

RV Investigator Voyage Plan

Voyage #	IN2018_C01		
Voyage Title:	RAN Hydrographic Survey		
Mobilisation:	Hobart, 0800 Monday May 28, 2018		
Depart:	Hobart, 1700 Monday May 28, 2018		
Return:	Hobart, 0800 Friday June 8, 2018		
Demobilisation:	Hobart, 0800 Friday June 8, 2018		
Voyage Manager:	Brett Muir	Contact details:	Brett.muir@csiro.au
Chief Scientist:	LCDR Nigel Townsend		
Affiliation:	RAN	Contact details:	Chris.watson@defence.gov.au

Scientific objectives

To gain an understanding of the nature of the marine environment in the survey area and to collect meteorological and oceanographic data in the area to contribute to current modelling systems. Additionally, this information will benefit the management of the Commonwealth Marine Reserve at Hogan Island.

Voyage objectives

To facilitate safe navigation for international and coastal shipping. This survey will also improve confidence for subsurface navigation in Bass Strait.

The overall focus for this survey is to conduct a modern survey in the primary shipping route through Bass Strait.

The MET and OC observations and data collection have three purposes, namely:

- a) To collect data from which a sonar or radar range prediction can be calculated (humidity, pressure, temperature, wind speed, ocean temperature and salinity profile, currents through depth, sediment type, sub-bottom classification (where possible);
 - Sub-bottom classification will incorporate sediment samples taken using the MNF Smith-McIntyre Grab. Samples will be kept and stored with Geoscience Australia (GA).
- b) To identify what observations can be conducted concurrently, and what observations have limiting factors that preclude concurrent operations/survey activity;
- c) To develop understanding of what types, accuracy and formats of data can be collected and how this might be of use to the scientific community and Defence.

A full GSM Survey Procedure pertaining to the hydrographic surveying elements of the primary voyage are included in appendix 1 – GSM Hydrographic Survey Procedure.

Operational risk management

Operating in the Traffic Separation Zone:

In order to mitigate the potential risks of operating within a traffic separation zone, ASP have been in direct communication with the Australian Maritime Safety Authority (AMSA) in order to implement the necessary control measures required for this voyage. ASPs primary measures of risk mitigation are;

1. ASP have notified the Australian Hydrographic Office of the intended details of the operation. From this notification the UKHO will distribute the information through their weekly Notice To Mariners service.
2. 24-48 hours prior to the commencement of operations, ASP will notify AMSA's Joint Rescue Coordination Centre (JRCC) who will issue an AUSCOAST warning to all vessels in the area. ASP will continue to liaise with the JRCC for the duration of any planned operation within a traffic separation scheme.
3. The vessel shall display all correct day shapes and lights to indicate her status to other vessels. The vessels AIS data will also reflect her status throughout the operation.
4. The vessels bridge crew have prepared an internal risk assessment to identify and mitigate all potential navigational hazards which may be encountered during the operation.

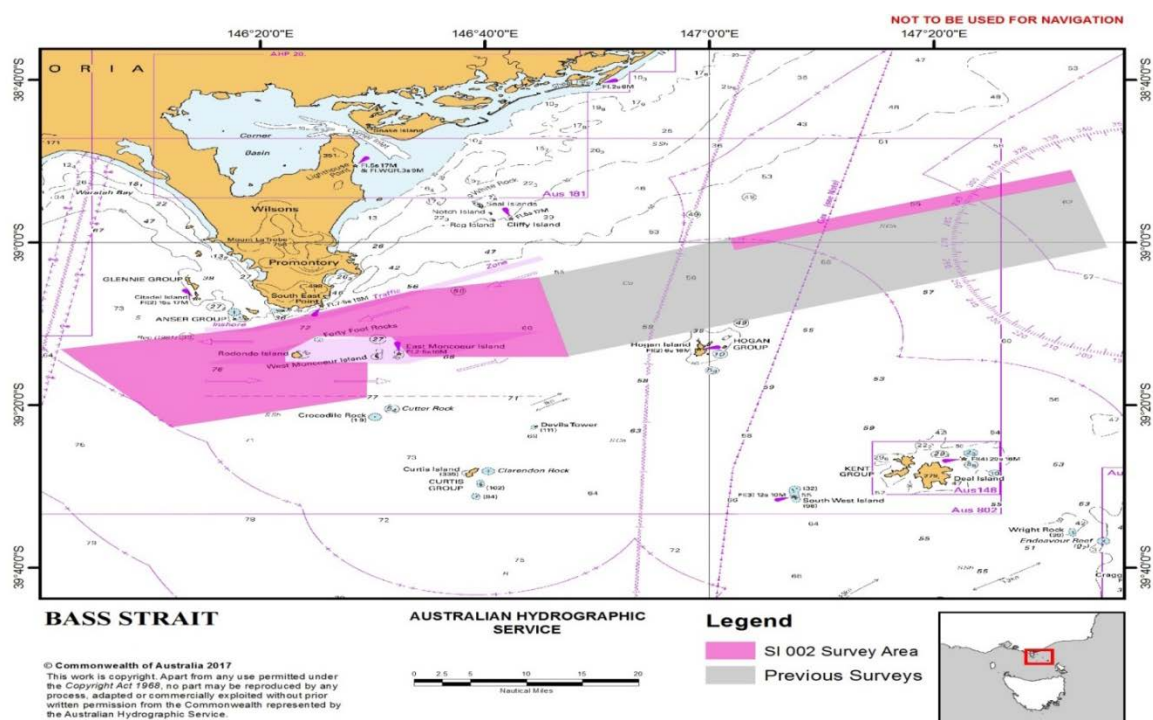
Woehler: Piggy Back Project 1:

Access to observational posts will be at the discretion of the Master and subject to existing protocols. No high-risk activities involved in seabird observation program.

Overall activity plan including details for the first 24 hours of voyage

RV *Investigator* will transit to the survey area and commence Hydrographic survey IVO Hogan Island. Detailed plan is included in GSM Procedure in appendix 1 – GSM Hydrographic Survey Procedure.

Survey area of operations



Waypoints and stations

	LATITUDE	LONGITUDE
Area A_1 (SE Corner)	39°13.994'S	146°47.452'E
Area A_2	39°04.204'S	146°44.701'E
Area A_3	39°05.930'S	146°33.432'E
Area A_4	39°10.454'S	146°19.234'E
Area A_5	39°13.122'S	146°02.133'E
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Area A_11	39°11.498'S	146°24.998'E
Area A_12	39°11.614'S	146°31.688'E
Area A_13	39°14.067'S	146°33.318'E

Table 1 - Survey Area A Coordinates

	LATITUDE	LONGITUDE
Area B_1 (SE Corner)	38°52.436'S	147°32.671'E
Area B_2	38°51.008'S	147°32.157'E
Area B_3	38°59.486'S	147°01.792'E
Area B_4	39°00.881'S	147°02.205'E

Table 2 - Survey Area B Coordinates

Survey area A is 974.44 km² equating to 283 nm², Survey area B is 126.11 km² equating to 36.8 nm²

Time estimates

Anticipated time frames for each survey area and the associated line spacing are detailed in the below table:

Survey Area	Line Spacing	Lines Required	Survey Time Req (Hrs)
A_Sub Area A	455m	15	19.07
A_Sub Area B	420m	44	54.17
A Sub Area C	504m	40	69.54
A_XLines	5000m	14	13.70
B	420m	6	18.89
B_XLines	5000m	9	1.83
Total Time (Hrs)			177.2

Table 3 - Line Planning Parameters

At vessel speed of 8 knots the time to run all lines within the specified survey areas is 177.2 hours. This does not include time for line turns. The GSM team will liaise with the vessel bridge team during the survey to establish the most efficient pattern of completing the proposed lines (such as surveying every 3rd/4th line in a 'leap-frog' pattern).

Piggy-back projects

Eric Woehler: Spatial and Temporal Variability in the Distribution and Abundance of Seabirds:

The project seeks to quantify the distribution and abundance of seabirds at sea around Australia using standardised seabird survey protocols. Two dedicated observers will collect real-time data on seabirds observed within 300m transect during daylight hours while the vessel is underway. Incidental observations will be collected while the vessel is stationary (e.g. CTD stations) or while the vessel is deploying/recovering moorings.

The data collected will be compatible with previous seabird at sea surveys conducted around Australia and farther south, allowing for analyses and assessments to be extended by the current surveys. The distribution of seabirds at sea is strongly linked with oceanographic features such as convergences that concentrate prey at densities that allow for efficient foraging by seabirds. Our surveys on the voyage will link with oceanographic investigations to identify the types and strengths of oceanographic features at which we observe different species of seabirds that utilise different methods of feeding (surface seizing, diving etc.).

No dedicated ship time is required for the seabird surveys. Surveys are conducted by observers while the vessel is underway during daylight hours.

Educator on Board Program (EoB)

'CSIRO Educator on Board' is a professional development program for Australian STEM (science, technology, engineering and mathematics) school teachers. Two teachers will sail on board *Investigator* for short (<2 week) voyages. Participants will: observe and assist alongside scientists and contribute to the national collaborative marine research effort; update their own STEM content knowledge; conduct and coordinate educational and outreach activities including live video broadcasts from the ship; develop curriculum linked resources, such as lesson plans, to be shared with other teachers; and promote RV *Investigator* and its research efforts.

No dedicated ship time is required for the EoB Program

Investigator equipment (MNF)

(i) Standard laboratories and facilities

Name	Essential	Desirable
Constant Temperature Lab	x	
Underway Seawater Analysis Laboratory		
GP Wet Lab (dirty)		
GP Wet Lab (Clean)		
GP Dry Lab (Clean)		
Sheltered Science Area		
Observation deck 07 level		
Walk in Cool Room		

(ii) Standard laboratory and sampling equipment

Name	Essential	Desirable
CTD - Seabird 911 with 36 Bottle Rosette		
LADCP		
Milli -Q System		
Laboratory Incubators		
Heavy Duty Electronic Balance		
Medium Duty Electronic Balance		
Surface Net		
Smith Mac grab	x	
Dissecting Microscopes		

(iii) Auxiliary CTD sensors

Name	Essential	Desirable
Dissolved oxygen sensor		
Altimeter		
PAR sensor (Biospherical QCP-2300)		
Transmissometer (wetlabs C-Star 25cm)		
Fluorometer – Chlorophyll- <i>a</i> (Chelsea Aquatracka III – 430/685nm)		

(iv) Specialised laboratory and sampling equipment

May require additional support

Name	Essential	Desirable
Continuous Plankton Recorder (CPR)		
Gravity Coring System		
Multi Corer		
XBT System		
Sherman epibenthic sled		
Rock Dredges		
Rock saw		

(v) Underway systems

Acoustic Underway Systems

Name	Essential	Desirable
75kHz ADCP		x
Multi Beam echo sounder EM122 12kHz (100m to full ocean depth)	x	
Multi Beam echo sounder EM710 70-100kHz (0-1000m approx.)	x	
Sub-Bottom Profiler SBP120	x	
Scientific Echo Sounders EK60 (6 bands, 18kHz-333kHz)	x	
Gravity Meter		
Biological Oceanography Underway Sensors	x	
Multi Beam echo sounder EM2040	x	

Atmospheric Underway Sensors

Name	Essential	Desirable
Polarimetric Weather Radar		

Underway Seawater Instrumentation

Name	Essential	Desirable
Thermosalinograph	x	
Fluorometer		
Optode		
PCO2		

User Equipment

- Secchi Disk (AHO)

Permits

- The survey will partially be conducted in the Beagle Commonwealth Marine Reserve and activities covered under the MNF CMR permit: CMR-17-000471 including the deployment of the Smith McIntyre grab.

Personnel List

1.	Brett Muir	Voyage Manager	CSIRO MNF
2.	Will Ponsonby	SIT Support	CSIRO MNF
3.	Trevor Goodwin - TBC	SIT Support	CSIRO MNF
4.	Stuart Edwards	GSM Support	CSIRO MNF
5.	Matt Boyd	GSM Support	CSIRO MNF
6.	Amy Nau	GSM Support	CSIRO MNF
7.	Phil Van Den Bossche	GSM Support	CSIRO MNF
8.	Craig Davey	GSM Support	CSIRO MNF
9.	Steve Van Graas	DAP Support	CSIRO MNF
10.	Anoosh Sarraf	DAP Support	CSIRO MNF
11.	Nigel Townsend	Chief Scientist	RAN
12.	Scott Lytton	AHS	RAN
13.	Kim Picard	Surveyor	Geoscience Australia
14.	Xinh Le Sy	Student	Curtin University
15.	Thomas Schroeter	Student	Curtin University
16.	Eric Woehler	Researcher	Birdlife Australia
17.	Jill Shephard	Researcher	Birdlife Australia
18.	Ben Arthur	EoB Supervisor	CSIRO MNF
19.	Thomas Coad	Teacher	Rose Bay HS, TAS
20.	Chad King	Teacher	St Peters Lutherin College, QLD
21.	Simone Burzacott-Gorman	Teacher	Wilderness School, SA
22.	Lloyd Godson	Teacher	Hastings Secondary College, NSW
23.	Leah Solymom	Education and Outreach	CSIRO

Signature

Your name	LCDR Nigel Townsend
Title	Chief Scientist
Signature	
Date:	

Appendix 1 – GSM Hydrographic Survey Procedure

GEOPHYSICAL SURVEY & MAPPING (GSM)
Hydrographic Survey Procedure

Voyage: IN2018_C01
Australian Hydrographic Office
Hogan Group Hydrographic Survey – Bass Strait

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1. Document Control

Revision History

Revision	Description of Change	Author	Date
0	Draft	Stuart Edwards	27-02-2018
1	Updated procedure	Stuart Edwards	11-04-2018

2. Introduction

The Australian Hydrographic Office (AHO) has secured sea time on board the CSIRO research vessel *RV Investigator* under a User Funded Voyage Agreement. This voyage will carry out a hydrographic survey in the Bass Strait (Area SI002), for nautical charting purposes, during May/June 2018. The survey will be carried out on board *RV Investigator* by members of the Geophysical Survey & Mapping (GSM) team.

There are two survey areas, Area A (approx. 283nm²) is south of the Anser Group, Area B (approx. 36.8nm²) is to the North of the Hogan Group. Water depths within the survey area are approx. in the range 50-75m.

The survey will be conducted using a Kongsberg EM2040c (Dual Head) Multibeam Echosounder (MBES) as the primary instrument. The EM2040c MBES is a high resolution seabed mapping system, capable of meeting all International Hydrographic Organisation (IHO) standards, this system has transmit and receive beamwidths of 1° and is capable of being operated between frequencies of 200-400KHz. This system is operated by the CSIRO Shallow Survey Internal Facility (SSIF) and will be mobilised to the *RV Investigator* for this project.

A Kongsberg EM710-MK2 Multibeam Echosounder (MBES) will be operated as the secondary instrument. The EM710-MK2 MBES is a high resolution seabed mapping system, capable of meeting all IHO standards. The EM710-MK2 is operated and permanently mobilised on board *RV Investigator* can transmit and receive beamwidths of 0.5° and 1° respectively and is capable of operating between frequencies of 40-100KHz.

Hydrographic data collected, will be processed on board *RV Investigator* using Caris HIPS/SIPS software. The data will be made available to the AHO upon completion of the project.

This survey will be carried out to IHO Order 1A standards, as per IHO SP-44 5th Edition.

The figure below outlines the extent of the survey area.

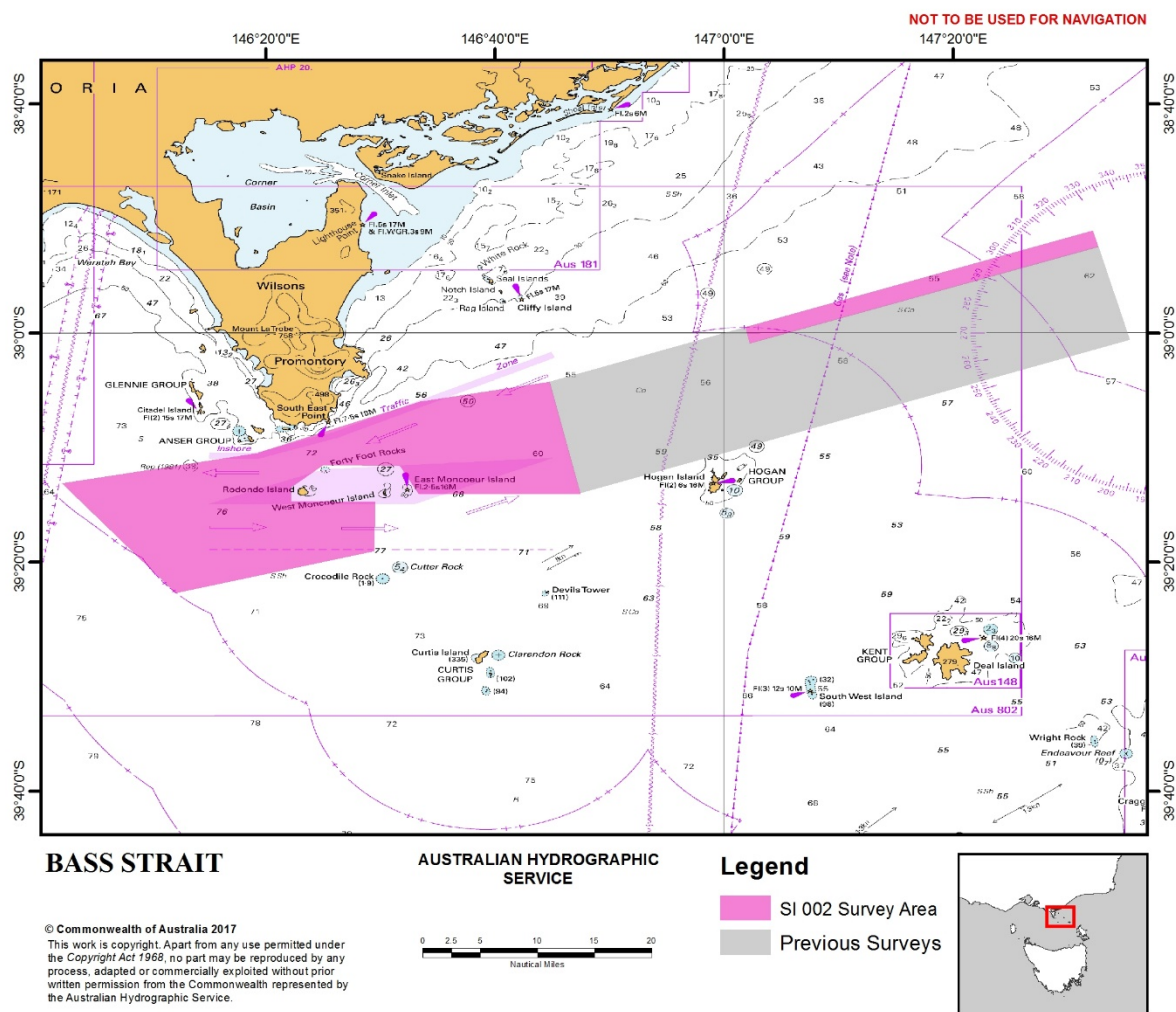


Figure 1 - Proposed Survey Area

3. Itinerary

MOBILISE	DATE	
Hobart	Monday 28 th May	
DEPART	DATE	TIME
Hobart	Tuesday 28 th May	1700
ARRIVE	DATE	TIME
Hobart	Friday 8 th June	0800
DEMOBILISE	DATE	
Hobart	Friday 8 th June	

Table 1 - Voyage Itinerary

Transit from Hobart to and from the SE corner of the proposed survey area is approx. 30 hrs. The passage plan supplied by RV Investigator marine crew, ASP, is contained in Appendix A.

4. Operations

4.1. Mobilisation / Demobilisation

Mobilisation of the RV Investigator will be undertaken alongside the CSIRO Wharf PW4 in Hobart on the 28th May, 2018. All survey systems required for the voyage will be declared operational by the GSM team leader to the CSIRO Voyage Operations Manager (VOM)/Voyage Manager (VM) prior to departure.

Upon completion of the survey, the vessel will transit back to Hobart for demobilisation.

4.2. Survey Calibrations

Details of the calibration activities relevant to this hydrographic survey, on board RV *Investigator* are outlined below.

Further verifications of the vessel positioning system will be undertaken in Hobart prior to departure of IN2018_C01

Multibeam patch tests will be conducted over the wreck of the SS Queensland prior to commencing survey activities.

4.2.1. MBES Calibration (Patch Tests)

The EM710-MK2 MBES was last calibrated during the RV *Investigator* trials and calibration voyages in December 2017. A MBES patch test was conducted on 29 January, 2015 on voyage IN2017_E04, in location 43°15.94'S 148°00.29'E approx. 150m water depth, to the south of Tasman Island.

The MBES patch test ran lines to resolve for any residual Pitch, Roll and Heading misalignments between the EM710-MK2 transducer and the vessel Motion Reference Unit (MRU). The following values were determined.

PATCH TEST VALUES	
PITCH	-0.17°
ROLL	+0.02°
YAW	-0.03°

Table 2 - EM710 Patch Test Values

Both the EM2040c and EM710-Mk2 will be recalibrated prior to commencing survey operations. It is proposed that calibrations will be undertaken over the wreck of the SS QLD which lies in close proximity to the survey area in location 39°06.500'S 146°43.814'E. This wreck was investigated during the IN2017_C02 survey of the Hogan Group.

4.2.2. Vessel Sensor Offsets & Orientations

Offsets on board the RV *Investigator* were measured during dimensional control surveys conducted by Parker Maritime and the CSIRO GSM Team. The offsets relevant to the correct operation of the MBES systems are summarised below.

SENSOR OFFSETS			
SENSOR	X OFFSET (M) (+Stbd)	Y OFFSET (M) (+Fwd)	Z OFFSET (M) (+Down)
MRU 5+	0.00	0.00	0.00
MRU 5+ (Drop Keel)	1.308	2.760	8.387
Stbd GNSS Ae	-0.040	-6.257	-31.315
Port GNSS Ae	-4.037	-6.299	-31.411
EM710 Rx	-4.877	8.792	7.738
EM710 Tx	-4.001	10.216	7.740
EM2040c	1.308	2.820	8.557
Waterline			0.339
SENSOR ORIENTATIONS			
SENSOR	PITCH (°)	ROLL (°)	YAW (°)
MRU5+ ¹	-0.11	0.22	359.10
MRU 5+ (Drop Keel) ²	0.00	0.00	0.00
EM710 Rx	-0.33	0.56	0.16
EM710 Tx	0.24	0.13	0.02
EM2040c ²	0.00	±40.00	0.00

Table 3 - MBES Offsets & Orientations

4.2.3. Seapath 330+ Verification

The Seapath 330+ system on board RV *Investigator* provides DGNSS positioning, attitude and heading data to the MBES systems. Fugro Starfix G2 orbit and clock corrections are received from a global network of reference station, Starfix G2 corrections utilise Precise Point Positioning (PPP) technology, which results in positional accuracy at the decimetre level.

Recent verifications of the performance of the Seapath 330+ system were undertaken on 08 December, 2016 while the vessel was in dry dock in Garden Island, Sydney. Terrestrial observations

¹ Please note that the orientation of the MRU5+ is compensated for in the Seapath itself. They are listed here for information purposes. The remaining orientation errors are compensated for by the patch test.

² The MRU within the drop keel is mounted directly above the MBES transducer. As such the installation orientations will be small and can be compensated for directly by the patch test.

were taken from established survey control marks to the GNSS antennas and to targets setup on the vessel centreline. The results of the verification are summarised below:

SENSOR	MEAN LINEAR MISCLOSE (M)	STANDARD DEVIATION (M)
DGNSS ANTENNA	0.21	0.03
SENSOR	HEADING CORRECTION (°)	STANDARD DEVIATION (°)
DGNSS BASELINE	-0.10	0.15

Table 4 - Seapath 330+ Verification Dec 2016

Please note following successful commissioning prior to this voyage an Applanix POSMV Wavemaster will be used in place of the Seapath 330+, details in section 4.2.5 below.

4.2.4. Sound Velocity Profilers Wet Test

A Valeport Monitor Sound Velocity Profiler (SVP) will be utilised on board RV *Investigator* to provide accurate information on the changes in seawater sound velocity through the water column. Prior to departure, a pressure, temperature and sound speed computation will be performed. The data will be downloaded using the Datalog Express Software and a verification that the instrument is operating correctly will be done by comparing the surface sound velocity to the AML SVP that is installed in port drop keel.

A Teledyne RapidCast SVP is due to be commissioned prior to this voyage, please see details in section 4.2.5 below.

4.2.5. New Hydrographic Equipment

The Marine National Facility (MNF) have purchased several key items of hydrographic survey equipment since the last AHO charter on board RV *Investigator*. This is in an attempt to improve the quality of data obtainable and provide a more efficient survey platform. These equipment items are:

1. Applanix POSMV Oceanmaster position and orientation system.
2. Teledyne RapidCast Underway Sound Velocity Profiler (SVP).

Both these items will be commissioned and declared operational prior to IN2018_C01 commencing.

4.3 Survey Operations

Hydrographic survey operations will be conducted in accordance to the IHO Standards and methods listed below.

It is expected that there will be approx. 9 days 'on station' to complete the survey.

Regular weather forecasts will be obtained and will be used as a guide to plan survey operations.

Due to the close proximity of the survey area to the vessel traffic separation scheme, south of Wilsons Promontory and in the Bass Strait, ASP will liaise with AMSA to issue an AUSCOAST warning for the duration of the survey.

Survey lines have been planned in consultation with RV *Investigator's* bridge team, ASP ship management.

4.3.1 Survey Standards

Survey operations will be to IHO Order 1A standards. As per the IHO Standards for Hydrographic Surveys (S-44), Order 1A is defined as:

“Intended for those areas where the sea is sufficiently shallow to allow natural or man-made features on the seabed to be a concern to the type of surface shipping expected to transit the area but where the under-keel clearance is less critical than for Special Order. Because man-made or natural features may exist that are of concern to surface shipping, a full sea floor search is required, however, the size of the feature to be detected is larger than for Special Order. Under-keel clearance becomes less critical as depth increases so the size of the feature to be detected by the full sea floor search is increased in areas where the water depth is greater than 40 metres. Order 1a surveys may be limited to water shallower than 100 metres.”

The maximum allowable Total Horizontal Uncertainty (THU) for an Order 1A Survey in an average water depth of 60m is $\pm 8\text{m}$ ($5\text{m} + 5\%$ depth).

The maximum allowable Total Vertical Uncertainty (TVU) for an Order 1A Survey in an average water depth of 60m is $\pm 0.93\text{m}$ ($\pm \sqrt{a^2 + (b \times d)^2}$, $a=0.5$, $b=0.013$, $d=60$)

Both the THU & TVU are quoted at the 95% confidence level.

A full seafloor search is required and survey lines will be planned to give 100% bottom coverage. **The seafloor search must resolve cubic features larger than 6m** (10% of depth).

The quoted system RMS accuracy for the Kongsberg EM systems on board RV Investigator is expected to be better than:

EM2040c		EM710 – MK2	
SD in % of WD	Angle from Nadir	SD in % of WD	Angle from Nadir
0.10	0-45°	0.20	0-45°
0.15	45-60°	0.30	45-60°
0.30	60-70°	0.50	60-70°

Table 5 - EM Quoted Accuracies

4.3.2 Survey Coordinates

The boundary coordinates of the survey area (taken from .shp file as supplied by the AHO) are reproduced below:

	LATITUDE	LONGITUDE
Area A_1 (SE Corner)	39°13.994'S	146°47.452'E
Area A_2	39°04.204'S	146°44.701'E
Area A_3	39°05.930'S	146°33.432'E
Area A_4	39°10.454'S	146°19.234'E
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Table 6 - Survey Area A Coordinates

	LATITUDE	LONGITUDE
Area B_1 (SE Corner)	38°52.436'S	147°32.671'E
Area B_2	38°51.008'S	147°32.157'E
Area B_3	38°59.486'S	147°01.792'E
Area B_4	39°00.881'S	147°02.205'E

Table 7 - Survey Area B Coordinates

Survey area A is 974.44 km² equating to 283 nm², Survey area B is 126.11 km² equating to 36.8 nm²

4.3.3 Survey Line Plan

The survey line plan has been calculated using the following parameters.

- Area A divided in 3 sections, sub areas A,B,C
 - Sub Area A average depth of 65m
 - Sub Area B average depth of 60m
 - Sub Area C average depth of 72m
- Area B average depth of 60m
- Survey Speed 8 Knots
- Line Overlap of 30%
- Expected swath width of 9-10 times water depth

Expected swath width has been based on a combination of, manufacturers specifications, theoretical calculations based on expected oceanographic conditions and seabed type and experience of using this particular multibeam system in similar conditions for an AHO survey in 2017.

Using these parameters the line spacing for each survey area are detailed in the below table:

Survey Area	Line Spacing	Lines Required	Survey Time Req (Hrs)
A_Sub Area A	455m	15	19.07
A_Sub Area B	420m	44	54.17
A Sub Area C	504m	40	69.54
A_XLines	5000m	14	13.70
B	420m	6	18.89
B_XLines	5000m	9	1.83
Total Time (Hrs)			177.2

Table 8 - Line Planning Parameters

At vessel speed of 8 knots the time to run all lines within the specified survey areas is 177.2 hours. This does not include time for line turns.

A total of 128 lines are required to fill survey area SI002 at variable line spacing listed in table 8

The GSM team will liaise with the vessel Bridge team during the survey to establish the most efficient pattern of completing the proposed lines (such as surveying every 3rd/4th line in a 'leap-frog' pattern).

The survey line plan will be exported from QINSy in ASCII format and converted into a .rux file to be loaded into the bridge ECDIS.

Figure below from QINSy showing the planned survey lines.

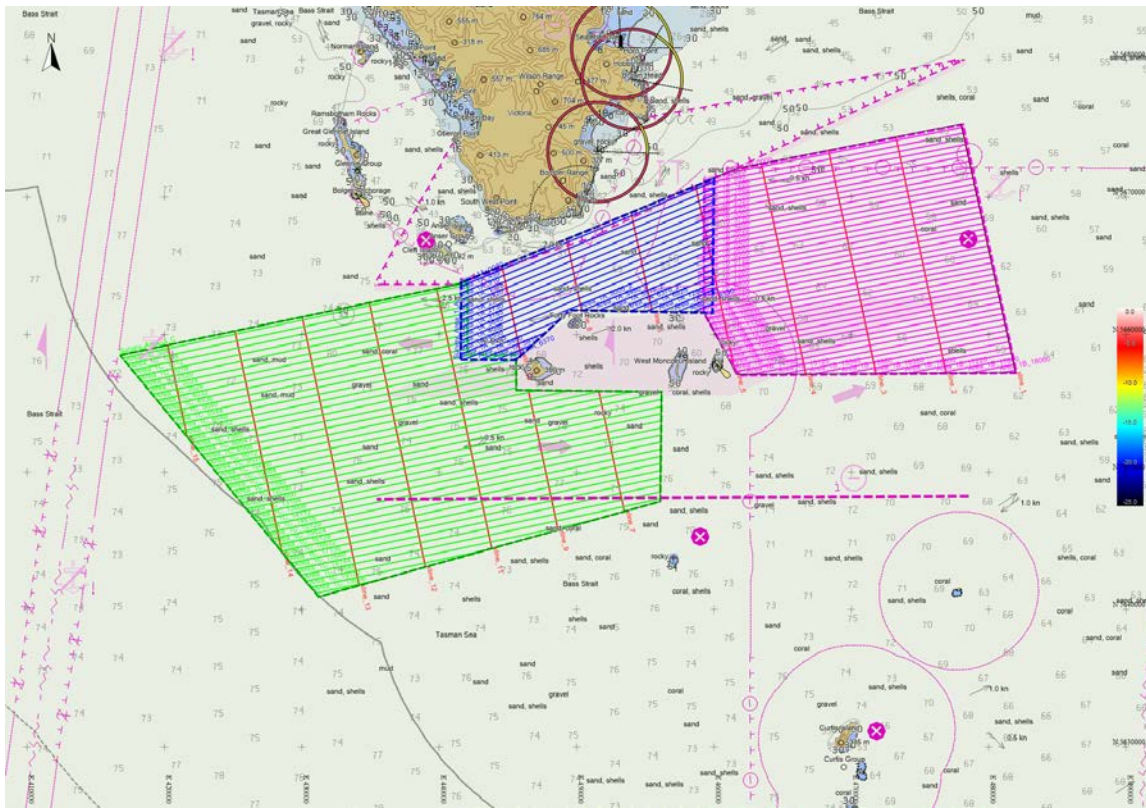


Figure 2 – Survey Area A Proposed Line Plan

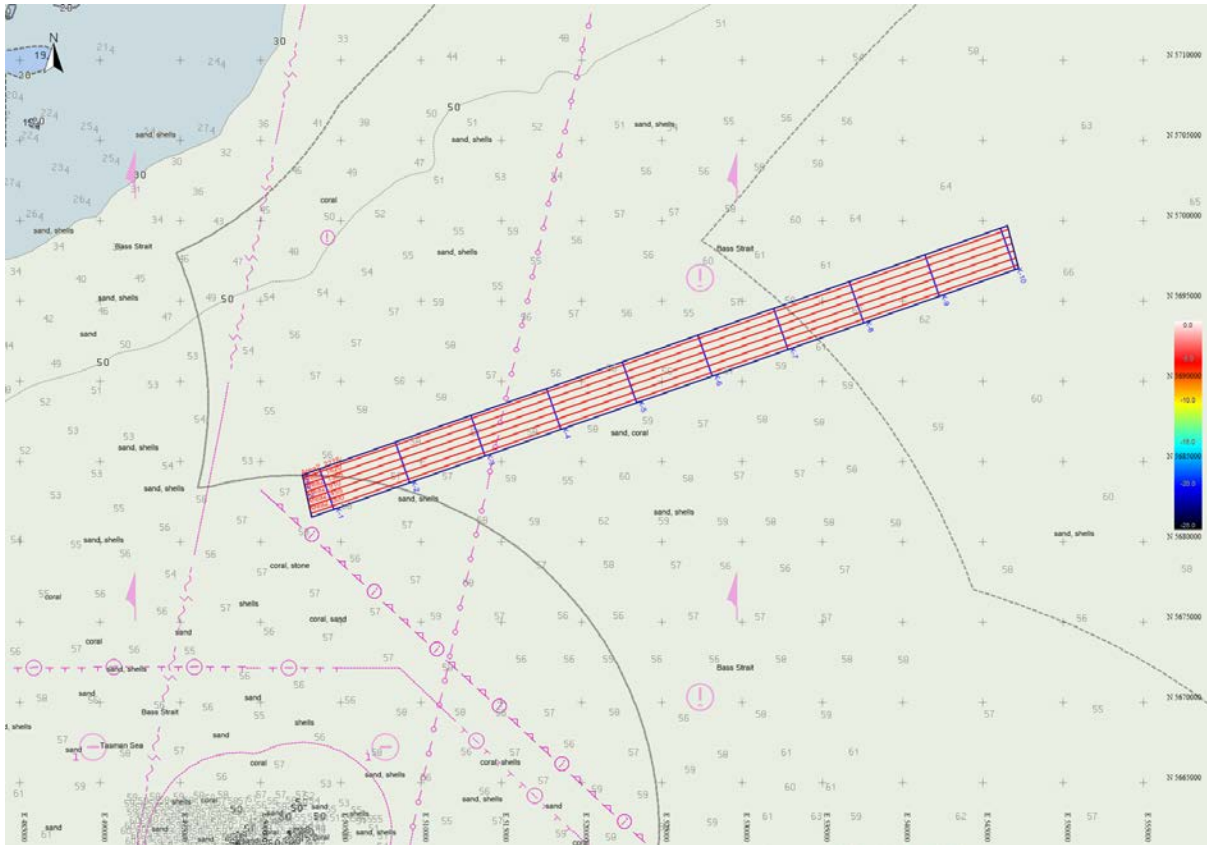


Figure 3 - Survey Area B Proposed Line Plan

4.3.4 Data Acquisition

During acquisition of MBES data in the survey area, RV *Investigator* operations room will be manned at all times. The surveyor on watch will monitor and control the acquisition of MBES data. The surveyor on watch will have the following responsibilities:

Ensuring the EM2040c/EM710-MK2 is operating correctly and the data being acquired is quality controlled.

Liaising with the vessel bridge team as to the order of lines to be surveyed.

Maintaining a log of survey operations and events.

Ensuring current Sound Velocity Profiles are loaded into the MBES systems.

4.3.5 Sound Velocity Profiles

Sound Velocity Profiles will be collected using a Valeport Monitor Sound Velocity Profiler (SVP) at intervals no greater than 6 hours for the duration of the survey.

The SVP will be configured with the Datalog Express software, fitted with switch plug to enable internal recording and then deployed on an appropriate winch.

The ASP vessel crew are responsible for driving the winch. Therefore the surveyor on watch will communicate with them the depth the SVP is to be lowered to.

Upon retrieval the data will be downloaded from the probe and processed & converted from Valeport (.000) format to Kongsberg (.asvp) format using DORIS SVP software.

4.3.6 Data Processing

Multibeam data will be logged in Kongsberg *.all format and will be converted for processing within Caris HIPS/SIPS (version 10.2.4). Once the data is converted it will be analysed and any outliers removed within the swath editor. Tide files will be loaded and TPU (Total Propagated Uncertainty) computed. The data will then be merged and CUBE surfaces generated at the highest possible resolution. The CUBE hypotheses can then be examined and any further data processing completed within the subset editor.

4.3.7 Tidal Reduction

Tidal reduction of data will be accomplished by the following means:

- DGNSS Tides computed from the Applanix POSMV/Seapath 330+ using Fugro G2+ corrections.
- Predicted tides for East Monceur Island (ANTT Tide Station 60615)

The computation of DGNSS tides on board RV Investigator is completed by using the Mean Sea Surface (MSS) software provided by Fugro. The MSS software logs GRS80 ellipsoidal heights from the Seapath 330+ in addition to vessel attitude from the MRU5+.

MSS provides time-stamped data in an .fbf file. Time, Latitude, Longitude and a Smoothed Water Line (Ellipsoidal) height value are extracted from the file and modified in a spreadsheet. This can then be run through the AusCoast VDT tool to reduce to the level of Lowest Astronomical Tide (LAT).

4.3.8 Seabed Topography

Multibeam backscatter data will be recorded for the duration of the survey from both the EM710 Mk2 and the EM2040c. Both MBES will have their frequency/pulse mode constrained for the duration of the survey.

Mosaics of recorded multibeam backscatter information will be created within the Fledermaus Geocoder Toolbox (FMGT). FMGT allows visualisation and analysis of multibeam backscatter data in addition to the processing of the sonar files into mosaics. FMGT processing is largely automated however the steps required to construct the mosaics are outlined below:

1. Adjust and extract the backscatter data and perform radiometric corrections based on sonar type and bottom topography.
2. Filtering, angle varying gain (AVG) adjustments, anti-aliasing of the backscatter data.
3. Creation of mosaic at highest possible resolution.

Angle vs Range Analysis (ARA) can be conducted to provide a method of seafloor characterisation. ARA compares the actual backscatter response to expected response curves for a wide range of seafloor types, based within the Jackson mathematical model.

Seabed sampling will also be conducted using a Smith McIntyre grab sampler. Grab sampling will be obtained at regular spacing across the survey area and where possible grabs will be obtained at the following locations, a seabed sample log will be maintained.

Banks, shoals and seamounts and in channels between them.

To ground truth MBES backscatter information, especially where changes in the nature of the seafloor are apparent.

4.4 Reporting

4.4.1 Daily Report

The GSM team leader will provide a daily report to the VM on board the RV *Investigator*, this information may then be disseminated in the daily VM sitrep. The information provided by the GSM team leader will include:

- A breakdown of survey activities over the past 24 hours, including actual line km surveyed.
- Planned survey activities for the upcoming 24 hours.
- Revised ETA (if required) for completion of survey.
- Any pertinent features identified.

4.4.2 Final Report

A final survey report will be rendered to the AHO within 30 days of demobilisation. The report will include the following sections:

- Executive Summary
- Survey Operations
- Data Processing
- Vessel Configuration
- Calibrations & Checks
- Geodetic Parameters

4.4.3 Survey Data

The data will be transferred to the AHO in the following format:

- Caris HIPS/SIPS (HDGS) Folder Structure
- ESRI Raster (.asc)
- ASCII gridded (.xyz)
- Acquisition (eLOG) logs (.txt)
- Processing logs (.xlsx)
- SVP files (.000/.asvp)
- MSS logging (.fbf converted to .csv)
- Tide files (.tid)
- Kongsberg PFreeheave (Delayed Heave) (.srh)

5. Geodetic Parameters

The Applanix POSMV/Seapath 330+ system on board RV *Investigator* is referenced to the International Terrestrial Reference Frame (ITRF2014).

The Global Positioning System (GPS) is referenced to the World Geodetic System 1984 (WGS84). Many providers of satellite positioning services however have receivers which output referenced to the International Terrestrial Reference Frame (ITRF). Due to continual refinement of the WGS84 reference frame, the WGS84 and ITRF2014 reference frame are considered to be the same.

5.1. ITRF2014 Datum & Projection

Datum Description	
Datum	ITRF2014 (Epoch 2014.0)
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)	0.006 694 380
Flattening (1/f)	298.257 222 101
Projection Type	Universal Transverse Mercator (UTM)
UTM Zone	55
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 9 - Horizontal Datum & Projection

5.2. Vertical Datum

Datum Description	
Datum	Lowest Astronomical Tide (LAT)

Table 10 - Vertical Datum

6. Equipment Specifications

POSITIONING SYSTEMS

Applanix POSMV Oceanmaster DGNSS Receiver utilising Fugro G2+ PPP corrections (Primary)

Kongsberg Seapath 330+ DGNSS Receiver utilising Fugro G2+ PPP corrections (Secondary)

HEADING & ATTITUDE SYSTEMS

Applanix POSMV Oceanmaster (Primary)

Kongsberg Seapath 330+ DGNSS Heading Sensor/Kongsberg Seapath MRU5+ (Secondary)

Kongsberg Seatex MRU5+ Motion Sensor

GEOPHYSICAL SYSTEMS

Kongsberg EM2040c (Dual Head) MBES

Kongsberg EM710-MK2 MBES

OCEANOGRAPHIC SYSTEMS

Valeport Monitor SVP

DATA PROCESSING/SOFTWARE

QINSy Survey Positioning System

Caris HIPS/SIPS

Fugro MSS Logging

7. Personnel

- Tegan Sime – MNF Voyage Operations Manager (VOM)
- Brett Muir – MNF Voyage Manager (VM)
- Stuart Edwards – GSM Team Leader / Hydrographic Surveyor (SIC)
- Matt Boyd – Hydrographic Surveyor / Data Processor
- Amy Nau – Hydrographic Surveyor / Data Processor
- Phil Van Den Bossche – Hydrographic Surveyor / Geophysicist
- Craig Davey - Hydrographic Surveyor / Data Processor

8. Distribution

Electronic copies of this survey procedure have been distributed for comment as follows:

- MNF Facilities Program Director
- MNF Operations Team
- GSM Team Members
- ASP Ship Management (RV Investigator Master & 2/O)
- Australian Hydrographic Office

Appendix 2 – Passage Plan

RouteName:IN2018_C01	LastUpdate:20180228 04:45:32		
WPName:	Latitude:	Longitude:	Radius:
Berth	-42.8862	147.3387	0.1733
Sullivans Cove	-42.885	147.3399	0.1733
Battery Pt.	-42.8849	147.3443	0.2
Blinking Billy Pt	-42.9125	147.3829	0.2
Hobart PBG	-42.9241	147.3823	0.2
White Rock	-42.9764	147.375	0.2
Iron Pot	-43.0608	147.3905	0.2
Raoul	-43.2717	147.75	0.2
Tasman Head	-43.2817	148.0333	0.2
Hippolyte	-43.15	148.15	0.2
Mistaken Cape	-42.7333	148.3833	0.2
Sonnerat	-42.3667	148.5	0.2
Eddystone	-40.9667	148.5667	0.2
E Banks Strait	-40.7333	148.4167	0.2
W Banks Strait	-40.5833	147.8667	0.2
Goose Island	-40.3	147.5	0.2
Bass Pyramid	-39.85	147.1	0.2
SS Queensland	-39.1083	146.7302	0.2
NE Corner of Area	-39.0699	146.745	0.2

Appendix 3 - AHO Project Specification

1.1 Survey Standards		Requirement
1.1.1	Order of Survey	IHO S44 Order 1a
1.1.2	Coverage Requirements	Full seafloor coverage is required

1.2 Survey Area		Requirement
1.2.1	General Description of Each Survey Area	<p>The survey area consists of an approximately 32 x 11Nm box in the vicinity of Wilsons Promontory and associated traffic separation scheme. The survey area excludes a ZOC A2 area South-East of East and West Monocoeur Islands, and adjoining data collected during SI 001.</p> <p>The survey area comprises of waters classified as ZOC B and C, with charted depths generally between 50 - 77 metres.</p> <p>The area has not been surveyed using modern equipment, therefore anomalies may be expected; however, due to the high amount of traffic that transits the area, dangers to navigation are considered unlikely.</p>
1.2.2	Purpose	<p>To facilitate safe navigation for international and coastal shipping. This survey will also improve confidence for subsurface navigation in Bass Strait.</p> <p>The overall focus for this survey is to conduct a modern survey in the primary shipping route through Bass Strait.</p>
1.2.3	Charts Affected	AU439146, AU439147, AU440146, AU440147, AUS 148, AUS 357, AUS 487 and AUS 802

2 Project Requirements

2.1 Positioning and Horizontal Control		Requirement
2.1.1	Horizontal Datum	<p>Datum: WGS 84</p> <p>Spheroid: GRS 80</p> <p>Projection: UTM Zone 55 South (CM 147°E)</p>
2.1.2	Positioning	<p>Quality of GNSS solution is to be monitored throughout all survey operations. A secondary positioning system is to be used and regularly compared with the primary positioning system.</p> <p>Definitive statements are to be made regarding the horizontal accuracy achieved (i.e. TPU(H) Horizontal $\pm 2.0\text{m}$ at 95% CL) for each area of differing survey quality.</p>
2.1.3	Additional Positioning Requirements	Not required
2.1.4	Extension of Existing Control	Not required

2.2 Vertical Control		Requirement
2.2.1	Sounding Datum	Sounding Datum to approximate LAT
2.2.2	Reduction of Soundings	Soundings should be reduced to approximate LAT using DGNSS Tides and predicted tides for East Monceur Island (ANTT Tide Station 60615). Definitive statements are to be made regarding the vertical accuracy achieved (i.e. TPU(V) Vertical $\pm 0.5\text{m}$ at 95% CL) for each area of differing survey quality.
2.2.3	List of Tidal Infrastructure	Not required.
2.2.4	List of Current Meters	Not Required.
2.2.5	Tidal Anomalies and Freshwater springs	Any tidal anomalies observed are to be reported in your report of survey.
2.2.6	Additional Tasks	ADCP measurements should be recorded for the duration of the survey.

2.3 Bathymetry		Requirement
2.3.1	Data Requirements	Full Bathymetric Coverage for all depths. Backscatter: Required. Side scan Sonar: Required (whenever used).
2.3.2	Wreck Investigations and Disproving Searches	Required. Two wrecks exist within the survey area and are not considered dangerous to surface navigation. One of known depth 53m in position 39°09.8'S 146°29.8'E – investigation not required. A second wreck of unknown depth in position 39°08.8'S 146°45.1'E – to be investigated if detected. Any other wrecks detected/identified are also to be identified/ investigated.
2.3.3	Passage Sounding	Required.
2.3.4	Channels and Recommended Tracks	Any dangers to surface navigation identified within or immediately adjacent to the survey area should be delineated.

2.4 Views, Conspicuous Objects and Coastline		Requirement
2.4.1	Obtaining Coastline Data	Not required
2.4.2	Conspicuous Objects	Not required
2.4.3	Views	Not required

2.5 Seabed Topography		Requirement
2.5.1	Bottom Sampling	Seabed sampling should be completed at regular spacing across the survey area. Where possible, samples should be obtained:

2.5 Seabed Topography		Requirement
		<p>a. On all banks, shoals and seamounts, particularly where these are likely to be unstable, and in the channels between them;</p> <p>b. Where required to ground truth the interpretation of SSS or backscatter data, especially where changes in the nature of the seafloor are apparent; and,</p> <p>c. All samples taken shall be recorded on the Seabed Sample Log.</p>
2.5.2	Side Scan Sonar (SSS)/Backscatter Mosaics	<p>Required.</p> <p>All areas where MBES backscatter/ SSS data has been collected are to have a SSS mosaic produced.</p>
2.5.3	Additional Tasks	Nil

2.6 Miscellaneous Requirements		Requirement
2.6.1	Aids to Navigation	Updates to charted Navigation Marks are to be submitted using form AH 103.
2.6.2	Amendments to Sailing Directions	Not required
2.6.3	Additional Tasks	Nil.

2.7 Oceanographic and Meteorological Observations		Requirement
2.7.1	Sound Velocity	<p>Regular sound velocity measurements will be required for the operation of the survey system and should be retained for rendering as oceanographic data.</p> <p>Down casts and up casts are to be maintained separately.</p> <p>If the combined cast is used for sounding reduction these should also be provided separately.</p>
2.7.2	Secchi Disc	<p>Required.</p> <p>Daily water clarity and colour observations via Secchi Disc or Transmissiometer should be taken. These observations are to be recorded in the Secchi Disc Log</p>
2.7.3	Bioluminescence	<p>Required</p> <p>Bioluminescence observations are to be recorded in the Bioluminescence Log when observed.</p> <p>The observed absence of Bioluminescence is also to be recorded.</p>
2.7.4	Meteorological	<p>Required.</p> <p>Hourly weather observations from the ship's automated weather station should be recorded for the duration of the survey.</p>
2.7.5	Salinity	Required.
2.7.6	Magnetometer	Not Required

2.7 Oceanographic and Meteorological Observations	Requirement
2.7.7 Deployment of Argo Buoys	Not Required
2.7.8 Deployment of Gliders	Not Required
2.7.9 Additional Tasks	Not required.

3 DELIVERABLES

3.1 Required Deliverables	Note
3.1.1 Digital Data Packs	<p>Survey Reports, Correspondence and Documents Pack:</p> <ul style="list-style-type: none"> - Progress Reports (SITREPs) - Report of Survey - Any pertinent correspondence <p>Quality Assurance Data Pack:</p> <ul style="list-style-type: none"> - All calibration and validation data - Vessel Configuration Report - 3D positional data quality assurance - All processing logs / checks - List of all survey personnel with sample signatures <p>Bathymetric Data Pack:</p> <ul style="list-style-type: none"> - Raw sounding data - Processed sounding data - Sound velocity profile data - Side scan sonar data - Backscatter / SSS mosaic - Seabed texture layer <p>Tidal Data Pack:</p> <ul style="list-style-type: none"> - Tidal data utilised for reduction of soundings <p>Ancillary Data Pack:</p> <ul style="list-style-type: none"> - Oceanographic observations - Navigation mark and publication amendments (<i>if required</i>) - Views (<i>if required</i>) - Copies of submitted Hydrographic Notes
3.1.2 Hydrographic Note (AH102 - F_05_51_AA217160)	Any Hydrographic Note produced in the execution of this survey is to be emailed to the AHO at datacentre@hydro.gov.au
3.1.3 Report of Survey (ROS)	The Report of Survey and associated Data Packs are to be rendered to the AHO by the 21/07/2018.