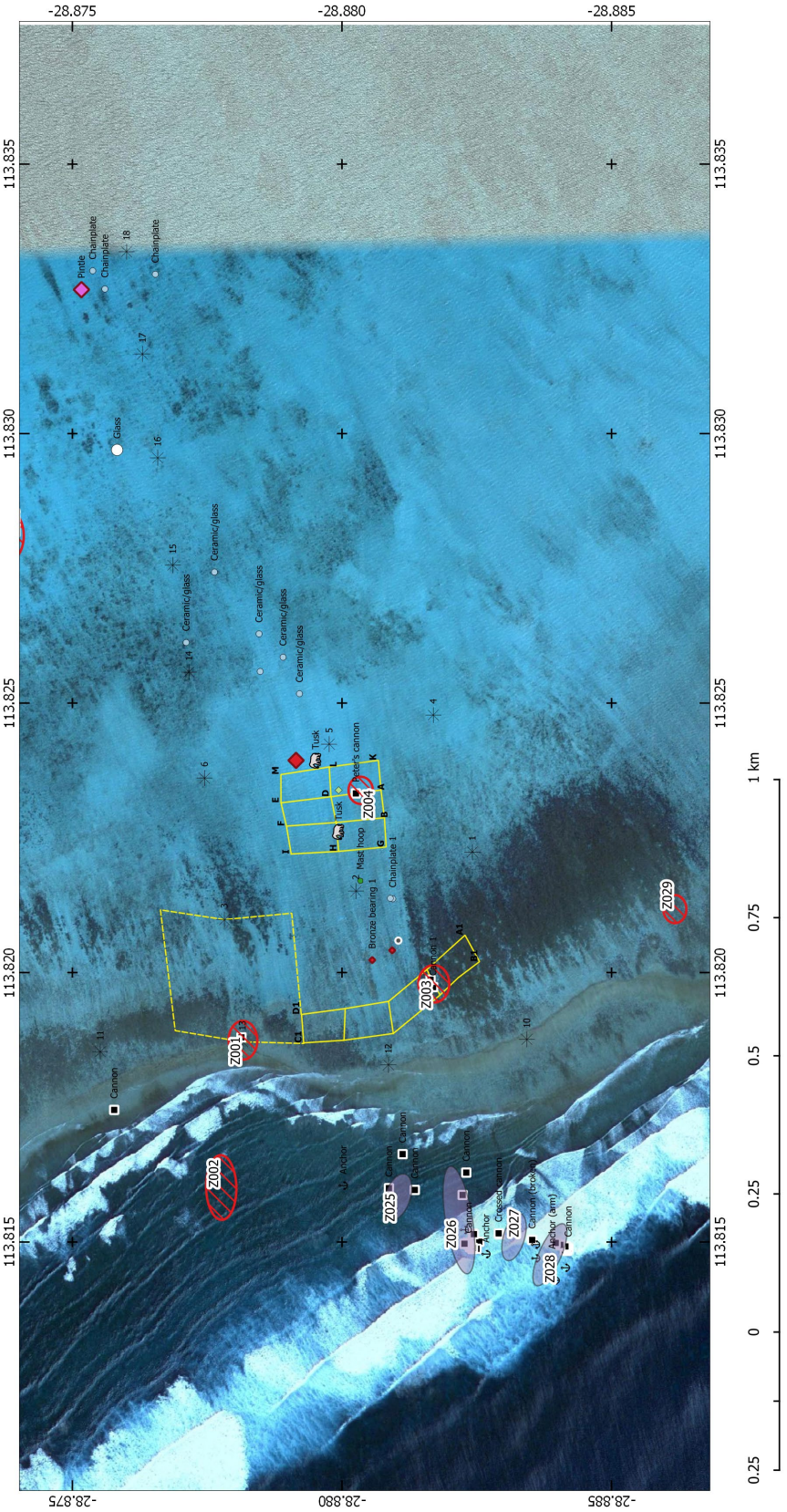

Fig. 7. GIS plan of outer and inner reef of the *Zeewijk* shipwreck area. Note anomaly Z002 in gutter 500m north of site (circled in red, centre left of image) that was found to be a 3-metre cannon in the 2019 fieldwork (J. Green, WA Museum; Landgate, 2015).

For the remainder of the 2019 fieldwork the team focussed its efforts on the lagoon inside the reef, which was accessible. They re-inspected and recorded the cannon in vicinity of Magnetic Anomaly Z001 and Z004 (‘Pete’s Cannon’) (Figs 6 and 7), and resurveyed Areas A and B on the inner reef but found no additional wreck material (Green and Paterson 2020:137–139; Paterson et al. 2019). Attempts to relocate two other cannon in Area A on the inner reef were unsuccessful, as they may have become overgrown with staghorn coral; historical aerial imagery shows that coral beds in this area have grown significantly since the 1980s.

Fig. 8. Wendy van Duivenvoorde recording 12-pounder cannon, Magnetic Anomaly ZW002 of the 2016 aerial magnetometer survey in 2019 (D. Shefi, WA Museum, 2019).

While the WA Museum and its partner organisations have revisited the inner lagoon sites in recent years, but they were unable to visit the outer reef location of the main wreck site due to a combination of unfavourable weather and swell conditions, and the expense and logistical difficulty of access; the last time archaeologists accessed this area was 1978. This aim was included in the 2019 ‘Shipwrecks of the Roaring 40s’ expedition to the Pelsaert Group; however, while this team could access the outer reef gutter they were unable to inspect the main site as aforementioned (Paterson et al. 2019). During this 2019 expedition, the Liddon family—Jane, Jesse and Sam—who fish the shallow reefs of the Pelsaert Group, offered to assist the team with logistics in any future planned inspection of the site.

Subsequently, Flinders University, in partnership with the WA Museum, University of Western Australia and the Rijksdienst voor het Cultureel Erfgoed (RCE), successfully obtained a grant from the Embassy of the Netherlands, Canberra (GCE-2019-03) to organise an expedition to conduct a photogrammetric survey of the outer reef site. Due to unsuitable swell conditions and COVID-19 travel restrictions occurring during the February–April waiting periods in 2020 and 2021, this work was held up until 2022.

Shipwreck Hunters Australia documentary (2021)

In October 2021, WA Museum maritime archaeologists Ross Anderson and Deb Shefi undertook an opportunistic inspection of the *Zeewijk* outer reef site with the Liddon family and a documentary team filming the *Zeewijk* episode 'Two Wreck Fever', as part of the Disney+ series 'Shipwreck Hunters Australia', which aired on 5 October 2022 (Hutchens 2022). During a short two-hour period of suitable weather and swell conditions, the team inspected the site and gathered digital footage, which assisted in refining the aims and methodology of the 2022 expedition.

Fig. 9. Site overview looking west with vessels moored inside the lagoon (the inner site), the outer reef site is in the surf in the centre of image, directly west of the boats (K. Edwards, WA Museum, 2022).

Weather window

For the expedition to be successful a suitable weather window of at least 1.5 to 2 days of low swell conditions was required to allow safe access to the site and clear photography of the seabed without white-water clouding the water column and reducing visibility. The team set aside a weather window of dates between 21 February and 14 April to wait for ideal weather conditions hoping for a single full day, or at best two days. The Liddon family monitored local weather conditions to provide advice on a suitable weather window, and between 11–17 March an expedition was mounted (Figs 9–32).

Field team

Unfortunately, due to COVID-19 travel constraints, the Flinders University team of Wendy van Duivenvoorde, John McCarthy and Hiro Yoshida, and Dutch project partner Martijn Manders and colleagues from the RCE were unable to participate in the fieldwork as planned.

The 2022 fieldwork team included:

- Ross Anderson, OIC, WA Museum, maritime archaeologist
- Rick Cameron, Boating support
- Kevin Edwards, Data Manager, Flinders University PhD candidate, 3D photogrammetry specialist, drone operator
- Edie Liddon, Deckhand
- Jane Liddon, Master *Justin Renae*
- Sam Liddon, Master *Libra*, jetski operator
- Patrick Morrison, 3D photogrammetry specialist, maritime archaeologist
- Shannon Reid, Maritime Archaeology Association of WA volunteer diver
- Deb Shefi, Curator, WA Museum/Flinders University, maritime archaeologist

Fig. 10. Liddon fishing vessels used for survey including carrier boat Libra, jetboat Justin Renae and jetski with tow float (K. Edwards, WA Museum, 2022).

AIMS

The aims of the 2022 expedition were to:

1. resurvey the main site using GPS to more precisely locate features and georeference the 1978 WA Museum site plan
2. record the archaeological features and site environment using digital photogrammetry to allow production of 3D models, digital elevation models (DEMs) and orthophotos
3. follow up on previously reported features not seen or recorded by the WA Museum.

PRIORITIES

Due to the potential for unexpected changes in weather and surf size, activities were prioritised to ensure the major aims of the expedition were met, as outlined below.

Priority 1—Map the main features of the outer reef site

1. GPS underwater site features to
    a. allow georeferencing of photogrammetry; and
    b. to enhance georeferencing of 1978 site plan.
2. Photography, video and 3D photogrammetry to digitally document the offshore reef site including major features in the following order of priority:
    a) 12-cannon area
    b) 8-cannon area
    c) Standing/main anchor
    d) Other isolated features including linking up features between 8-cannon and 12-cannon areas and gutter sites e.g. one-armed anchor, crossed cannon, broken cannon, broken arm, broken palm, pintle, and anchor stock
    e) Site environment (rock holes etc).

Priority 2—Record outer reef site features in detail and search for new material

3. Take close-up photography and videography of identifiable features, e.g. wreckage concretions, stone ballast, artefacts
4. Search for any evidence of wreck material in rock holes on outer reef site
5. Follow up report of four extra cannon described in shallows ‘approximately 60m east of the 8-cannon’ area (Ingelman-Sundberg 1978b:9).

Priority 3—Map and record inner lagoon sites

1. Revisit chainplates/rigging, cannon and timber sites (Areas D and F on 1978 site plan) and other sites in inside lagoon area and record with 3D photogrammetry
2. Search inner lagoon in wreck plume area between outer reef and Gun Island.

METHODOLOGY

To achieve the aims and priorities, the following methodology was prepared so all team members knew the tasks.

1. Position underwater site features using GPS to align photogrammetry and correlate with 1978 WAM site plan:
   a) Use jetski with snorkeler and waterproof GPS to locate and buoy underwater between five to six major features spanning the site e.g. main anchor, an identifiable cannon in the 12-cannon area, an identifiable cannon in 8-cannon area, 'tangled anchor' (near the 12-cannon area), anchor shank east of 12-cannon area, two 'crossed cannon' between the 8-cannon and 12-cannon areas
   b) Obtain GPS positions of features.
2. Digitally photograph the site, including major features (cannon, anchors) and site environment (reef, rock holes etc).
   Priority A included:12-cannon area, 8-cannon area, and standing anchor. Priority B included all other scattered features: palm, crossed cannon, broken cannon, anchor shank, bar shot and cannon, and anchor 150m north of main site.
   a) Swim (using snorkel, SCUBA and scooters depending on conditions) overlapping lines throughout 12-cannon area to obtain coverage of approximate 30m x 30m or greater area to include all cannon and anchors and any identifiable wreckage/concretions. Take particular note of any wreckage-related features and concretions such as the 'tangled mat of wreckage' associated with 12-cannon area.
   b) Repeat the above steps for 8-cannon area (if conditions safe/suitable use two buddy teams in water simultaneously).
   c) Attempt to link 8- and 12-cannon areas 150m apart with 3D mapping and photogrammetry coverage by drift snorkelling/diving down-current from 8-cannon area to 12-cannon area, trying to include site features such as anchor palm, broken cannon and crossed cannon.
3. Take close-up photography/videography/photogrammetry of identifiable features, particularly any stone ballast wreckage concretions:
   a) Diver buddy team on SCUBA to focus on 8-cannon area and 12-cannon area with described 'tangled mat of wreckage', and photograph ballast and concretions using a 1-m scale bar.
   b) Undertake close-range photogrammetry on individual features for measurement and display.
4. Search for any evidence of wreck material in rock holes:
   a) Follow Liddons' directions to investigate caverns/rockholes in the reef with potentially trapped materials.
   b) Use jetboat and/or jetski to drop buddy team in location of rockholes and use floating GPS unit with tracking on and camera on video setting to document/3D record rockholes.
5. Follow up report to search for extra cannon in shallows:
   a) Use jetboat and jetski to survey shallow water using lookouts around georeferenced position of reported site 60m east of 8-cannon area. Record GPS tracks.
6. Lagoon chainplates/rigging site and lagoon sites—Record in 3D:
   a) Follow up public report with GPS position for rigging site in lagoon.
   b) Obtain GPS positions of targets, place 2m and 1m scale bars and record in 3D.

7. Search inner lagoon in wreck plume area between outer reef and Gun Island.
   a) If weather conditions do not permit diving on outer reef, then search for any uncovered materials in lagoon seabed.
   b) Use floating GPS unit with tracking on and photograph any located objects; and
   c) Ensure camera and GPS clocks are set to same time stamp, to allow correlation of any photographed features with GPS positions.

SITE FORMATION CONSIDERATIONS

The two main concentrations of wreckage, i.e. the 8-cannon and 12-cannon areas, situated about 300 metres apart, and other site features can be interpreted by correlating the 1978 WA Museum site plan with the description of *Zeewijk* wrecking events provided in the journal of the ship's captain, Jan Steijns (Ingelman-Sunberg 1977d:226–227; Steijns 1727). The shipwrecking event can be correlated to the ship's initial impact on the reef, the jetsam from the ship intended to lighten its load, and the final wrecking of the ship on the main site:

1. Impact: On Monday 9 June 1727 *Zeewijk* strikes the reef on its starboard side, bow facing north, in about 3.5m of water;
2. Jetsam site: *Zeewijk* remains in this position until the evening of Sunday 15 June when it was struck by a storm and heavy swell. The ship shifts so the crew '[t]hrew our lee-side guns overboard because the ship began to shift in such way over starboard or the lee-side that we feared we would be capsized' (Steijns 1727:34)[1]; and
3. Main site: During the night of Sunday 15 June *Zeewijk* was 'taken up by the breakers and hitting with great force shifted over starboard (Steijns 1727:34)[2].

By comparing these descriptions with the *Zeewijk* site plan (Fig. 5), the initial impact site was likely the location of the outside reef main anchor. While Steijns does not mention deploying an anchor, normal seafaring practice would be to immediately let go of an anchor in order to stabilise the ship and bring its head into the WNW wind and SW swell. The ship would then have moved to lie about 40m farther to the ESE. Here, *Zeewijk* was located in the impact zone of the heaviest outer reef surf break, and stayed in this position until 15 June when a strong SW storm hits causing the ship to heel over alarmingly. At this point the lee-side guns were jettisoned to stabilise the ship, with this jetsam site likely to be the 8-cannon area. Due to a combination of a lightened ship and heavy swell during the night of 15 June, Steijns describes the ship as being 'taken up by the breakers' and transported further along the reef. The final resting place of the ship is thus likely to be the '12-cannon area' located 190 metres NE of the jetsam site on the inner part of the reef shelf under breaking surf, and is associated with stone ballast and a number of artefact-rich concretions.

As *Zeewijk* broke up, it created both northward and eastward wreckage plumes. The dispersal of heavy materials indicates the ship would have broken up into large wooden 'rafts' of timber decks and hull, which with heavy items attached were transported in both directions. The presence of heavy material such as cannon and lead sheathing in the gutter up to 500m northward of the main site indicates the strength and influence of the

[1] (NL-HaNA 1.04.02, 9353) […] 'wierpen ons lij geschut overboort dewijl 't schip over stuurboort of de lijkant sodanig begon te setten dat wij vreesden ongeslagen zoude worden' […] (translated by Adriaan de Jong).
[2] (NL-HaNA 1.04.02, 9353) […] door de branding op geset en met groote force stootende over stuurboort […] (translated by Adriaan de Jong).

predominantly northward-flowing, longshore current and WSW swell. Similarly, the influence of this prevailing swell and WSW winds has resulted in a wreckage plume up to 2.5km distant from the wreck, across the inner lagoon.

PLANNED OUTPUTS

Based on the successful achievement of the aims, the following outputs were expected.

1. Georeferenced 3D photogrammetric model of site and individual features
2. Updated georeferenced 1978 site plan incorporating GPS positions of features
3. Digital Elevation Model (DEM) of outer and inner reef areas and concentrations of wreckage material
4. Digital photography and videography of major site features and wreckage concentrations
5. GPS tracks of areas searched
6. Measurements of features such as cannon and anchor shanks, wreckage/concretions/site extent from photogrammetry
7. Correlated overlay of 1978 WAM site plan with 2022 photogrammetric model (to ascertain accuracy and correlate all features)
8. Publish final report for the Embassy of the Netherlands and on-line content for WA Museum webpage, and 3D models posted to the WA Museum's Sketchfab page.

Fig. 11. Deb Shefi, Patrick Morrison and Shannon Reid preparing to dive (R. Anderson, WA Museum, 2022).

RESULTS

Weather conditions permitted four days of diving on the outer reef site, the swell on the first day (Sunday 13 March) being still a bit large with consistent 1.2-metre sets, with swell conditions steadily decreasing to Wednesday 16 March, which dawned with almost flat surf conditions, with some occasional 60-to-90-centimetre sets. During these four days the following activities were undertaken in accordance with the project aims:

1) All identifiable features mapped on the WA Museum 1978 site plan were relocated, including cannon, anchors, broken anchor components and an iron pintle. GPS positions were obtained, with the exception of one cannon mapped to the northeast of the site that was unable to be relocated and is believed to be non-existent (see No. 11 below).
2) 3D photogrammetry was successfully obtained of the main '8-cannon' and '12-cannon' areas. SCUBA and snorkel traverses, both free-swimming and using a Diver Propulsion Vehicle (DPV or 'scooter'), were subsequently able to link up all features on the outer reef, as well as with the inside gutter area.
3) 3D photogrammetry was achieved of the main anchor and most other individual features.
4) General photography and video were obtained of the outer and inner reef sites.
5) Aerial drone photography and video was obtained of the outer and inner reef sites.
6) On the 12-cannon area a variety of material including mounds of stone ballast, copper and lead sheeting, rolled lead, broken glass, a length of lead deck scupper, small copper alloy artefacts, grey Dutch bricks and a breech block were observed, supporting the hypothesis that this is the final location of the wreck or 'main site area'.
7) On the 8-cannon area no artefacts other than cannon were observed supporting the hypothesis that this is the jetsam area. Two of these cannon were in fact broken pieces of the same cannon— reducing the overall cannon count by one and making this a '7-cannon' area.
8) Previously mapped features to the northeast of the main outer reef area were relocated and inspected, including an anchor and three cannon (see No. 11 below). The anchor—a kedge with a shank length of 2.60m—was located 113 metres SSW from the position indicated on the georeferenced 1978 site plan, 128m NNE of the 12-cannon area.
9) The 'tangled anchor' that had been variously drawn on site plans as a single anchor, or two anchors, was confirmed to be only a single anchor.
10) The anchor with buried crown in outside reef gutter area was observed to have a fluke/palm next to it.
11) The 1978 WA Museum site plan mapped a total of four cannon northeast of the main site; however, only three were relocated. One additional cannon was probably mistakenly mapped on the 1978 site plan due to the difficulties of mapping this widely dispersed area in strong currents and surf (see 'Discussion' below), further reducing the cannon count.
12) An area 60m east of the 8-cannon area was closely inspected for any evidence of four cannon reported in 1978, with no evidence for any cannon in this or adjacent areas.
13) Large rock holes in the reef just north of the main area were inspected for trapped artefacts. Isolated glass sherds, mainly onion bottle fragments, were noted in most rock holes, with no major features noted.

14) The distance between the main anchor and northern-most iron cannon on the outer reef site is 688m.
15) A cannon (Z002) 500m north of the site was reinspected to determine the nature of a reported ‘bell-shaped concretion’, which was confirmed to be a large soft coral.
16) A number of inner lagoon sites were relocated and their positions fixed.

Fig. 12. Sam Liddon operating the jetski to ferry divers and equipment to and from the site (R. Anderson, WA Museum, 2022).

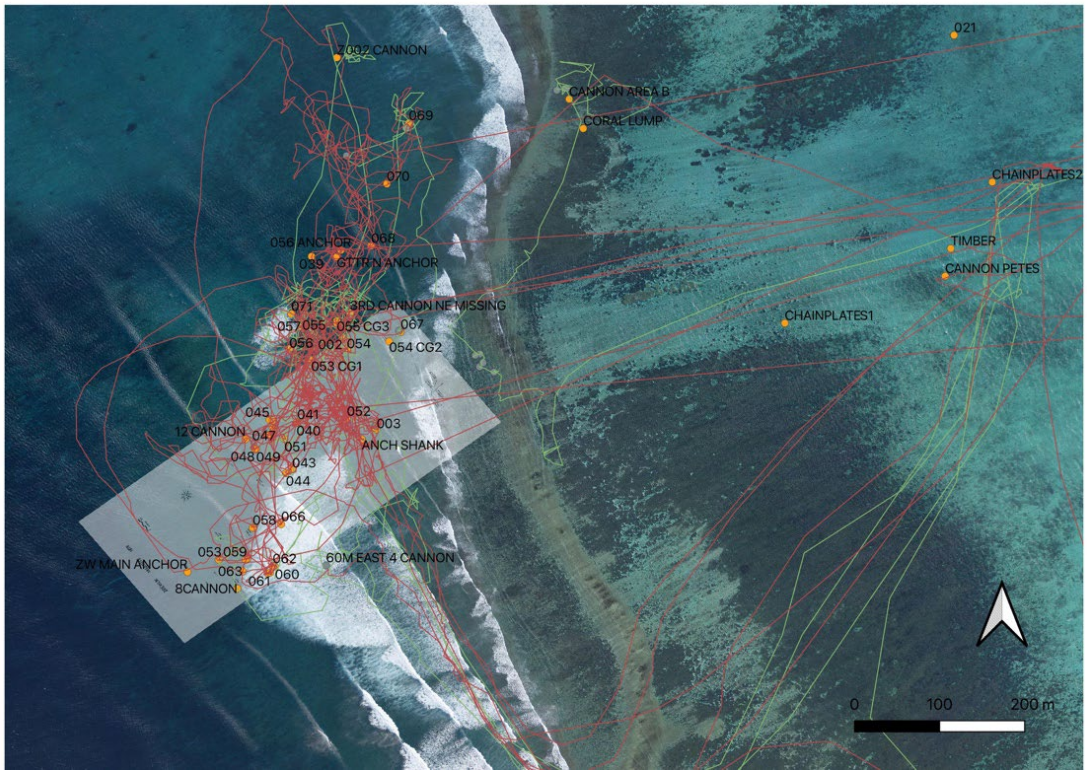

Fig. 13. GIS map of site and vessel survey tracks showing area of activity/coverage (R. Anderson, WA Museum, 2022).

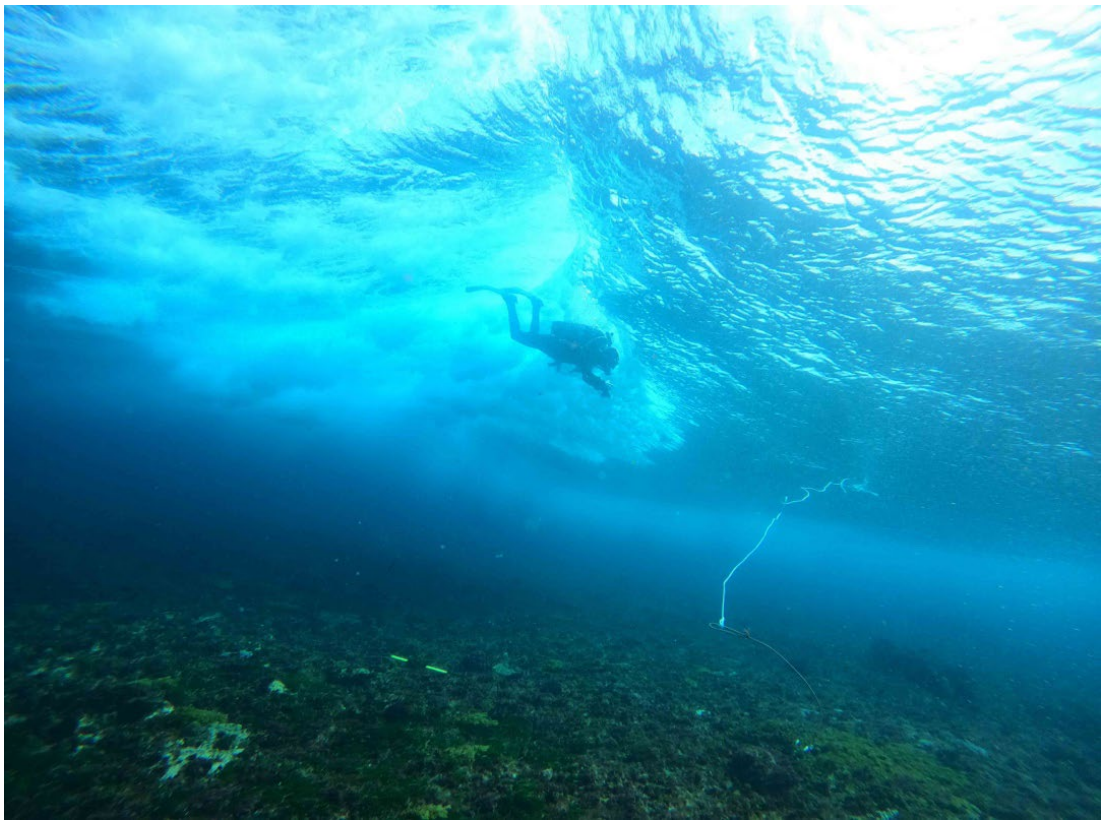

Fig. 14. Patrick Morrison undertaking 3D photogrammetry survey in the 8-cannon area as a wave passes overhead (R. Anderson, WA Museum, 2022).

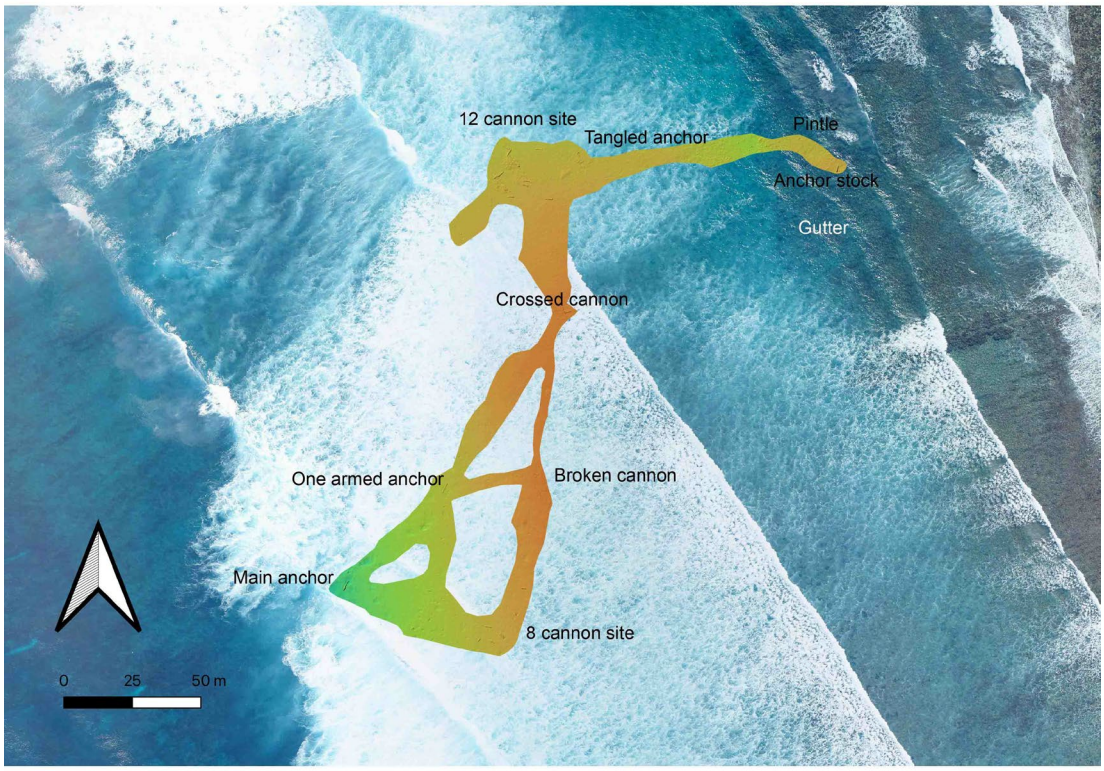

Fig. 15. GIS map with Digital Elevation Model (DEM) showing 3D photogrammetry coverage of the *Zeewijk* outer reef site with some of the main features labelled (R. Anderson and P. Morrison, WA Museum, 2022).

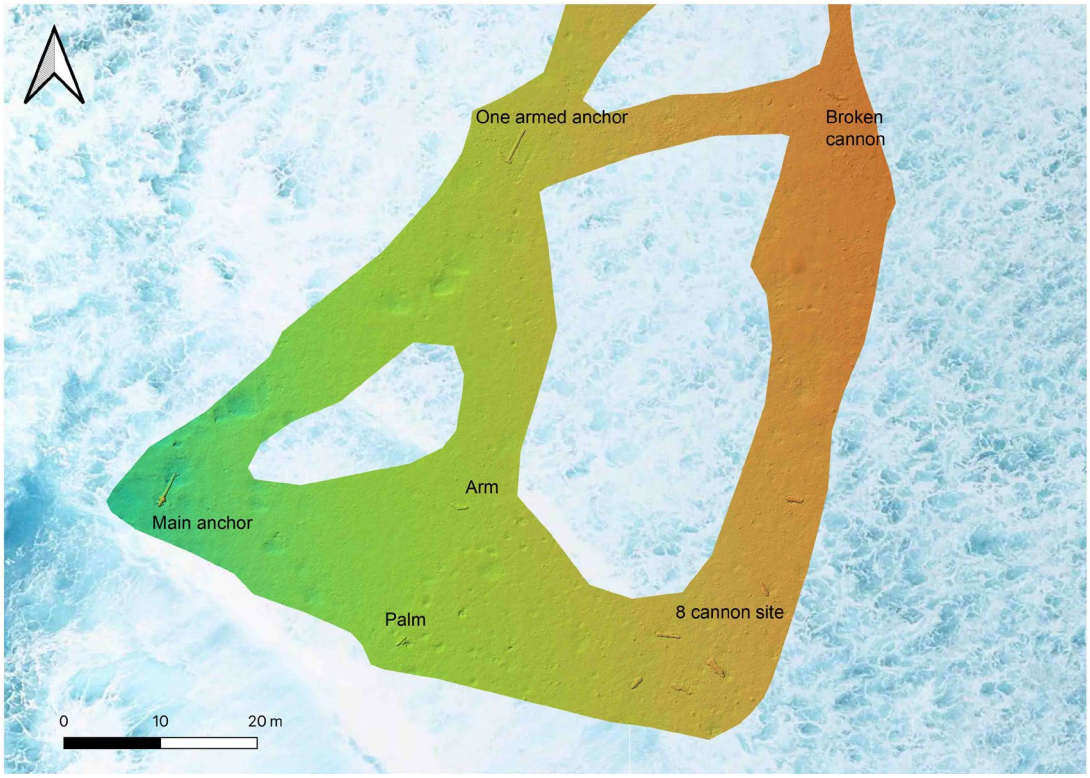

Fig. 16. GIS map with DEM of southern end of site with main features labelled (R. Anderson and P. Morrison, WA Museum, 2022).

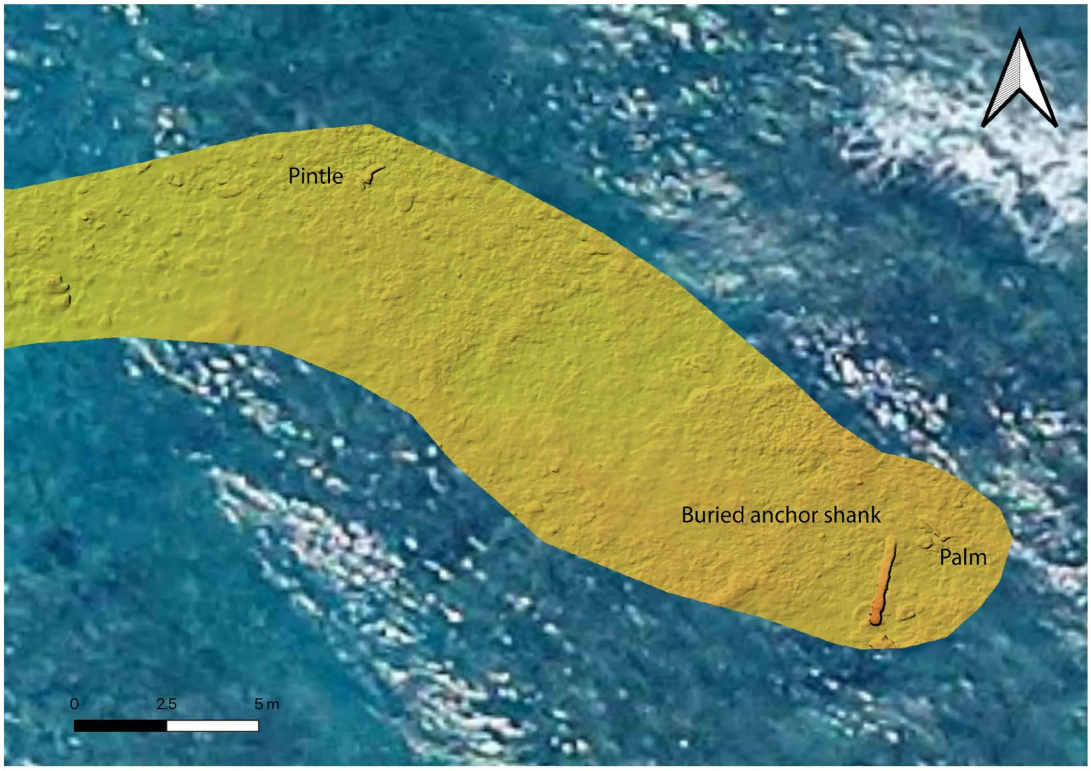

Fig. 17. Detail of GIS map with DEM showing anchor shank and iron pintle in gutter area (R. Anderson and P. Morrison, WA Museum, 2022).

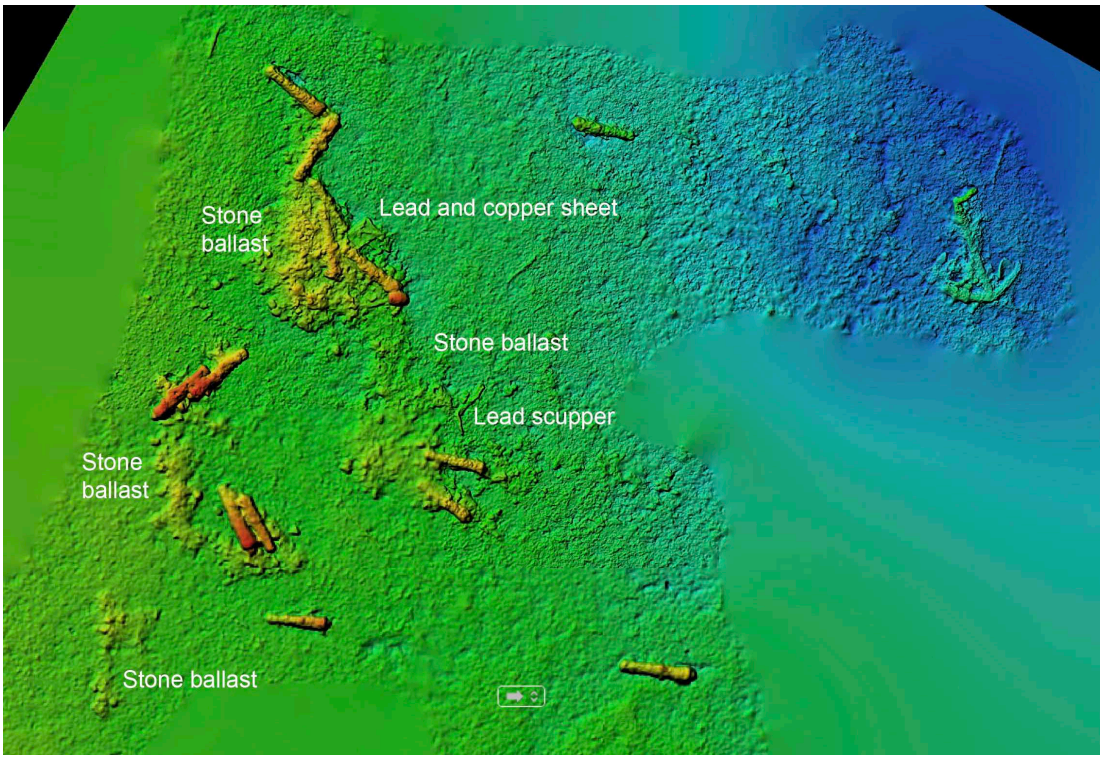

Fig. 18. DEM of 12-cannon area showing additional outlying two cannon (14 cannon total), 'tangled anchor', piles of stone ballast, lead deck scupper and lead and copper sheets. The concentration of cannon, stone ballast and variety of different materials is interpreted as the main area and final resting place of the wreck (R. Anderson and P. Morrison, WA Museum, 2022).

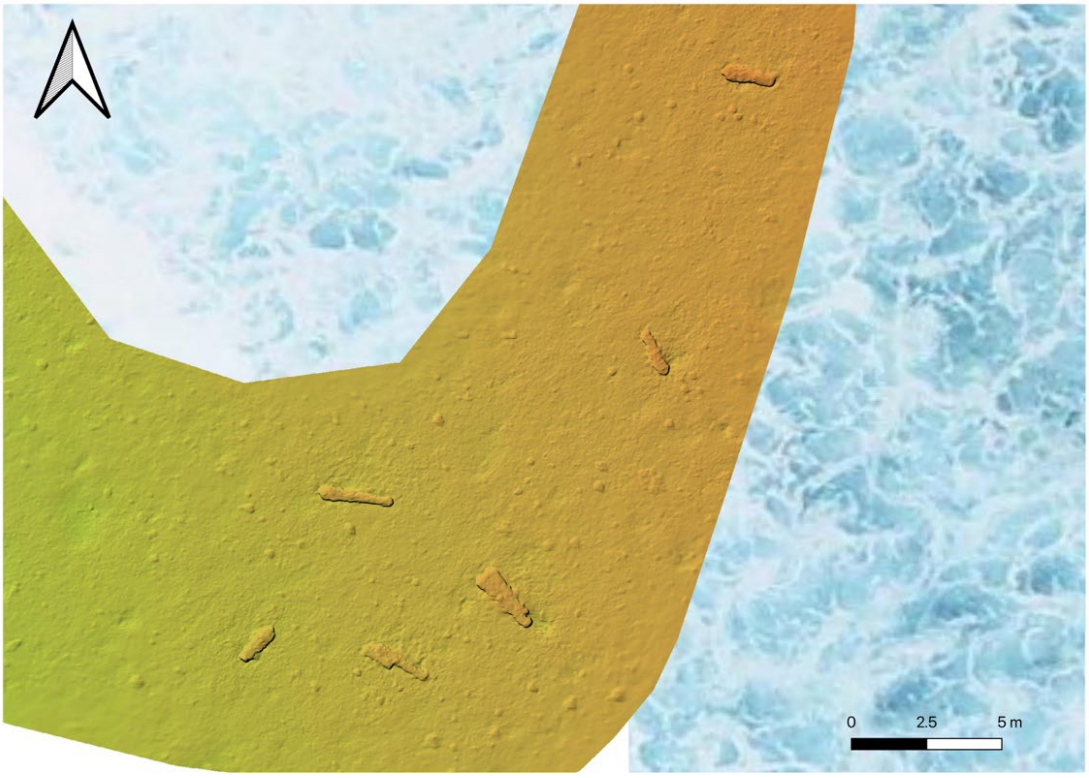

Fig. 19. DEM of 7-cannon area. The seabed is flat limestone reef with some rocky reef protuberances and slight depressions, with no other artefacts present, supporting the interpretation of this area being a jetsam site (R. Anderson and P. Morrison, WA Museum, 2022).

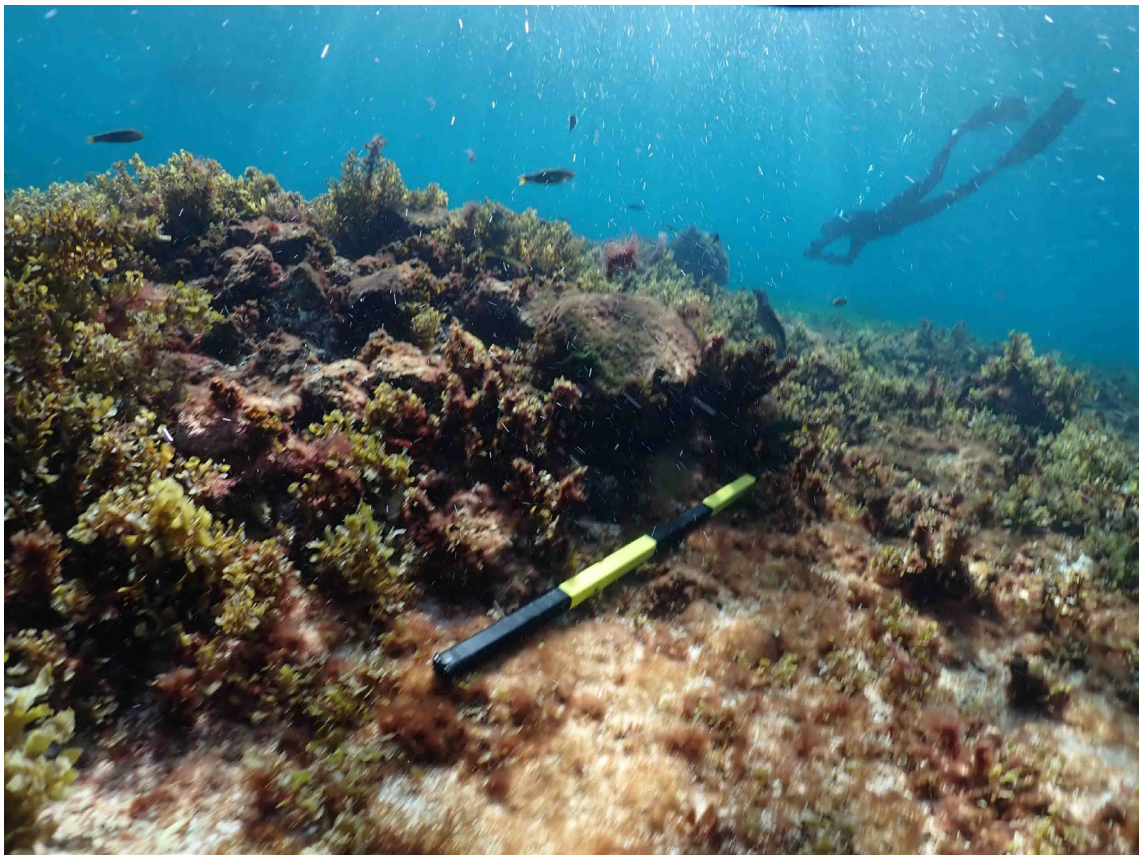

Fig. 20. Stone ballast in vicinity of 12-cannon area (R. Anderson, WA Museum, 2022).

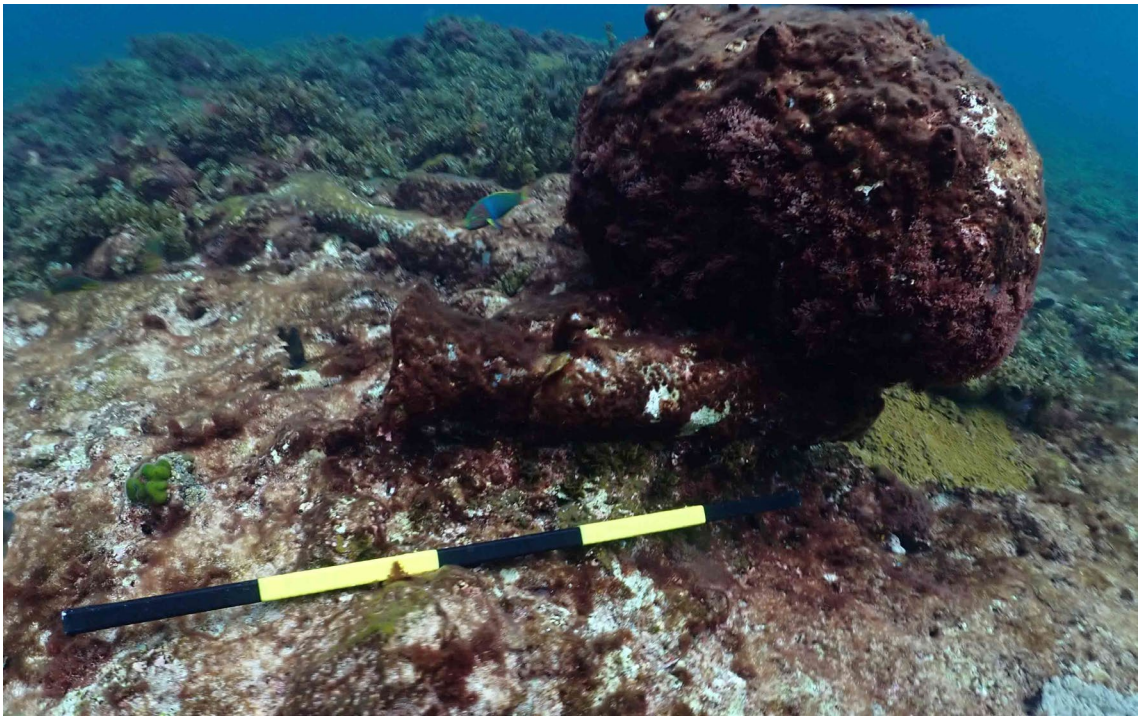

Fig. 21. The context of this cannon overlying a roll of lead and stone ballast in the 12-cannon area indicates the site formation process—as the wooden hull and gun decks deteriorated heavy items collapsed into the hold and onto the underlying materials and seabed (R. Anderson, WA Museum, 2022).

Fig. 22. Ross Anderson photographing a lead deck scupper in 12-cannon area (P. Morrison, WA Museum, 2022).

Fig. 23. Deb Shefi inspecting the anchor shank and palm in the gutter area (R. Anderson, WA Museum, 2022).

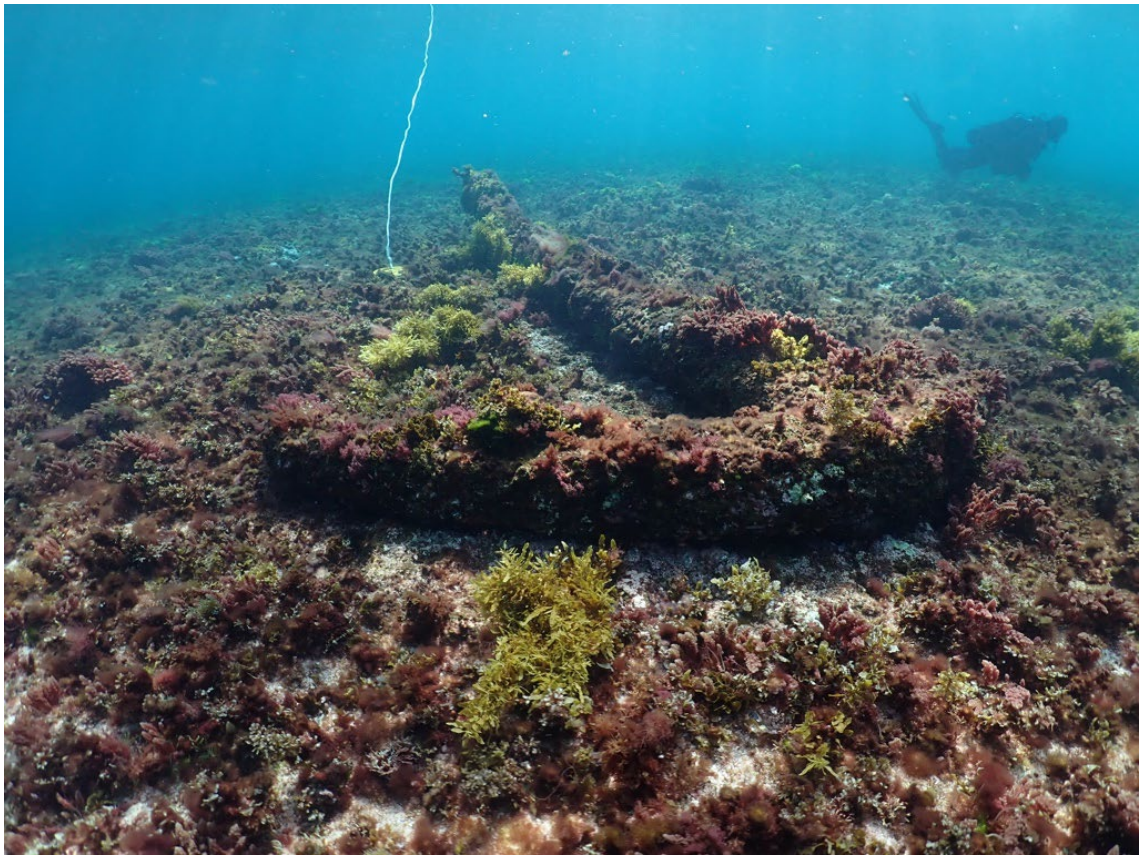

Fig. 24. One-armed anchor (D. Shefi, WA Museum, 2022).

Fig. 25. 3D model of main standing anchor (P. Morrison, WA Museum, 2022).

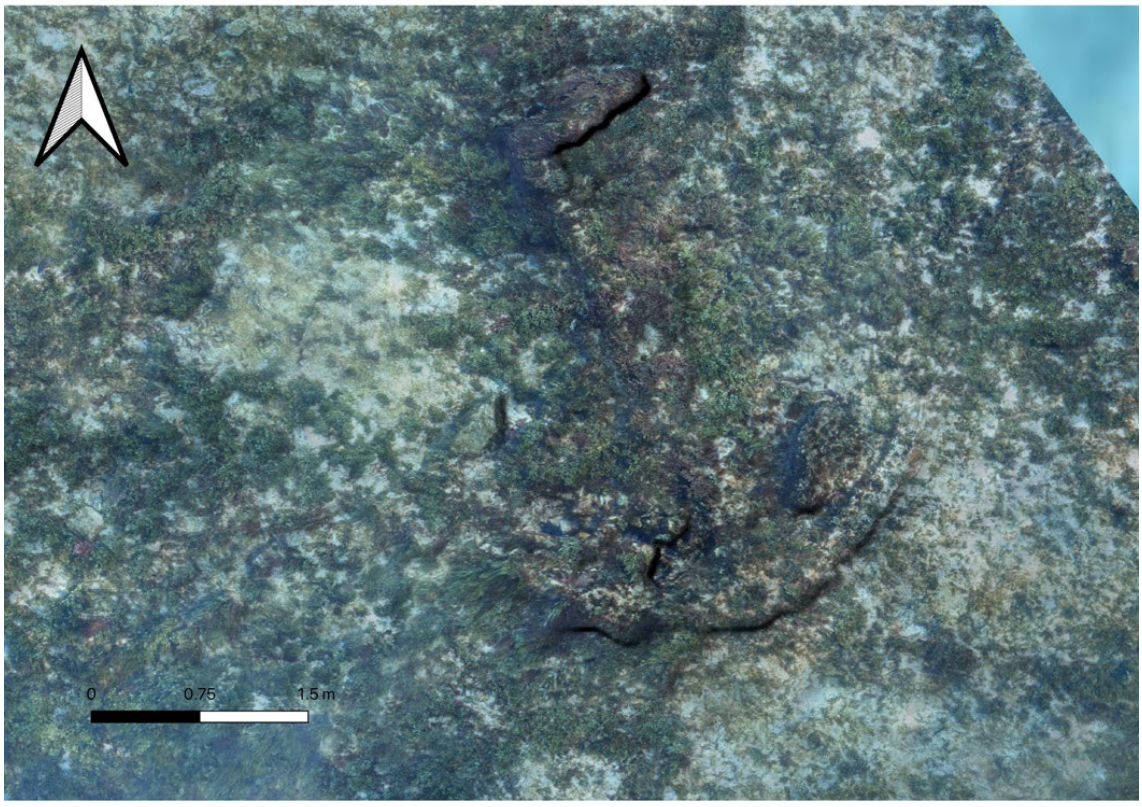

Fig. 26. Orthophoto from 3D model of ‘tangled anchor’ east of 12-cannon area, confirming it is a single anchor, and not two anchors (P. Morrison, WA Museum, 2022).

ANCHORS

In further investigating Hugh Edwards' claim to have located a second wreck in the same area as *Zeewijk*, it was necessary to relocate all existing mapped features, and search for any other possible features. Edwards claimed that the site contained 47 iron cannon and 9 anchors, and therefore represented the remains of two VOC wrecks (Edwards n.d.:3), *Zeewijk* having been outfitted with 36 iron cannon and eight bronze, breech-loading swivel guns (NL-HaNA 1727; Steijns 1727:1).

To accurately count the number of anchors on site, only those anchors with shanks were counted to reflect the Minimum Number of Individuals (MNI). Broken and disassociated anchor parts (e.g. palm, crown, arm) that did not include shanks were not counted. Table 1 lists the six anchors that were relocated, with their shank length measurements.

Table 1. Anchors relocated on the *Zeewijk* site.

Description	Shank length
Main standing anchor with ring	4.21m
No arm anchor (anchor shank) with ring, W of 12-cannon area	4.05m
One arm anchor with ring, SW of 12-cannon area	4.24m
'Tangled anchor' with ring, E of 12-cannon area	4.27m
Kedge anchor with broken ring, NE of main area	2.60m
Buried anchor shank in gutter, no ring, palm visible	NA

All other disassociated anchor parts previously mapped in the 1970s such as the broken arm, palm and crown were relocated in 2022. A previously unidentified palm was identified concreted into the reef associated with the protruding anchor shank in the gutter. Furthermore, the 'tangled anchor' east of the 12-cannon area is marked on one WA Museum site plan as 'anchors', though on another as just one 'anchor'. The 2022 survey confirmed it to be a single anchor, with some unidentified ironwork and ballast stones trapped/concreted around it.

The six anchors on the site confirm that they represent the outfitting of no more than one ship. The VOC instructions of 1697 specify that a 145-feet long ship was to carry eight anchors of the following sizes: one of 3,000, one of 2,900, one of 2,800, one of 2,700, one of 2,600, one of 750, one of 700 and one of 180 pounds in weight (Van Dam 1927:504). It is unknown whether *Zeewijk* was fitted with eight anchors of these sizes, but it is known that the ship lost two anchors at the Downs roadstead on 23 November 1726, when the weather had forced it to stay there for ten days (13–23 November)—it had only been five days since it departed from its homeport Rammekens (Bruijn et al. 1979:2622.1; NL-HaNA 1727). It is possible that the two missing anchors were replaced when the ship was at the Cape of Good Hope from 26 March to 21 April 1727 as the vessel was also provided with extra swivel guns (NL-HaNA 1729; Steijns 1727:1),especially as there were plenty of large anchors in storage at the Cape of Good Hope in the 1720s (CIE 2014:92 [76 anchors are listed for example in the year 1724]).

After the ship's wrecking in Houtman Abrolhos, the crew raised a 'werpancker' or a kedge anchor (a light stocked anchor) from the site, which weighed about 909 pounds, took it to the reef where it was dropped, and they transported it later to Gun Island (CIE 2014:70; Green 2015:25). This weight of this anchor is at odds with the weights listed in the VOC's

1697 instructions. This anchor is most likely the anchor that was used on the voyage to Batavia in the survivors' self-built vessel. Another anchor may have been recovered in the 1963 recovery operation, but Green (2015:25) points out this remains uncertain. If the ship indeed received two new anchors at the Cape, the crew salvaged one in the Houtman Abrolhos, and one was removed in 1963, then the six anchors observed on the site in 2022 support the hypothesis that there was only one ship at the site. If it did not, there should have only been four anchors on the *Zeewijk* site. VOC ships often carried anchors and cannon in scrap in their hold as ballast as discussed in detail in Van Duivenvoorde et al. 2013 (154). Such ballast included swivel-guns, breech-blocks, cannon and broken anchors, usually intended for recycling, but sometimes even good cannon were used (Van Duivenvoorde et al. 2013:154). Ballast in metal was usually much larger than just two anchors. The CIE (2014:29) report for example details how VOC ship *Borssele* arrived at Batavia in 1726 with 'twelve pieces of useless artillery as ballast, which were not registered in the invoices or the bills of cargo'. Another example details how 249 old cannon were shipped as ballast to the Netherlands on a fleet of seven ships (Van Duivenvoorde et al. 2013:154). It is therefore much more likely that *Zeewijk* received two new anchors at the Cape of Good Hope to replace those lost at the Downs.

ARTILLERY

Prior to the 2022 fieldwork the WA Museum's cannon count on both the inner and outer reef areas was tallied as having been 38 iron cannon—accounted for as either having been salvaged, or still *in situ* and mapped on the WA Museum 1978 site plan. A possible further four cannon reported 60m east of the '8-cannon area', if confirmed, would make a theoretical total of 42 cannon. Therefore, it was deemed important to the 'second wreck' question to attempt to search for and locate any reported/unconfirmed cannon, as well as relocate all existing cannon.

A total of eight swivel guns—consistent with *Zeewijk*'s original complement—have been accounted for, either having been salvaged from the underwater site, or from Gun Island between 1840 and the 1950s (Appendix 1).

Four cannon area report

The 2022 expedition found that there was no evidence for a report of four cannon located 60m east of the 8-cannon area (similarly, none were seen by the WA Museum team during the fieldwork campaigns between 1976 and 1978). This area of about 2m depth was traversed using the Liddon's jetboat with lookouts on the flybridge during near-flat conditions, in clear water with good visibility. Any feature lying proud of the flat reef bottom would have been easily seen. Additionally, Jane Liddon advised she has never seen any such features during her lifetime of fishing this area, as she regularly sets lobster pots and traverses this area in low swell conditions. Therefore, this 4-cannon report can now be positively discounted, reducing the cannon count from a possible 42 cannon, to 38 cannon.

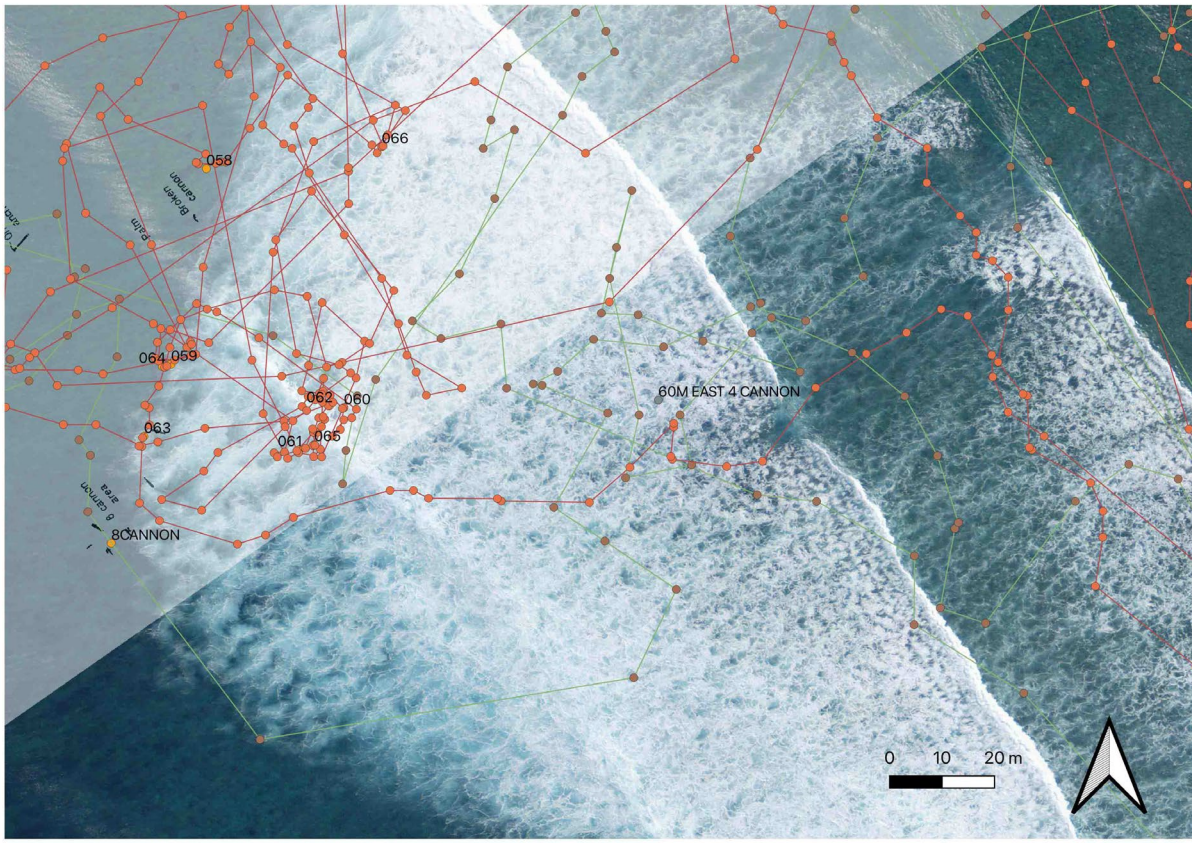

Fig. 27. Vessel and jetski GPS tracks showing survey coverage in area of reported 4 cannon lying 60m east of 8-cannon area—'60M EAST 4 CANNON' point indicates search position obtained from georeferenced 1978 site plan (R. Anderson, WA Museum, 2022).

North-east 'missing' cannon

The 1978 WA Museum site plan mapped three cannon and one anchor northeast of the 12-cannon area. Despite extensive searching of this area in good visibility conditions using both boat-based and diver searches, only two cannon and one anchor were located. The two cannon were both similarly located 8m ENE from their georeferenced positions, while the anchor was located a much greater distance of 113m SW from its georeferenced position. The most likely explanation for this discrepancy appears to be that the location of these features was confused being some distance away from the main concentrations of wreckage on the outer reef site, resulting in an additional cannon being mistakenly mapped. Similarly, the 2022 expedition faced the same challenge of tying in the mapping of these more widely scattered features using 3D photogrammetry, and broad area photogrammetry was not accomplished in this area during the 2022 fieldwork. The efficacy of the 2022 search coverage in this area is confirmed by the anchor being relocated 113m SW from its georeferenced position. This 'missing' cannon therefore allows revision of the 1970s count of 38 iron cannon to be reduced by one cannon.

8-cannon area, now 7-cannon area

The '8-cannon area' was observed to consist of six intact cannon and two broken cannon sections. The two broken cannon sections were measured to be 1.5 and 1.0m respectively (intact cannon across the site vary in size from between 2.1 to 3.0m in length), and only one of the broken cannon parts has a cascabel. The other broken part with no cascabel has two straight broken edges at each end, with the bore visible at both

ends, and is not worn or eroded. These broken cannon sections are thus interpreted as two broken parts of a single 2.5m length cannon which would make it a ‘7-cannon area’, further reducing the cannon count by one. Significantly, this area is interpreted as the jetsam site where the crew described throwing the lee guns overboard to stop the ship heeling over, and not the main ’12-cannon’ area where broken cannon could have conceivably been carried as ballast, to be found amidst the deteriorating ship’s hull structure and ballast. Logically this would mean the heavy hull of the ship—when it was lifted up and moved 190m north down the reef by the powerful storm—would have impacted upon the jettisoned cannon as it ground over them, during which process it could have broken one of them. In terms of site formation, it is conceivable that this was one of the jettisoned guns that was trapped and rolled by the ship’s hull as it moved down the reef, the heavy forces breaking it in the process. Notably, there is only one other broken cannon, which lies between this 7-cannon area and the 12-cannon area, which could have been broken in the same way as the heavy ship impacted it while being moved down the reef by natural forces.

The orthophotos of the site show dark patches of algae associated with cannon and anchors due to elevated levels of iron leaching from the corroding cannon into the seabed and water column promoting macroalgal growth. This phenomenon of ‘black reefs’ has been studied on tropical coral reef environments where both modern steel and historic iron vessels have been wrecked (Hatcher 1984; Kelly et al. 2012; Malliaros and Hunter 2017).

Fig. 28. Jane Liddon, Edie Liddon, Rick Cameron, and Deb Shefi searching for underwater features aboard Justin Renae (R. Anderson, WA Museum, 2022).

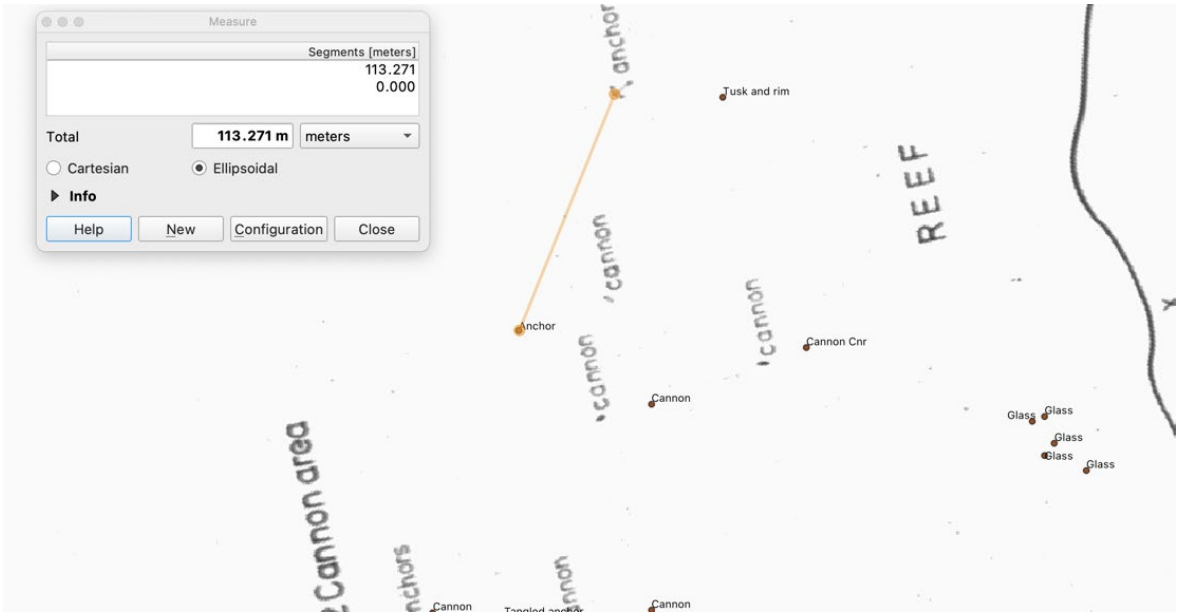

Fig. 29. Screenshot of GIS showing distance between 1978 georeferenced map and actual location of anchor. Note 2022 GPS positions (red dots) of only two cannon relocated in this area, and 1978 mapped positions of three cannon (R. Anderson, WA Museum, 2022).

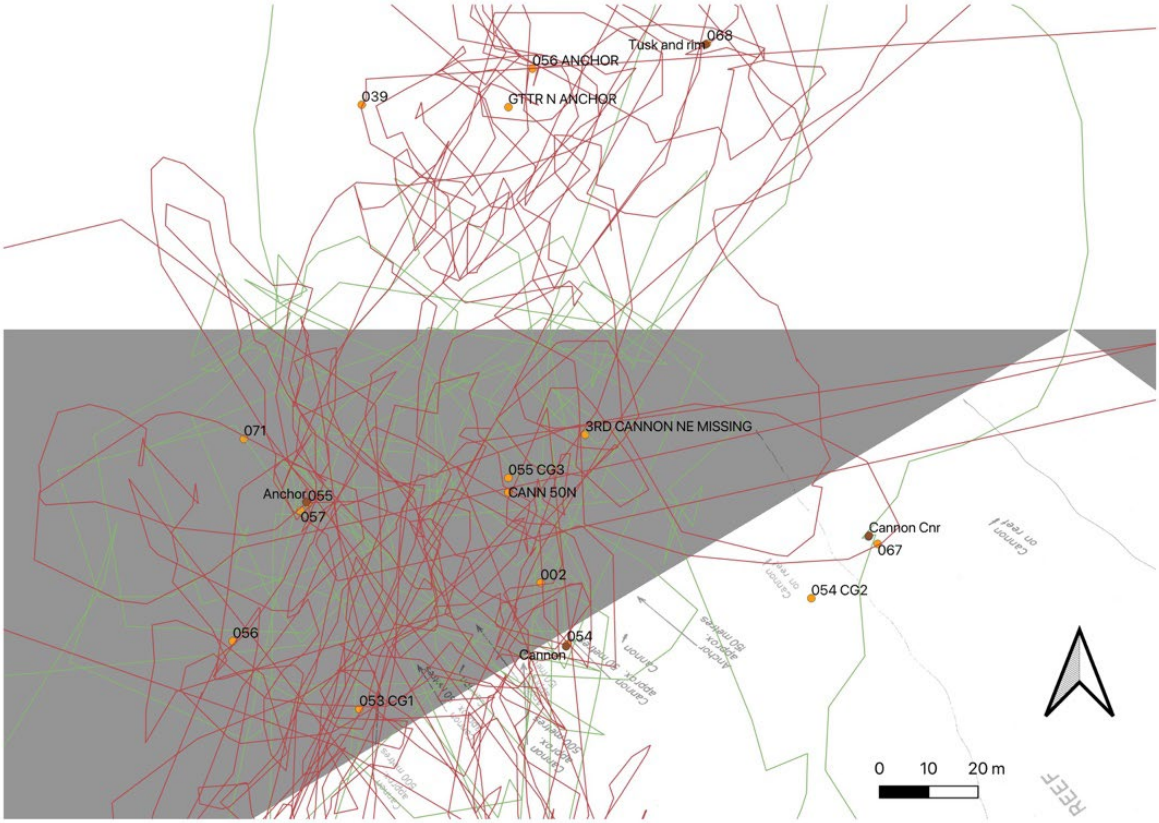

Fig. 30. Vessel and jetski GPS tracks showing comprehensive survey coverage in area of missing north-east cannon—'3RD CANNON NE MISSING' point indicates search position obtained from georeferenced 1978 site plan (R. Anderson, WA Museum, 2022).

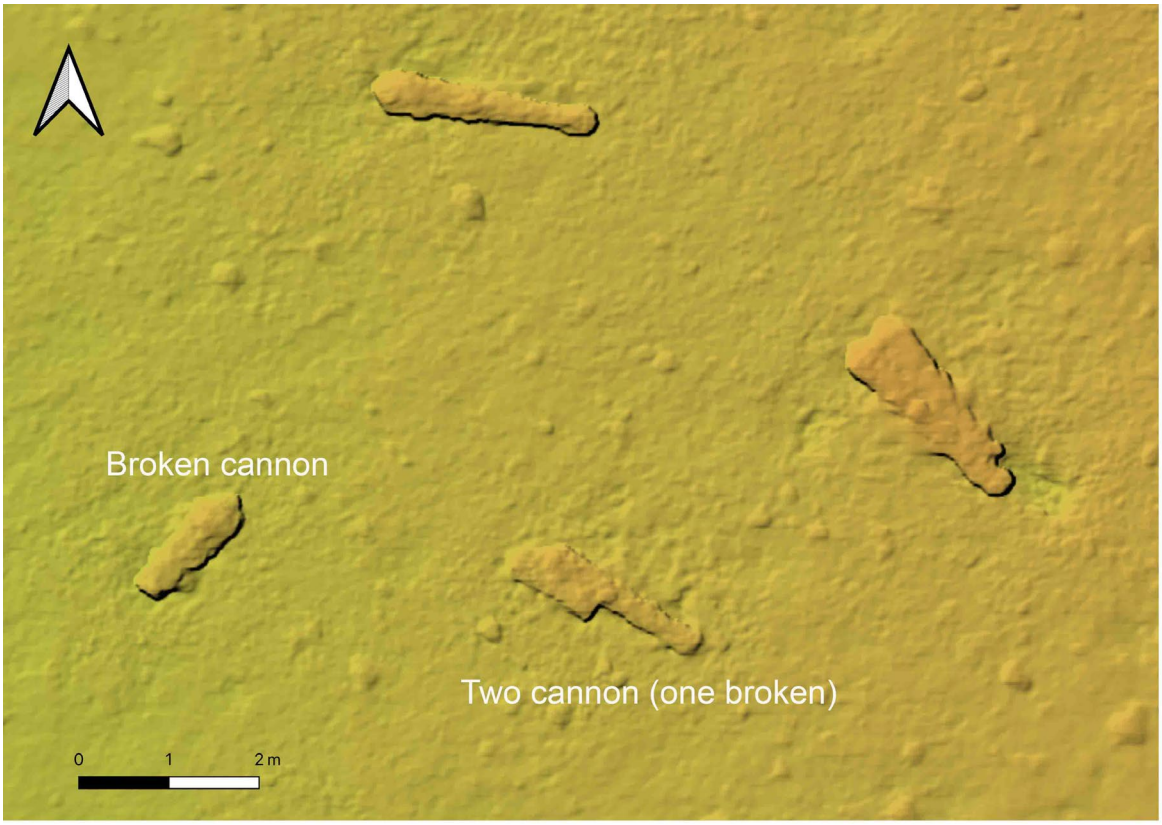

Fig. 31. Detail of DEM of SW area of 8-cannon area showing 4 intact cannon and two broken cannon sections. The larger, broken section with cascabel is visible on the left (R. Anderson and P. Morrison, WA Museum, 2022).

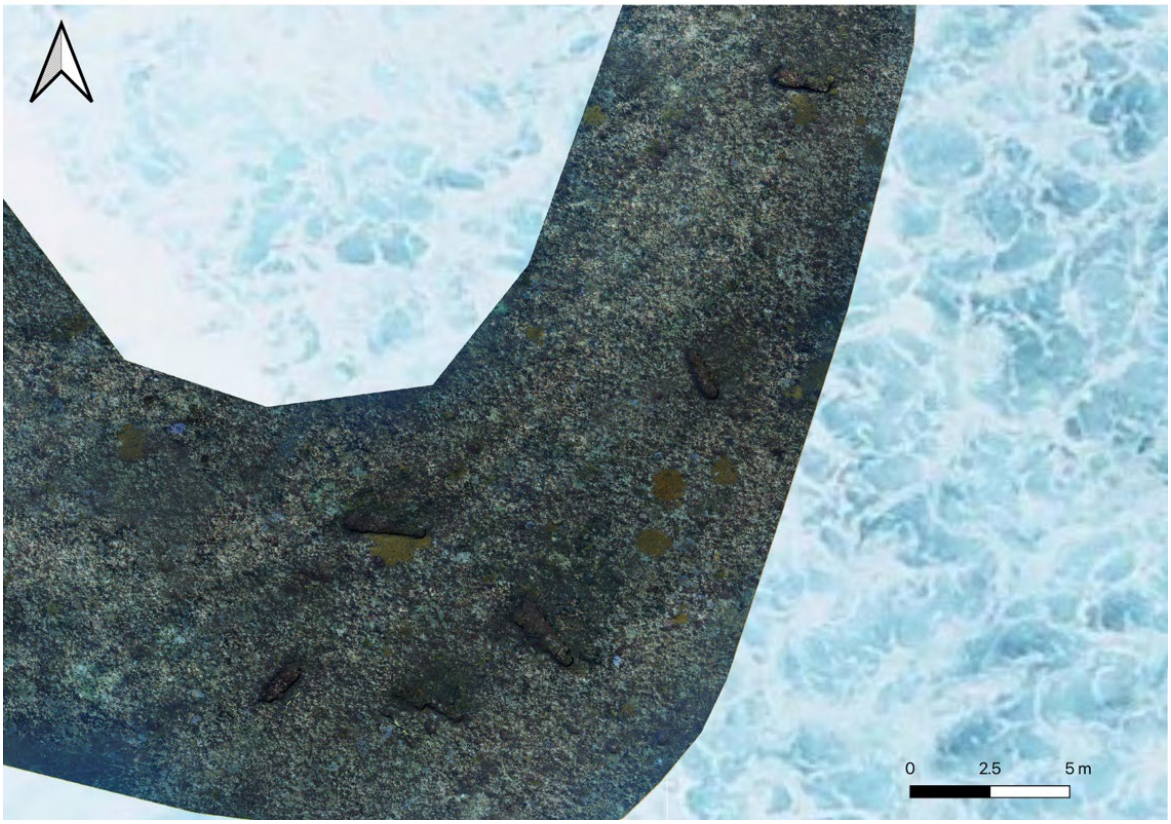

Fig. 32. Orthophoto of 8-cannon area. Note dark patches of algae on seabed in vicinity of cannon (R. Anderson and P. Morrison, WA Museum, 2022).

PHOTOGRAMMETRY REPORT

Over 6,000 images were recorded during four diving and snorkelling days, across the 8-cannon, 12-cannon, main anchor, and gutter areas. All these recordings were able to be aligned in a single model, georeferenced using nine GPS points and ten 1-m scale bars. Key metrics are reported in Table 2.

Images were recorded using a Sony RX100IV compact camera with a Fantasea UWL-400Q Wide Angle Wet Lens. The 3D models were reconstructed using Agisoft Metashape Professional (Build 1.7.1.1797) and uploaded to Sketchfab. It can be accessed via: https://sketchfab.com/3d-models/zeewijk-1727-wreck-site-2022-5c8a8b3e71d34389b9e9c5572df37f42

Table 2. Key photogrammetry metrics

Area	6130 m^2
Images	6413
GPS Points	9
Scale bars	10
Ground resolution	1.09 mm/pix
Projections	14,204,048
Reprojection error	4.73 pix
GPS total Root Mean Square Deviation (RMSD)	2.8 m
Scale bar total error	0.024 m

THE QUESTION OF TWO WRECKS—VOC SHIP *AAGTEKERKE* (1726)

VOC ship *Aagtekerke* was built in the same shipyard of the VOC chamber of Zeeland as *Zeewijk* and by the same shipwright Hendrik Raas (Matthaeus 1759:15, nos 150 and 152). It measured about 800 metric tons, and it had the same length of 145 Amsterdam feet (41 meters) as *Zeewijk*. Its construction had commenced on 16 May 1724, it set sail on 27 May 1725, leaving the Cape of Good Hope in South Africa on 27 January 1726, after which it disappeared (Matthaeus 1759:15, no. 150; Bruijn et al. 1979:2622.1).

Aagtekerke was armed with 36 cannon, mainly 'gotelingen' which are cast iron, muzzle loaded guns. These cannon would have included an assortment of three, six, and twelve pounders. In addition, the ship was fitted with four bronze, breech-loading swivel guns, or 'bassen' (CIE 2014:24). The records detailing the arrival and departures from the Cape of Good Hope confirm that the ship carried 36 cannon and 4 swivel guns in January 1726 (NL-HaNA 1726).

Aagtekerke thus had a similar number of large iron cannon, and half the number of bronze swivel guns that *Zeewijk* carried. Green (2015, 2018, 2020:36) previously noted this: 'As evidence for two wrecks, the amount of ironware found falls far short. The 38 cannons and six anchors found on the site are not consistent with the remains of two wrecks'.

Ideally, there would have to be a greater number of guns approaching the maximum potential of 72 cannon and 12 swivel guns in the Pelsaert Group to confirm the presence both *Zeewijk* and *Aagtekerke* in the same area. More importantly, the number of cannon

and swivel guns accounted for on the *Zeewijk* shipwreck site perfectly account for the number of cannon (36) and swivel guns (8) carried by *Zeewijk* (see Appendix 1), and is inconsistent with those aboard *Aagtekerke,* which had four swivel guns less.

With the report of four cannon 60m east of the '8-cannon area' now positively discounted; identification of two broken parts of a single cannon at the '8-cannon area' making it a '7-cannon area'; and an apparently mistakenly mapped cannon to the northeast of the main area reducing the number of cannon in this area from three to two, this results in an overall revised total of 36 iron cannon. This number perfectly matches *Zeewijk* having been outfitted with 36 iron cannon. As there are no extra cannon on the site, this convincingly discounts the theory that it is a composite site of two large VOC ships.

CONCLUSIONS

The 2022 fieldwork comprehensively mapped the *Zeewijk* shipwreck site on the inner and outer reef using 3D photogrammetry and GPS technology. It resulted in significant new findings allowing a re-evaluation of the total count of all cannon and anchors in the offshore reef, and inshore lagoon areas. This work, when combined with findings of the earlier 'Roaring Forties Project' (Paterson et al. 2019), provides convincing evidence that confirms there is only one shipwreck on the *Zeewijk* site, and negates the hypothesis of two VOC shipwrecks present within the Pelsaert Group, Houtman Abrolhos Islands. The resulting updated corpus of high-resolution digital imagery, 3D models and site data will greatly facilitate future studies, public interpretation outputs and on-going site monitoring and management of this significant Dutch-Australian mutual heritage site.

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APPENDIX 1

Zeewijk artillery and anchor count

Historical research and archaeological surveys conducted in the 1970s and 2022 have accounted for a total of 36 iron guns, eight bronze swivel guns and six anchors on the *Zeewijk* site, consistent with *Zeewijk*'s original armament. A total of 30 iron cannon remain on the *Zeewijk* site, with six guns having been removed.

A desktop study undertaken in 2020 counted a possible maximum number of 42 iron cannon, with 38 iron cannon counted from the 1978 WAM site plans, and with the conservative inclusion of an unconfirmed report of four iron cannon reported 60m east of the 8-cannon area. Other sources consulted in the desktop study included the Department of Maritime Archaeology's Artefact Database, all previous WAM *Zeewijk* expedition archaeological reports and archival newspaper reports.

The 2022 3D photogrammetry expedition comprehensively covered the entire *Zeewijk* outer reef site. One of the aims was to follow up on the (now proven non-existent) four-cannon report, providing new data to enable a revision of the 2020 count.

Tables 1, 2 and 3 below record the total counts of iron guns, bronze swivel guns and anchors removed from, and remaining on the *Zeewijk* shipwreck site. Anchor shanks only were counted, while broken crowns or palms were excluded from this tally, to arrive at a minimum number of individuals (MNI) (Table 3).

Table 1: Iron cannon count

Description	Location	2020 Count	2022 Count
8-cannon area	Outer reef	8	7
Broken cannon	Outer reef	1	1
Crossed cannon	Outer reef	2	2
12-cannon area	Outer reef	12	12
Bar shot and cannon	Outer reef	1	1
Cannon approx. 500m NNW **(not surveyed into 1970s site plan)**	Outer reef	1	1
Cannon approx. 50m NW **(not surveyed into 1970s site plan)**	Outer reef	1	1
Cannon close to reef	Outer reef	1	0
Cannon on reef ('corner cannon')	Outer reef	1	1
4 cannon inside reef area	Inside reef	4	4
3 cannon removed from inside reef by HMAS *Mildura* 1952–1953 ZW5572, ZW5573, ????	2 in WAM Collection, 1 missing	3	3

Table 1: Iron cannon count, continued

Description	Location	2020 Count	2022 Count
2 cannon removed from inside reef in 1963 by Hugh Edwards/West Australian Newspapers ZW5574, ZW5575	WAM Collection and ANMM Collection	2	2
1 cannon removed from inside reef by Bill Sutcliffe 1962 ZW5578	WAM Collection	1	1
4 cannon reported by fishers in shallows on outer reef but not observed in any archaeological surveys between 1970s–2022	Outer reef – 60m east of 8-cannon area	4 – not confirmed	0: confirmed no cannon in this area
TOTAL		**42**	**36**

Table 2: Bronze swivel gun count

Description	Location	Number
2 swivel guns salvaged by *Zeewijk* survivors and placed on rescue sloop	Taken to Batavia	2
1 swivel gun recovered by Lt Cdr Stokes RN from Gun Island 24/4/1840 - (ZW1111)	Tower of London Armoury	1
'Boschetti swivel gun' found NW of Gun Island in 1968 (ZW1049)	WA Museum Collection—Museum of Geraldton	1
2 eroded remains of swivel guns recovered by WA Museum (ZW2163, ZW1345)	WA Museum Collection	2
2 swivel guns recovered from Gun Island during guano mining operations by Saddington 1891	Missing	2
TOTAL		**8**

Table 3: Anchor count from WAM site plans

Description	Number
Main ('standing') anchor	1
'One armed anchor'	1
'No armed anchor'—shank only	1
'Tangled anchor'	1
'Shank of anchor' near pintle	1
Anchor approx. 150m NW from main site	1
TOTAL	**6**