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Hydrographic Survey of the Freycinet, Huon and Tasman Fracture Australian Marine Parks

Project: BF2019_v01

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1	Address Neville Barrett comments	B.Heaney / C. Davey	27-08-2019

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Figures and Tables

1 Executive summary

CSIRO's Geophysical Survey and Mapping, Shallow Survey Facility (SSF) was contracted by the Institute for Marine and Antarctic Studies (IMAS) of the University of Tasmania (UTAS) in collaboration with Parks Australia, to undertake a 2 week hydrographic survey of the Freycinet Australian Marine Park to complete surveying of the Park out to approximately 300 m. Depending on weather conditions further surveying of the Huon and Tasman Fracture sites could also be attempted. Two sites, Pedra and South West Cape survey areas, were undertaken for comparison data outside of Marine Park areas.

Nick Dando from Geoscience Australia (GA) mobilised their Kongsberg EM2040c Mulitbeam Echosounder (MBES) system onboard the MV Bluefin in Hobart on Thursday and Friday 7-8 March with assistance from Stuart Edwards, Craig Davey and Bernadette Heaney, CSIRO. Divers from IMAS attached the transducer to the hull of the ship.

The GA system also included a POSMV navigation system, a Valeport sound velocity profiler (and a spare profiler) Bridge display laptop and Bridge display screen.

Onboard the Bluefin were Master Chris Lambert, Chief Engineer Ashley Dean, Chief Mate Daniel Garwood, 2nd Mate Steven King, 3rd Mate Ian Miller and cook, Emanuel Hiras; Dr Neville Barrett, IMAS, and Bernadette Heaney, CSIRO.

The Bluefin departed Hobart on the evening of 8 March; returning to Beauty Point on 22 March.

During the survey, the data were mapped to Lowest Astronomical Tide (LAT), but for the final survey products, the soundings and map products have been reduced to the Australian Height Datum (AHD).

1.1 Summary of the Survey Details

CATEGORY	DETAILS
Survey Area	Freycinet, Huon, Tasman Fracture Marine Parks; Pedra Branca and South West Cape areas.
Survey Dates	8 – 22 March 2019
Survey Vessel	MV Bluefin
Survey Personnel	Neville Barrett (IMAS), Bernadette Heaney (CSIRO), Ian Miller
MBES System	Kongsberg EM2040c (single head)
Positioning System	POS MV V5 (aided with Fugro G2 Marinestar signal). *Accuracy: 0.10 m (Horizontal) & 0.15 m (Vertical) @ 95%.*
Motion & Gyro System	POS MV V5 *Accuracy: 0.02° (Heading), 0.02° (Roll/Pitch), 5 cm or 5% (Heave) & 2 cm or 2% (TrueHeave)*
Sound Velocity	Valeport MiniSVS (Head) & MiniSVP (Water Column)
Horizontal Datum & Projection (Processed)	WGS84, UTM Zone 55 (South)
Reduced Vertical Datum (Processed)	AHD (Australian Height Datum) using AUSGeoid09
Survey Standard (Processed)	IHO Order 1a

Table 1: Summary of the survey details

1.2 Summary of raw files by area

Surveying commenced underway to and at the Freycinet MP. Lines were planned to collect data to fill in gaps in bathymetry data coverage.

The Freycinet survey was interrupted to return to Coles Bay to rendezvous with a diver to secure the transducer as the data quality was suffering due to movement. Calibration lines were run over Jo’s patch on the way back out to recommence the Freycinet survey.

Due to a set up problem POSMV data was not collected correctly until 10 March 2019 07:36.

AREA	START FILE	END FILE
Transit 1	4	28
Freycinet MP	29	423
Transit to Coles Bay **And Calibration lines**	424	441
Freycinet MP	442	512

Transit 3	513	536
Huon MP	537	632
Transit 4	633	635
Pedra Branca	636	659
Transit 5	660	666
Tasman Fracture MP	667	786
Transit 6	787	789
South West Cape	790	894
Transit 7 (Blythe Star 898)	895	986

Table 2 Data files per area

1.3 Summary of the Data Acquired

INSTRUMENT	DATA TYPE	RAW DATA SIZE	NUMBER OF FILES
EM2040C	Multibeam Echosounder Bathymetry & Backscatter (.ALL)	128 Gb	886
EM2040C	Multibeam Echosounder Water Column Data	1.30 Tb	729
POS MV	RAW GNSS & IMU (000 file)	26.2 Gb	421
SVP Casts	Sound Velocity Profile	17 Kb	18

Table 3: Raw data collected by instrument

1.4 Summary of Bathymetry Results

SITE	MINIMUM DEPTH	MAXIMUM DEPTH	COMMENTS
Freycinet MP	78.7	384.3	Mainly flat, Interesting slumps at shelf edge
Huon MP	55.3	178	Interesting rocky outcrops near coast; scoured sand cover deeper
Tasman Fracture MP	47	363	Rocky outcrop at most northern section inside and outside the MP. Very flat till shelf intersection. Some survey data collected around shelf break.
Pedra Branca	15	165	Good data coverage
South West Cape	17.1	193.8	Good data coverage

Table 4: Bathymetry results

1.5 Summary of Backscatter Results

SITE	NOTEABLE ROCK OUTCROP	SIGNIFICANT FEATURES
Freycinet MP	No	Not much to show in backscatter results. A few slumps at the shelf edge.

Huon MP	Yes	Rocky outcrops well defined to the north of the survey area
Tasman Fracture MP	Small	Rocky outcrops in the northern edge of the survey area. Mainly outside the MP
Pedra Branca	Yes	Very rocky
South West Cape	Yes	Two significant rocky areas.

Table 5: Backscatter features noted

2 Site Location

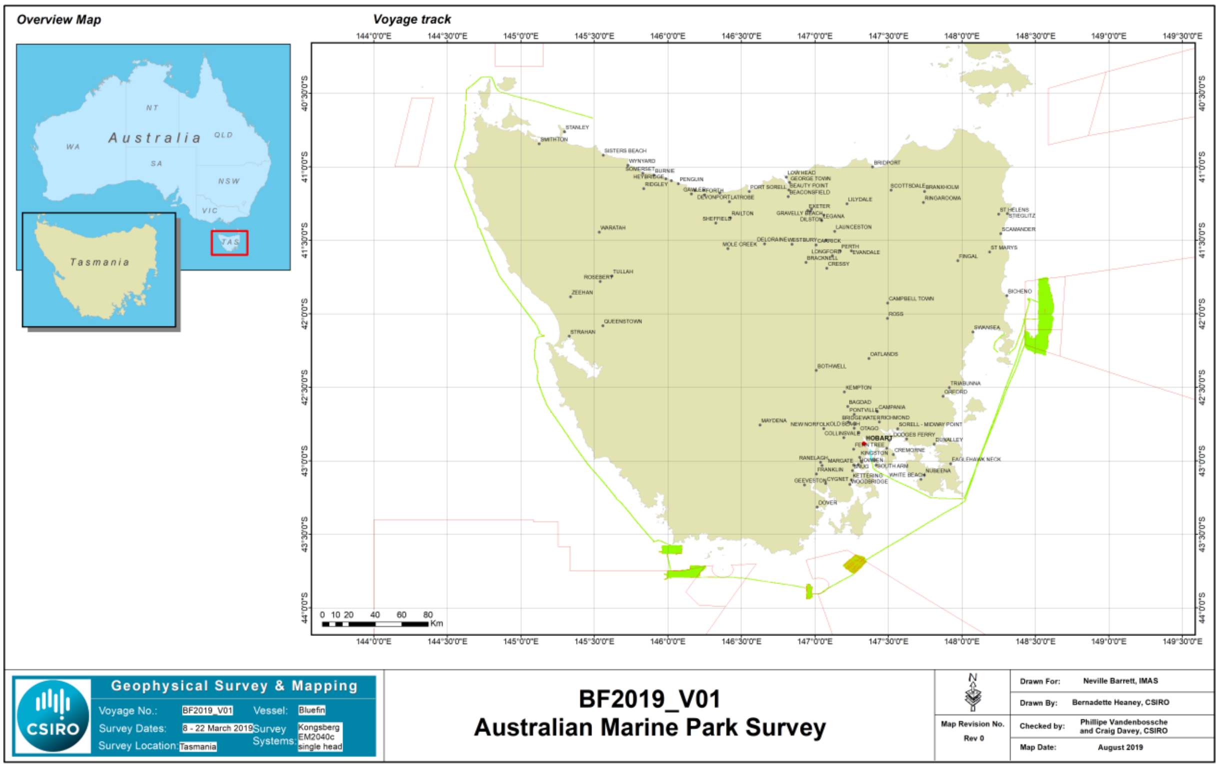

Figure 1 BF2019_V01 voyage track

3 Results

The data provided is presented in the WGS84, UTM55 (South) projected horizontal datum, and the vertical datum is referenced to the Australian Height Datum (AHD).

Backscatter data is derived from the amplitude strength of the returning sound from the MBES, and is useful in that it can give an indication of seafloor characterisation. Greyscale mosaics have been produced from the backscatter data and are presented, along with the bathymetry, in the sections below.

The processed data set consists of an ascii text file of 2 m xyz data, and bathymetry and backscatter tif images for each area as presented below.

A bathymetry image of the wreck of the Blythe Star is also presented.

Data products of the west coast transit have been prepared.

3.1 Freycinet Australian Marine Park

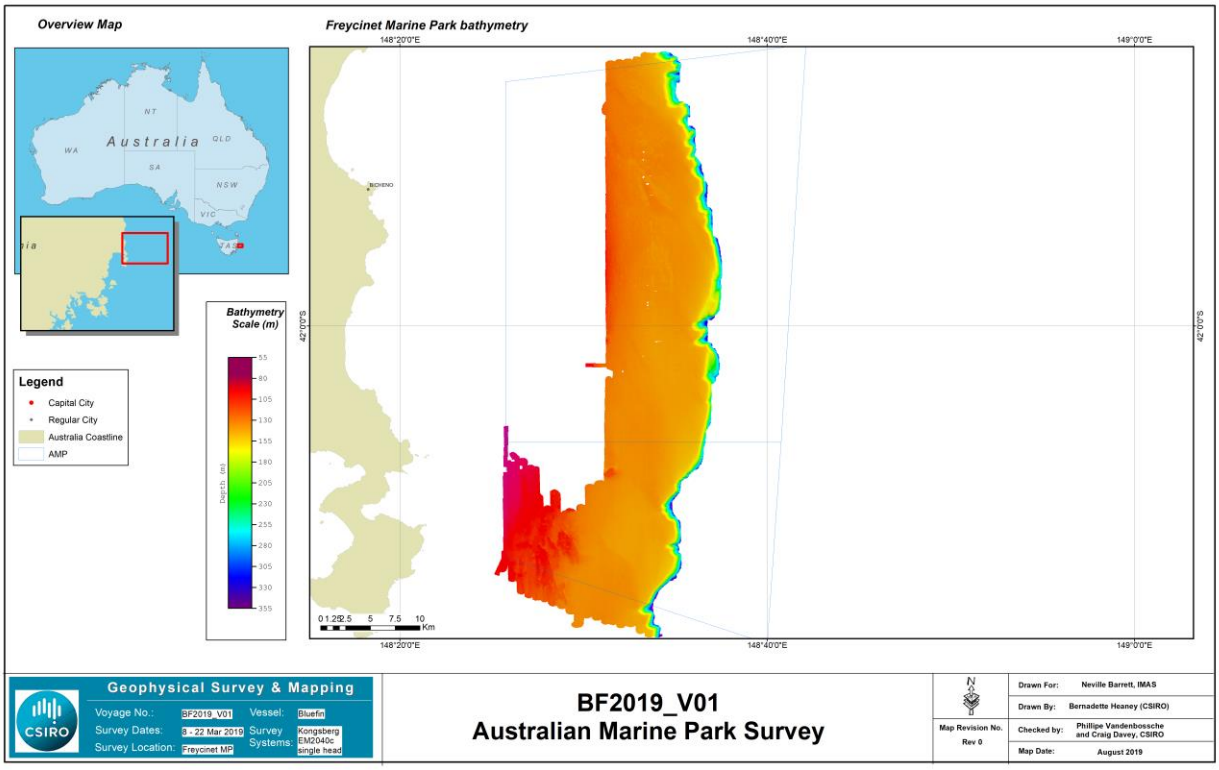

Figure 2: Freycinet Marine Park bathymetry

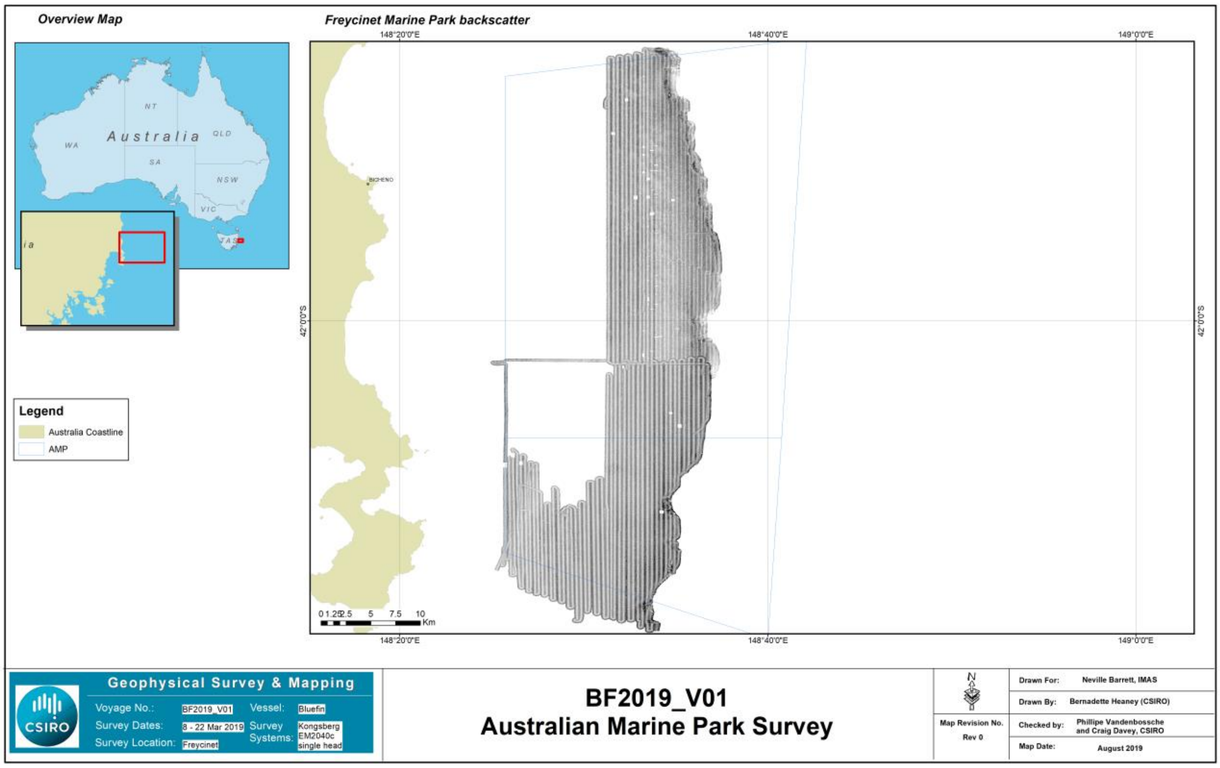

Figure 3: Freycinet Marine Park backscatter data

3.2 Huon Australian Marine Park

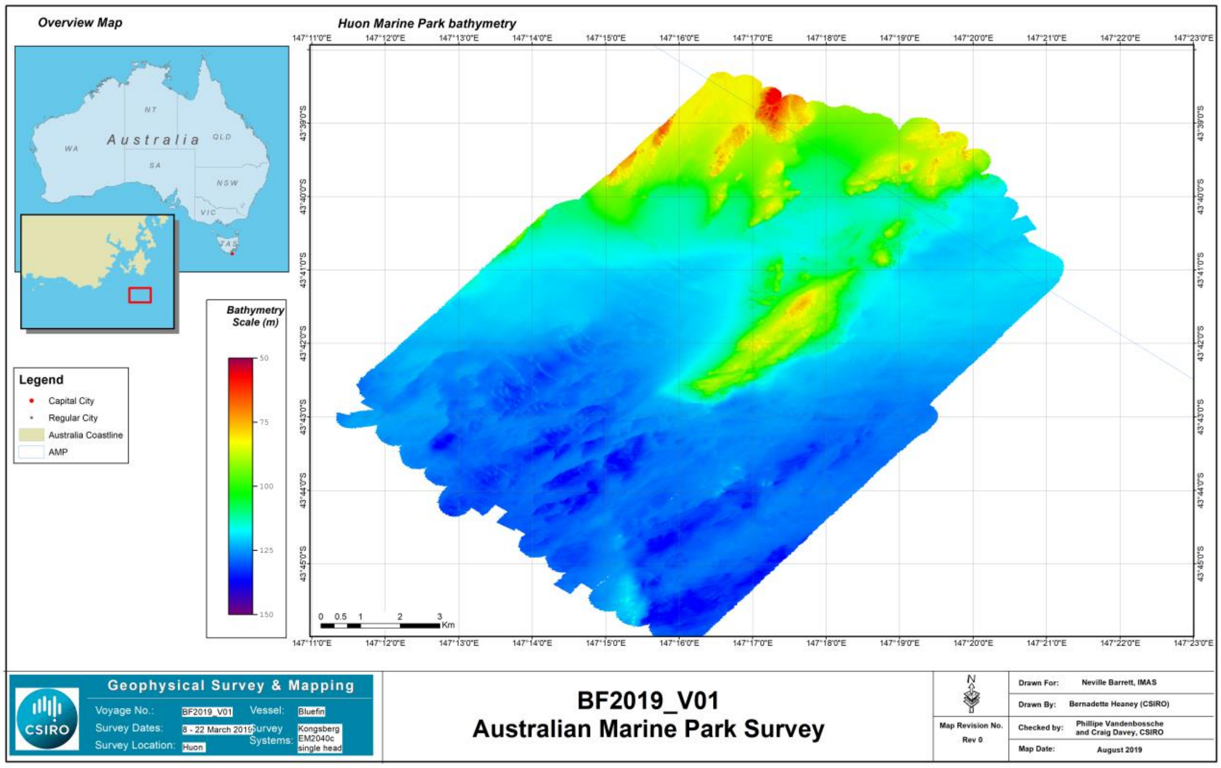

Figure 4: Huon Marine Park bathymetry

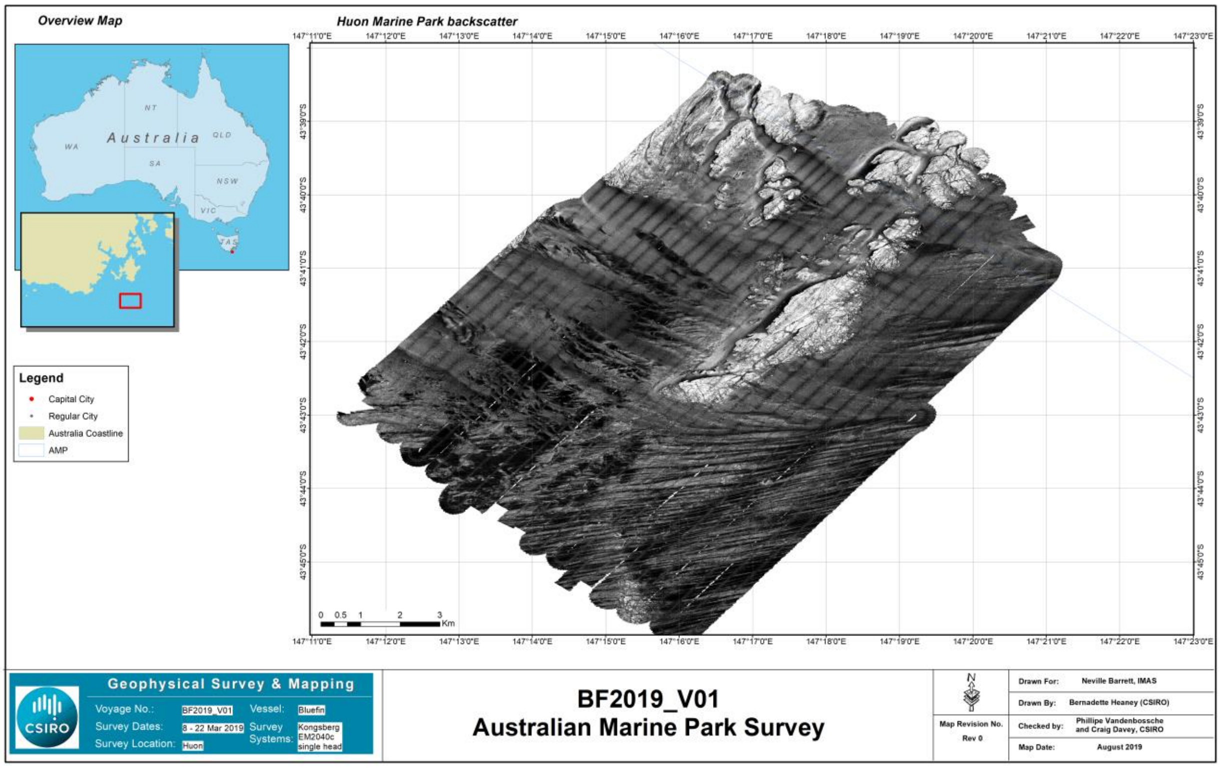

Figure 5: Huon Marine Park backscatter

3.3 Tasman Fracture Australian Marine Park

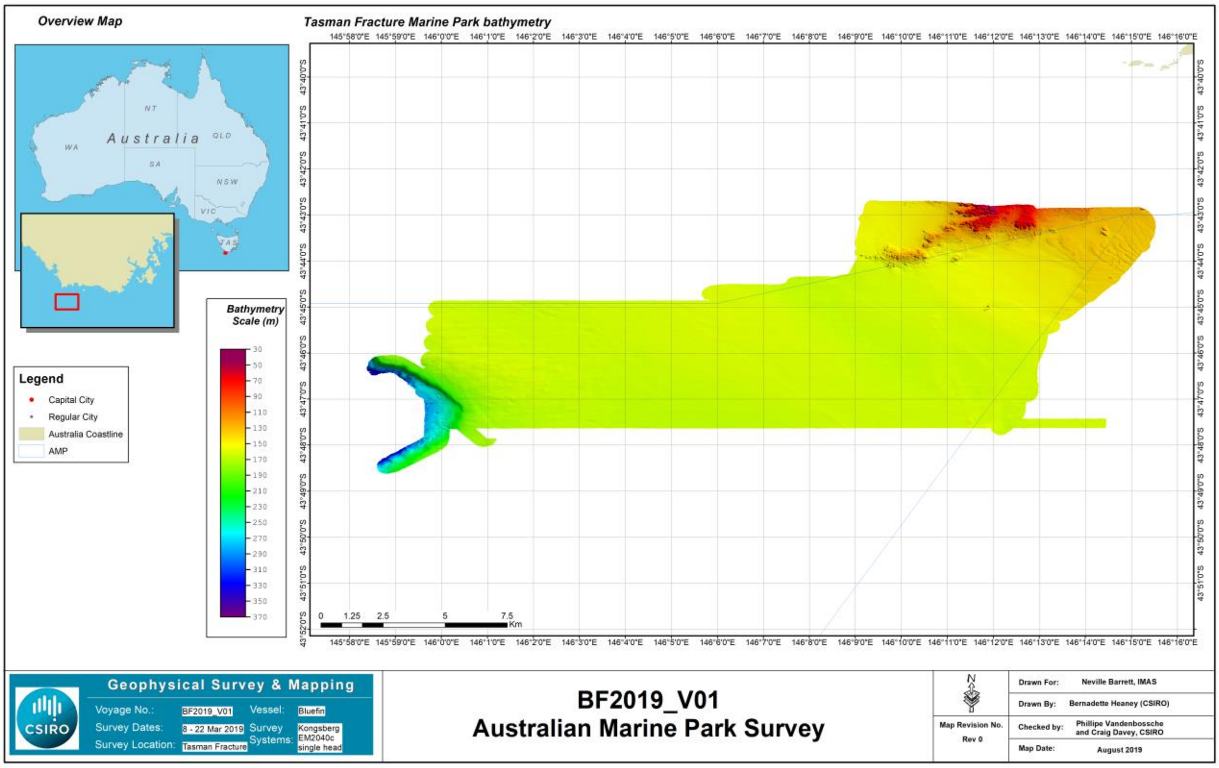

Figure 6: Tasman Fracture Marine Park bathymetry

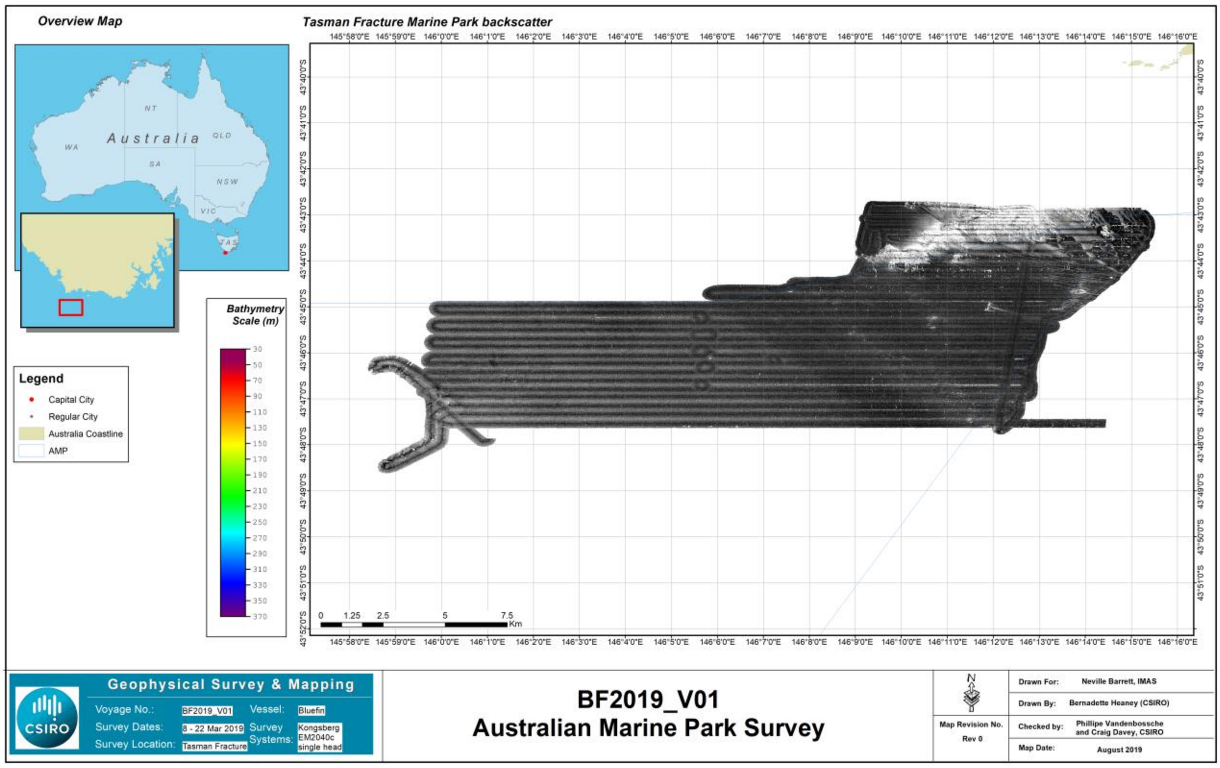

Figure 7: Tasman Fracture Marine Park backscatter

3.4 Pedra Branca

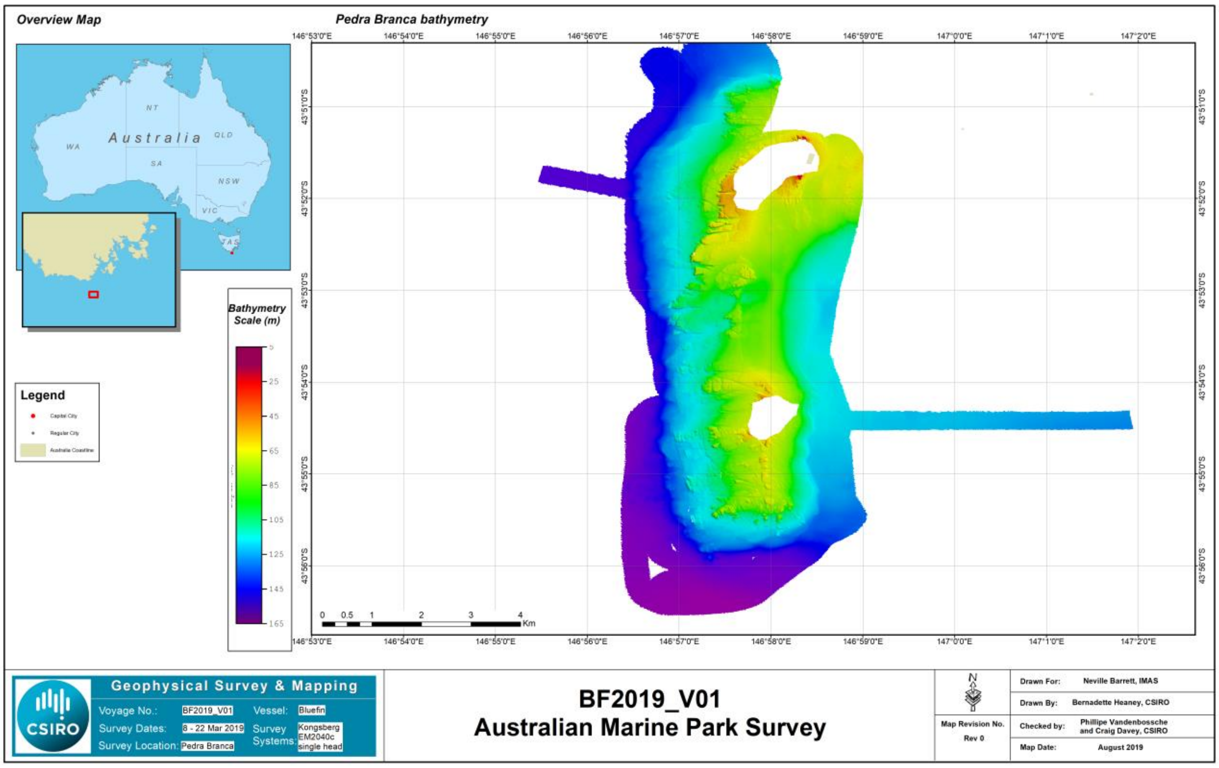

Figure 8: Pedra Branca bathymetry

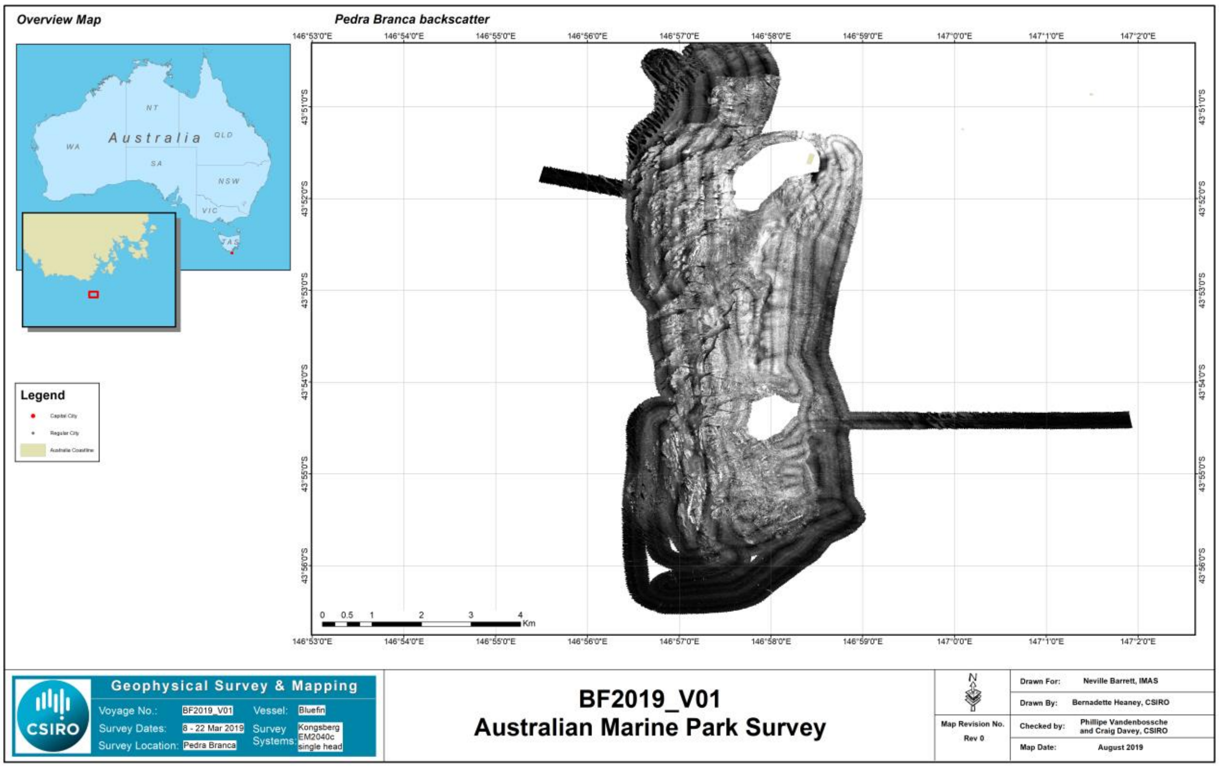

Figure 9: Pedra Branca backscatter

3.5 South West Cape

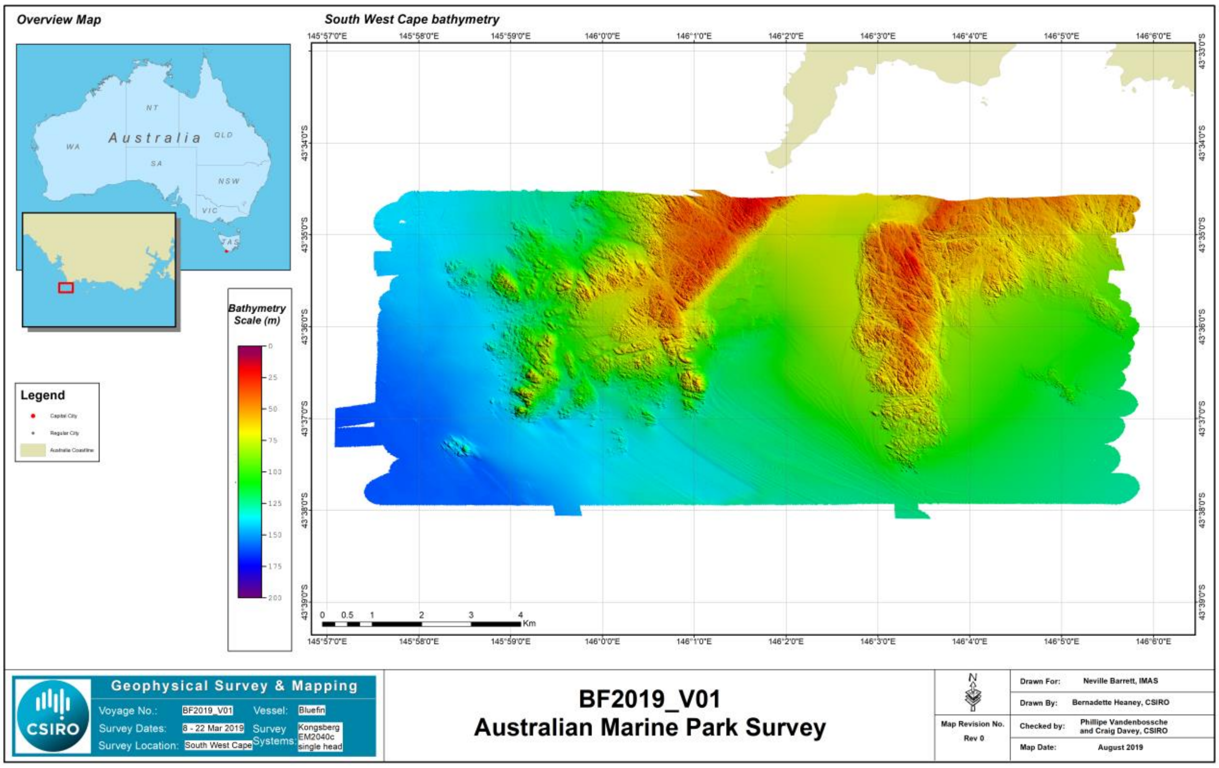

Figure 10: South West Cape bathymetry

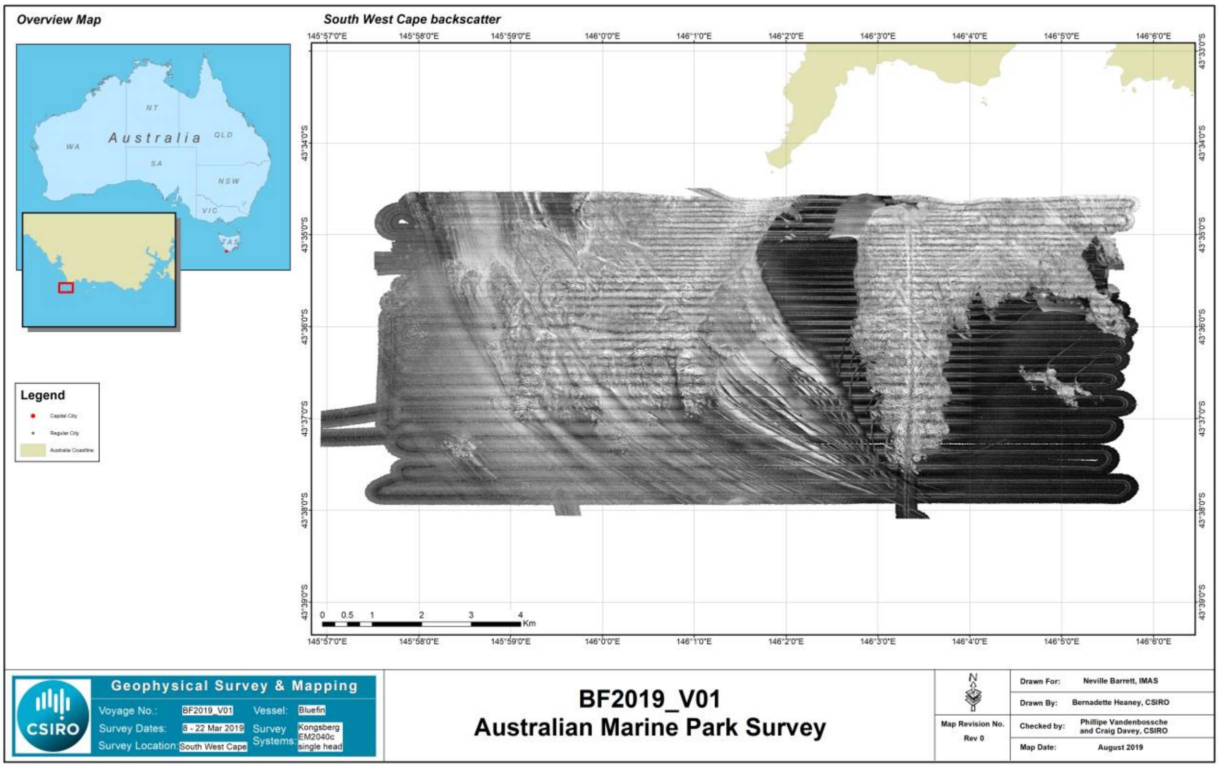

Figure 11: South West Cape backscatter

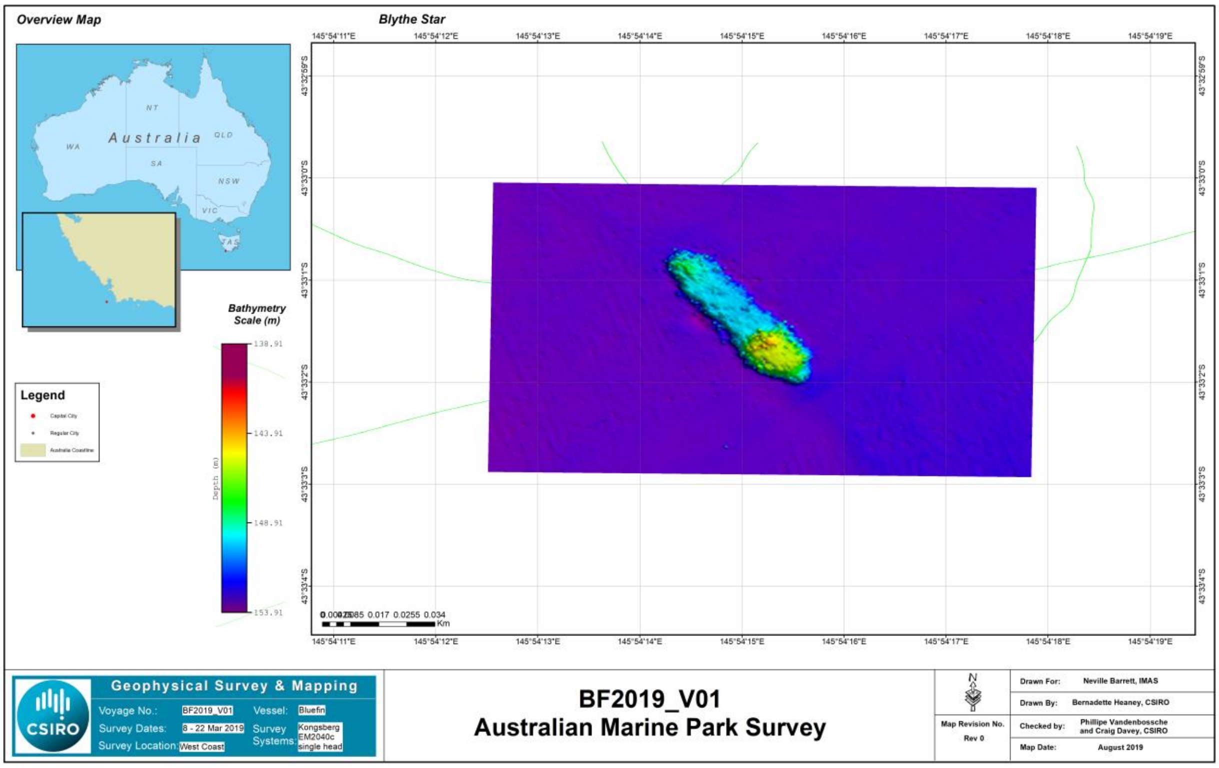

Figure 12: Blythe Star wreck

4 Survey & Processing Details

4.1 Vessel & Equipment

4.1.1 Vessel

The 35 m AMC (Australian Maritime Collage) operated training vessel, *MV Bluefin,* was used for the survey operations.

Figure 13: MV Bluefin

4.1.2 Survey Hardware

The following survey equipment, owned and installed by GA, was used for the survey operations.

ITEM	MANUFACTURER	MODEL	SERIAL NO.
Acquisition Computer	Custom built	Workstation HWS window 7	No. 2
Ancillary Computer	Toshiba (SVP)	Tecra A50-A	4E056637H
MBES (Processing Unit – PU	Kongsberg (Norway)	EM2040C slim PU	127
MBES Transducer	Kongsberg (Norway)	EM2040C dual-swath	1338
Motion Reference System	Applanix	POS MV V5	5810
Motion Reference Unit (MRU)	Applanix	IMU7	2383
SV Sensor (MBES Tx)	Valeport UK	miniSVS	42869
SV Sensor - Profiler	Valeport UK	miniSVS	34826
SV Sensor – Profiler (spare)	Valeport UK	Midas SVX2	44514

Table 6: Survey equipment (Source: GA)

Figure 14: Data acquisition set up

Figure 15 Bridge display - surveying around Pedra Branca

4.1.3 Survey Software

The following GA survey and CSIRO processing software was used on board the vessel.

ITEM	MANUFACTURER/VENDOR	MODEL	VERSION
Data Acquisition	Kongsberg	SIS	4.3.2
Motion Reference Unit	Applanix	POS MV FW	9.29
Sound Velocity	Valeport UK	Data Log Express	G11
MBES Data Processing	CARIS	HIPS & SIPS	10.4
Backscatter Data Processing	CARIS	HIPS & SIPS	10.4

Table 7: Survey software (Source: GA & CSIRO)

4.2 Acquisition

4.2.1 General Data Acquisition Information

Survey acquisition was undertaken according to the following criteria:

- A Kongsberg EM2040C single head MBES (with a 1.3° x 1.3° beamwidth) was used to acquire all data. Auxiliary sensors included an Applanix POS MV for position and motion information (aided with a Fugro Marinestar GNSS G2 subscription signal), a Valeport MiniSVS for sound velocity at the transducer and a Valeport MiniSVP (S/N 34826) for water column sound velocity profiles.
- The MBES system was installed by GA as a fully calibrated and operational system.
- The bathymetry data were acquiring using Kongsberg's SIS (Seafloor Information System) software.
- Dual Swath mode (dynamic setting) was utilised throughout the survey to increase the along track resolution.
- A sonar frequency of 300 kHz was selected.
- Sector coverages were set as required. The maximum was 63 degrees port and 63 degrees starboard.
- Angular coverage mode was set to Auto and Beam Spacing was set to HD EQDST.
- Vessel speed was typically 6-7 knots for the majority of the survey.
- Eighteen sound velocity profiles were taken throughout the survey.
- Survey cross/check lines were performed at each site for data QC.

4.2.2 Surface Positioning

An Applanix POS MV was used to provide real time surface positioning aided with a Fugro Marinestar GNSS G2 correction signal. The POS MV combines the Inertial Measurement Unit (IMU) and Global Navigation Satellite System (GNSS) data into an integrated navigation solution.

Real time position information was output to the EM2040C processing unit (PU) via RS232 at a frequency of 100 Hertz. Offsets entered into the Applanix POSMV were done to reduce the position information to an arbitrary location (RP) on the vessel.

4.2.3 Heading and Motion Data

An Applanix POS MV was used to provide heading and motion data in real time. Motion and heading was output to transceiver unit via RS232 at a frequency of 100 Hertz. Applanix TrueHeave was recorded for application in post processing.

4.2.4 Multibeam Bathymetry

Multibeam bathymetry was acquired using a Kongsberg EM2040C single head echosounder.

Position data was input directly to the transceiver unit via a NMEA GGA string at 1 Hertz. Time information was input directly to the transceiver unit via a NMEA ZDA sting in conjunction with a 1PPS input via RS232 from the POS MV. Velocity information was input directly via an Ethernet real time output packet at 100 Hertz. Motion and heading data were input directly to the transceiver unit via an EM3000 string at 100 Hertz.

Sound velocity at the transducer was interfaced to the EM2040C acquisition computer at 1 Hertz.

Multibeam bathymetry was corrected for position, motion and sound velocity in real time and recorded in Kongsberg's standard datagram format with .all extension.

Multibeam bathymetry data was monitored for quality throughout the survey through the Seafloor Information System (SIS) software provided by Kongsberg.

4.3 Processing

4.3.1 Multibeam Bathymetry Data

Multibeam data was logged in the Kongsberg's proprietary *.all format and was converted to be processed within Caris HIPS and SIPS version 10.4. Converted data had sound velocity profiles reapplied using the nearest profile in distance where necessary.

Total Propagated uncertainty was computed, and gridded Combined Uncertainty and Bathymetric Estimator (CUBE) surfaces were created at a 2 m resolution for the survey sites.

Final post processing of the data undertaken in the office in Hobart, involved additional swath and surface editing of the bathymetry in CARIS HIPS and SIPS to visually remove any remaining outliers, as well the application of True Heave and POSPac derived SBETs (Smooth Best Estimate of Trajectory) files. Applanix's POSPac MMS 8 aided-inertial post-processing software was used to generate these SBET files. POSPac is a post-processing tool that incorporates raw position and orientation measurements, precise clock & ephemeris data (satellite) as well as private (if required) and publically available GNSS base station correction data, to provide, (a) QC of the MBES/GNSS-INS installation biases, and (b) improved vertical and horizontal positional accuracy of the data.

The remote location of the survey areas meant that the only available form of post-processing in POSPac MMS, was the stand-alone "Primary Marinestar Nav" mode (as no appropriately close-by base stations could be used).

Final cleaned CUBE surfaces, referenced to the WGS84 UTM Zone 55 (South) horizontal datum, and reduced vertically to the Australian Height Datum (using the AusGeoid09 model), were generated at 2 m resolution for the survey areas.

Line data for the transit data was processed in Swath editor in CARIS and .GSF and xyz files produced for each line.

4.3.2 Navigation, Motion and Time Data

The real-time position and attitude solution was not used for the majority of this dataset and instead the raw logged ranges and azimuths (from GNSS antennas) and angular rates and accelerations (from IMU) were reprocessed. Reprocessing was conducted within the Applanix POSPac MMS 8.3 software (as described above) using the Marinestar (satellite based) mode to compute a new solution for time, latitude, longitude, height, roll and pitch. From the new solution, new lever arms and angles of the antennas, with respect to the IMU and the RP of the mounting pole, were derived and applied.

The reprocessed dataset (SBET files) were used to overwrite the attitude and motion data that was logged in real time, and were applied to the entire dataset within CARIS HIPS & SIPS.

4.3.3 Backscatter Data

Backscatter information was processed from the raw .all files CARIS software. A final 2 m backscatter mosaic was produced for each of the survey sites and exported as GeoTiff images.

4.3.4 Water Column Data

Water column data (.wcd format) was acquired through out the survey as an additional dataset. The processing and reporting of these datasets is beyond the scope of this report.

4.3.5 Sound Velocity Correction

Eighteen sound velocity profiles were conducted during the survey operations.

4.3.6 Tidal Data Processing

Tidal reduction of acquired data was performed by calculating a GPS tide in CARIS HIPS and SIPS based on the Applanix PosMV and Marinestar G2 ellipsoidal height. A text file containing Ausgeoid09 values (AUSGeoid09_GSA94_55G.txt) was applied to bring the ellipsoidal height to the AHD datum.

4.3.7 Waterline

The recording of accurate daily waterline measurements was not possible at sea, and since the vessel did not return to port during the survey campaign, these measurements were not taken. Instead the vessel's draft was noted at the start of the initial voyage (by GA), and a final draft value was recorded (by CSIRO) at the end of the voyage in Beauty Point. These measurements are summarised in Table 8 below.

DATE/TIME (UTC)	FORWARD DRAFT (M)	AFT DRAFT (M)	MEAN DRAFT (M)
Beauty Point 7/3/19	3.05	4.00	3.525
Coles Bay 13/3/19	2.90	4.00	3.45
Beauty Point 22/3/19	2.65	4.00	3.325

Table 8: Waterline/Draft Measurements

The overall average change in draft was 0.40 m over the full duration of the vessel's charter, from 7/3/2019 to 22/3/19. The final waterline measurement used with reference to the sonar setup, was determined by GA to be **-4.186 m**.

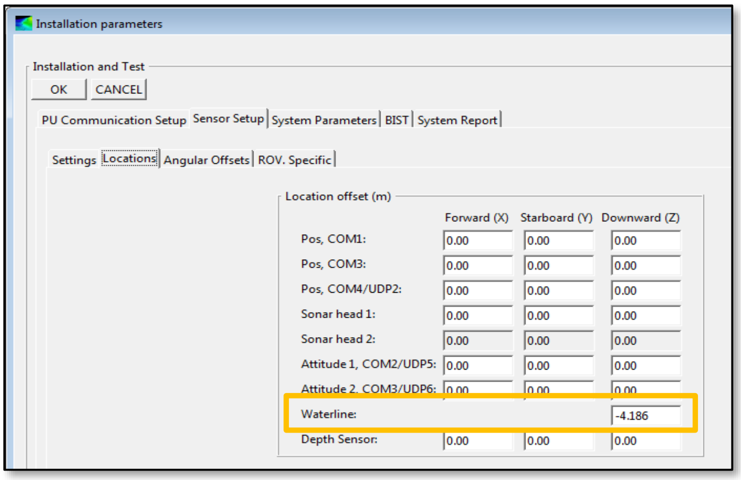

Figure 16: Waterline offset applied in SIS

5 Vessel Configuration

5.1 Sensor Offsets

Sensor offsets on-board the MV Bluefin were provided by GA and are summarised in Table 9, and a screen-capture of the offsets as entered into the POS MV are shown in Figure 17.

SENSOR	X OFFSET FORWARD +VE (M)	Y OFFSET STARBOARD +VE (M)	Z OFFSET +VE DOWN (M)
Sonar Head 1 – EM2040c (Ref)	0.000	0.000	0.000
***Ref to IMU**	-8.340	0.005	-6.455
***Port GNSS Antennae (Pri)**	-8.280	-1.241	-14.493
***Ref to Centre of Rotation**	-7.995	0.542	-4.186
Waterline			-4.186

Table 9: Sensor Offsets (as per POS MV sign convention)

**Please note that the offsets between the Ref, IMU and the GNSS antennae's are reduced by the POS MV before being sent to the EM2040C PU. Offsets between the Ref and the EM2040C Transducer were entered into the SIS acquisition software. As such all data within the .all raw files is reduced to the EM2040C Transducer. They are listed here for information purposes.*

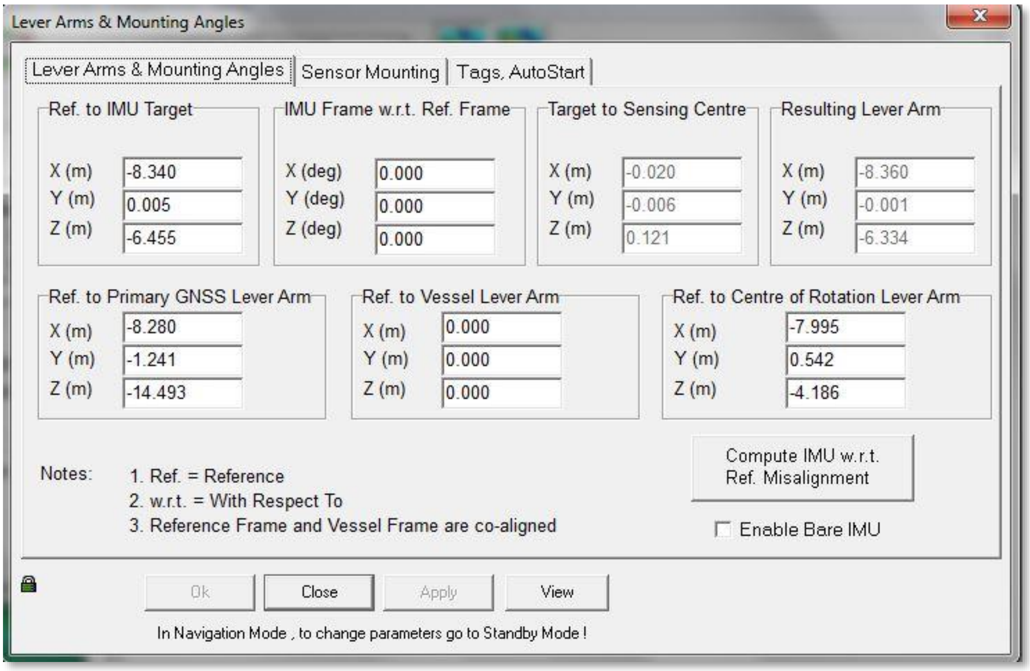

Figure 17: POS MV Lever Arms

6 Calibrations and Checks

6.1 Calibrations

6.1.1 POS MV

The POS MV was calibrated by GA on the 17th June 2017. The calibration, called a GAMS calibration, required manoeuvring of the vessel to induce velocities in the IMU. As such figure of eight style manoeuvres were conducted by the vessel while logging data. The calibration converged in real time and produced a final baseline vector between the primary and secondary antennas as shown in Table 9.

CALIBRATION	X VECTOR (M)	Y VECTOR (M)	Z VECTOR (M)
GAMS (Pri to Sec GNSS)	-0.049	3.648	-0.037

Table 10: POS MV GAMS Calibration Values

6.1.2 PreVoyage Calibration

The patch test calibration of the EM2040C was conducted by GA on the 17th June 2018 and the values obtained are summarised in the Table 10 and Figure 11 below.

SENSOR	PITCH (°)	ROLL (°)	YAW (°)
EM2040C Transducer	1.710	-1.180	0.000

Table 11: Patch Test Calibration Values

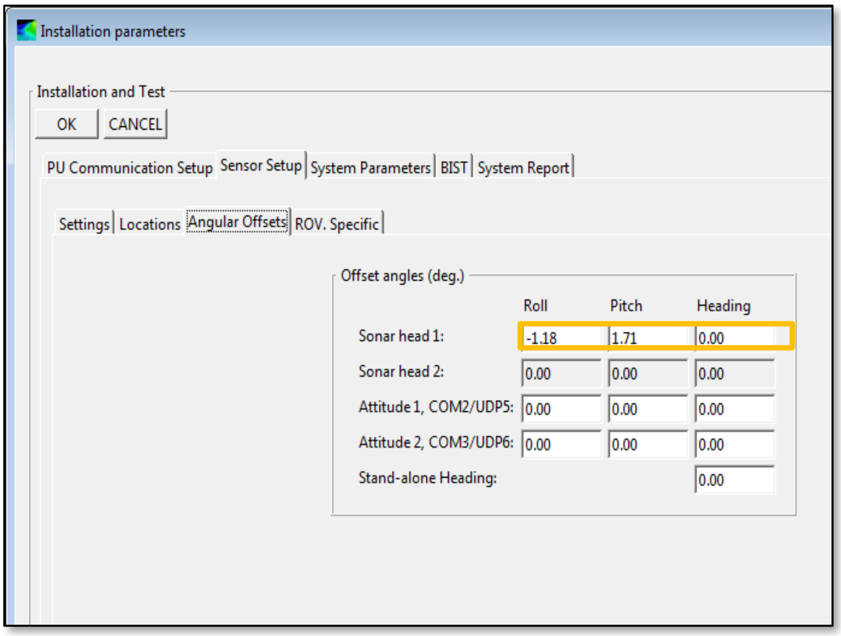

Figure 18 Angular offsets in SIS

6.1.3 Patch Test Calibration

Patch test lines were run after the call into Coles Bay, lines 433 – 440. Offsets were applied in CARIS via the vessel file prior to on shore processing

SENSOR	PITCH (°)	ROLL (°)	YAW (°)
EM2040C Transducer	0.22	0.25	0.40

Table 12: Patch Test Calibration Offset Values applied for post processing

6.2 Post Survey Checks

6.2.1 POSPac Adjusted Offsets

After post processing the POS MV "000" data in POSPac MMS 8, it was determined that a lever arm bias was present in the REF to Primary GNSS antenna measurement and in the measurement between the Primary and Secondary GNSS antennae. A series of convergence iterations were run within POSPac until suitable values were obtained. The post processed offsets are presented in Tables 13 & 14.

SENSOR	X OFFSET FORWARD +VE (M)	Y OFFSET STARBOARD +VE (M)	Z OFFSET +VE DOWN (M)
***Port GNSS Antennae (Pri)**	-8.395	-1.341	-14.463

Table 13: POSPac adjusted Offsets

CALIBRATION	X VECTOR (M)	Y VECTOR (M)	Z VECTOR (M)
GAMS (Pri to Sec GNSS)	-0.042	3.648	-0.038

Table 14: POSPac adjusted Heading Vector

6.2.2 Data Check Line Verification

Line QC (or check lines) were performed using lines run perpendicular to, or at an angle across the main survey lines. This was done to verify that the data were meeting the desired survey criteria and standard. From the results obtained, the survey standard was confirmed to conform to IHO Order 1a (results presented below).

Checkline 0630 Huon

Beam Angle	Count	Max (+)	Min (-)	Mean	Std Dev	Order 1a (%)
-65.0 - 0.0	1,462,381	22.534	20.667	-0.145	0.372	99.823
0.0 - 65.0	1,482,578	27.040	21.870	0.009	0.321	99.926

Checkline_0752 Tasman Fracture

Beam Angle	Count	Max (+)	Min (-)	Mean	Std Dev	Order 1a (%)
-65.0 - 0.0	1,047,253	72.382	31.985	0.213	1.304	99.332
0.0 - 65.0	1,087,951	66.121	31.820	0.367	1.272	99.261

Checkline_0786 Tasman Fracture

Beam Angle	Count	Max (+)	Min (-)	Mean	Std Dev	Order 1a (%)
-65.0 - 0.0	940,477	26.831	2.996	-0.366	0.353	99.986
0.0 - 65.0	976,186	27.813	13.925	-0.174	0.293	99.988

7 Geodetic Parameters

Positions derived from the POS MV aided with a Fugro Marinestar G2 solution are referenced to the International Terrestrial Reference Frame (ITRF2014). The relevant datum and projection information is summarised in Table 13 below.

7.1 ITRF2014 Datum and Projection

DATUM DESCRIPTION	
Datum	ITRF2014
Ellipsoid	Geodetic Reference System 1980 (GRS80)
Semi-major Axis (a)	6 378 137.000m
Semi-minor Axis (b)	6 356 752.314m
Eccentricity Squared (e^2)	0.006694380
Flattening (1/f)	298.257222101
Projection Type	Universal Transverse Mercator (UTM)
UTM Zone	55 S
Central Meridian	147° East
Scale Factor at CM	0.9996
False Easting	500 000m
False Northing	10 000 000m
Latitude of Origin	0° (Equator)

Table 15: ITRF2014 Datum Description

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