Manly Hydraulics Laboratory

NSW WAVE CLIMATE ANNUAL SUMMARY

2023-2024

Report MHL3067

June 2025

Prepared for:

NSW Department of Climate Change, Energy, the Environment and Water – Conservation Programs, Heritage and Regulation

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June 2025

Matthew Phillips

MHL Coast and Marine

110B King Street

Manly Vale NSW 2093

T: 02 9949 0200

E: matthew.phillips@mhl.nsw.gov.au

W: www.mhl.nsw.gov.au

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110B King Street
Manly Vale NSW 2093
T 02 9949 0200
ABN 27 578 976 844 www.mhl.nsw.gov.au

Foreword

Manly Hydraulics Laboratory (MHL) is a business unit within the Water Group of NSW Department of Climate Change, Energy, the Environment and Water, which operates and maintains a number of ocean wave monitoring stations along the NSW coast under a service level agreement with the NSW Department of Climate Change, Energy, the Environment and Water - Conservation Programs, Heritage and Regulation (DCCEEW CPHR).

This annual summary presents the ocean wave information collected along the New South Wales coast from 1 July 2023 to 30 June 2024. Previous annual summaries have documented the available wave data for each offshore wave data station from the start of records.

Wave data are being collected to provide essential input into design, construction and performance monitoring of projects undertaken as part of the NSW Government programs in the areas of coastal management, beach improvement, estuary management, ports and marine facilities, fishing and wastewater engineering. The wave data also supports a broad range of industry and research applications as well as interests from the general public particularly for coastal recreation activities.

The summary has been prepared to catalogue available wave data and provide information on the analysis/presentation software resident at Manly Hydraulics Laboratory.

Requests for further information should be directed to:

Manager Environmental Data
Manly Hydraulics Laboratory
110b King Street
Manly Vale NSW 2093

Email : data-request@mhl.nsw.gov.au
Website : http://www.mhl.nsw.gov.au/
Telephone : (02) 9949 0200

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- NSW Coastal Rainfall
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  ISSN: 2205-5576 (Online)
- NSW Ocean and River Entrance Tidal Levels and Air Pressure Annual Summary 2023–2024
  Manly Hydraulics Laboratory
  Report No. MHL3065
  ISSN: 2205-555X (Online)
- NSW Estuary and River Water Quality
  Annual Summary 2023–2024
  Manly Hydraulics Laboratory
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  ISSN: 2205-5614 (Online)

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Executive Summary

This annual summary presents ocean wave data captured by the wave monitoring buoy network along the coastline of NSW over the period 1 July 2023 to 30 June 2024. It provides a catalogue of all ocean wave data collected in NSW by MHL for the NSW Department of Climate Change, Energy, the Environment and Water – Conservation Programs, Heritage and Regulation (DCCEEW CPHR).

During this period, the overall data capture across the wave monitoring network, excluding missing data and data outside of desired quality tolerances, was 90%.

This report contains:

- a brief description of the wave climate monitoring program
- guidelines of how to use this report
- information on how to access the wave data
- a summary of wave climate program operations and significant developments for 2023–2024 including data capture, data plots, ocean wave storm events and system downtime
- maps of the location history of each offshore wave monitoring station
- a brief description of wave data capture and analysis
- an index of all ocean wave data available for the NSW coast, including at inshore locations, that has been collected by MHL
- **Appendix A** which includes selected data presentation options available
- **Appendix B** provides a glossary of terms
- **Appendix C** provides a bibliography of other publications which may be of interest.

Contents

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FIGURES

1 Wave climate program

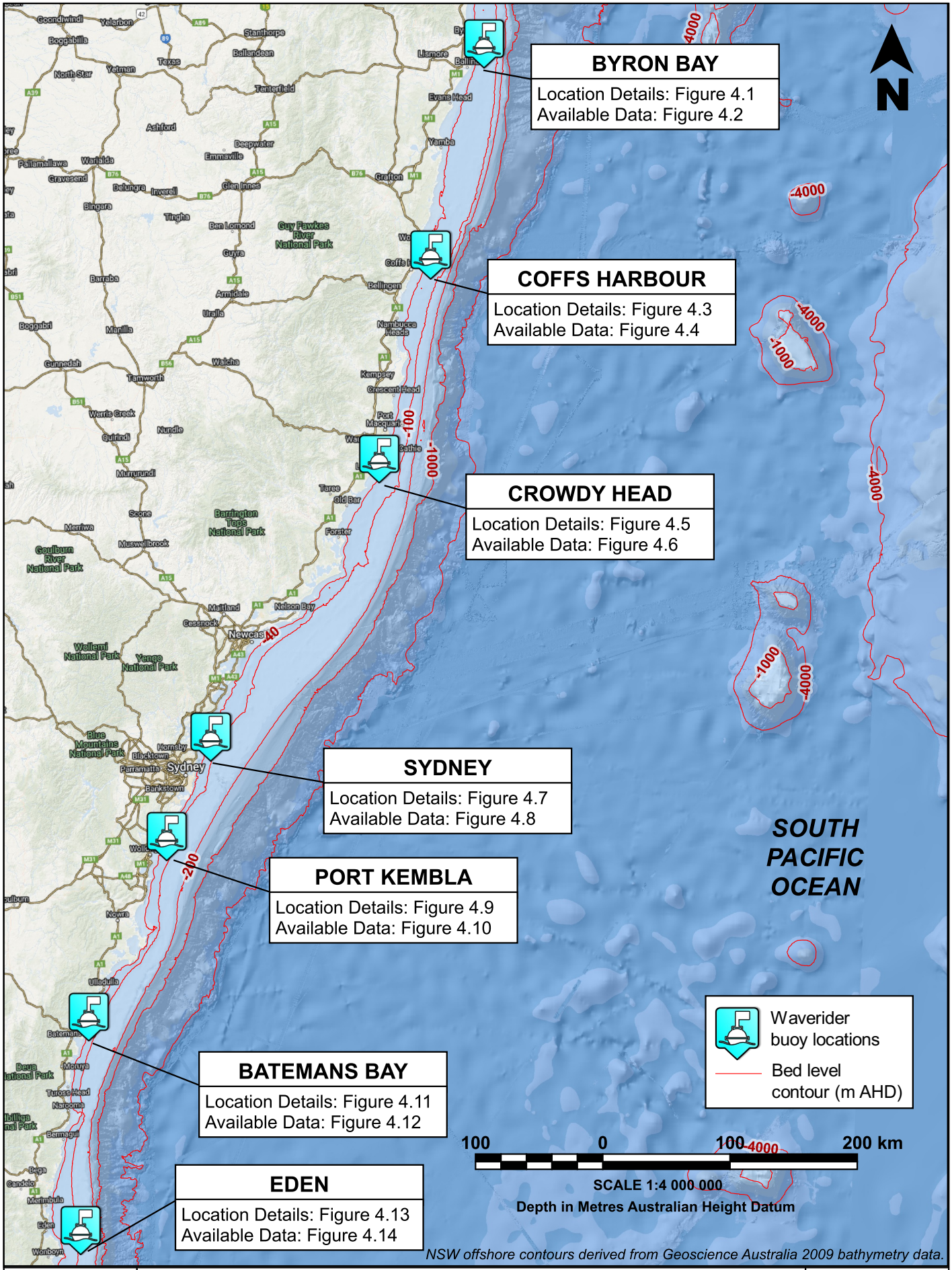
The NSW Wave Climate Program is centred around a network of offshore wave sensing buoys (**Figure 1.1**) which telemeter information to onshore recording stations. All stations are based on the Datawell Waverider system which uses an accelerometer mounted in a loose-tethered buoy to measure the vertical accelerations of the buoy as it moves with the ocean surface. The accelerations are integrated twice within the buoy and the displacement signal obtained is then transmitted to the shore station. Buoys that also measure wave direction replaced the original non-directional buoys during the period between1992 to 2012. The Directional Waverider buoys currently deployed are developed by Datawell and utilise three accelerometers and a compass to provide wave direction information. At the receiving station the Waverider data signal is processed and stored by a desktop computer (PC) and transferred every hour to Manly Hydraulics Laboratory's (MHL's) private cloud storage database via the internet.

Routine offshore wave measurement commenced in 1971 with the establishment of a Sydney station by the Maritime Services Board off Botany Bay. This was followed in 1974 by the then Public Works Department's first station at Port Kembla. Following the establishment of the Port Kembla station, coastal studies by the Public Works Department required further Waverider buoys to be deployed to monitor site specific wave conditions. During these early deployments the importance of reliable long-term wave statistics for coastal management and design purposes was emphasised by several destructive storms that caused severe beach erosion and considerable damage to coastal structures. As a result, during the 1980s the operation of the Waverider buoys was continued to establish a database of offshore wave statistics for the NSW coast.

Table 1.1 provides a summary of the non-directional and directional offshore ocean wave records available for the NSW Waverider buoy network. **Figure 1.2** presents a schematic of the wave data transfer system operated by Manly Hydraulics Laboratory. Detailed station location information and data plots for 2023–2024 for all offshore sites are presented in **Figure 4.1** to **Figure 4.14**.

Table 1.1 NSW Waverider buoy summary – June 2024

Waverider Station	Non-directional Waverider		Directional Waverider		Total record length (years)
	Date commissioned	Record length (years)	Date commissioned	Record length (years)	
Byron Bay	14-Oct-1976	23.03	26-Oct-1999	24.68	47.71
Coffs Harbour	25-May-1976	35.72	14-Feb-2012	12.38	48.10
Crowdy Head	10-Oct-1985	25.86	19-Aug-2011	12.86	38.72
Sydney	17-Jul-1987	4.62	03-Mar-1992	32.33	36.95
Port Kembla	07-Feb-1974	38.37	20-Jun-2012	12.03	50.40
Batemans Bay	27-May-1986	14.74	23-Feb-2001	23.35	38.09
Eden	08-Feb-1978	33.85	16-Dec-2011	12.54	46.39



NEW SOUTH WALES OFFSHORE
DIRECTIONAL WAVERIDER BUOY LOCATIONS

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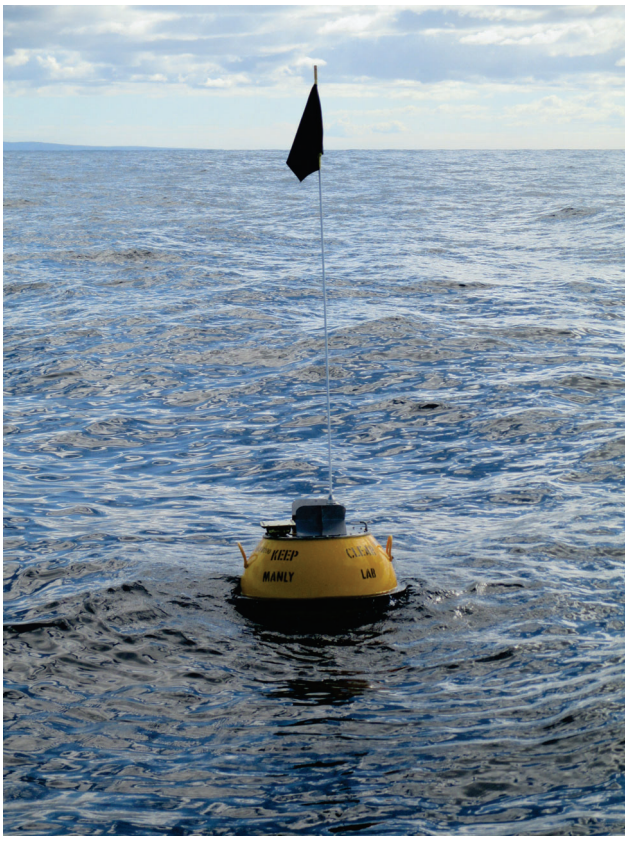
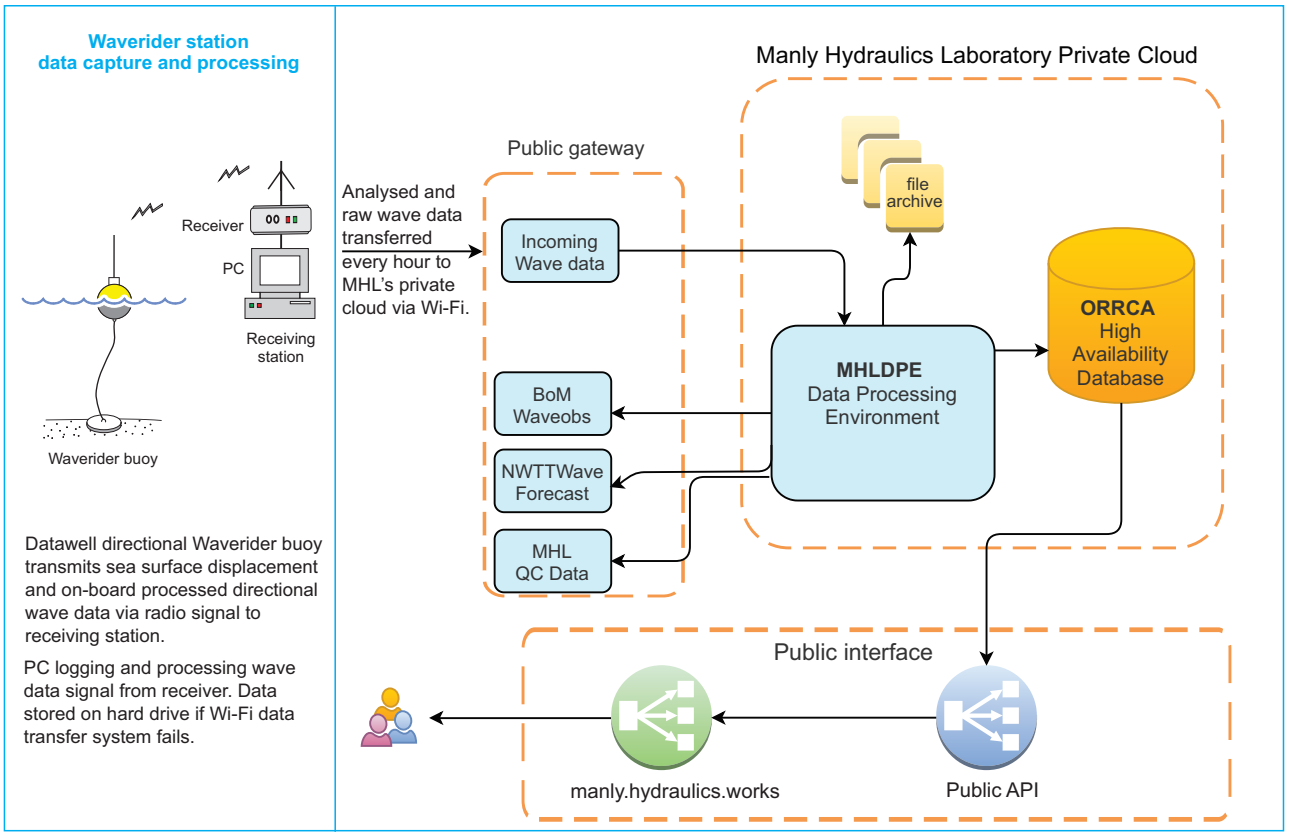
Figure
1.1

Dwg_3067-01-01



Waverider buoy

Receiving station



Data transfer schematic

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WAVE DATA COLLECTION SYSTEM

Manly Hydraulics Laboratory

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Figure

1.2

Dwg 3067-01-02

2 How to use this report

This report intends to provide a snapshot summary of the wave data collected over the annual monitoring period from July 2023 to June 2024.

Over this period wave data has been collected from each of the Waverider buoy locations shown in **Figure 1.1**. **Figure 1.1** also provides reference to a detailed station location map for each Waverider site and to the timeseries plots of wave height collected over the annual monitoring period.

The latest measurements from the NSW Wave Climate Program and a variety wave data analysis information is available via the Manly Hydraulics Laboratory website:

www.mhl.nsw.gov.au/Data-Wave

For readers desiring access to quality controlled wave information, this report can be used to identify what data is available and storms that have been recorded over the annual monitoring period. Once a choice has been made of the location and time period for which wave data is required, users can request from Manly Hydraulics Laboratory a variety of quality controlled wave information and statistics to support more detailed investigations (refer to **Section 3**).

Samples of wave data presentation formats available via the Manly Hydraulics Laboratory website are provided in **Appendix A**.

In addition to the NSW offshore Waverider buoy data presented in this Wave Climate Annual Summary, details of project-specific sites for which accompanying wave data is available in the same formats are catalogued in **Section 5.3**.

THE SITE INFORMATION IN THIS REPORT HAS BEEN PRESENTED AS A CATALOGUE OF DATA FOR EACH SITE. THE GRAPHICAL SCALES HAVE BEEN SELECTED FOR THIS PURPOSE. AT THESE SCALES THE INFORMATION IS NOT NECESSARILY DIRECTLY SUITABLE FOR ANALYSIS PURPOSES. IT IS THEREFORE RECOMMENDED THAT THIS REPORT ONLY BE UTILISED TO SELECT THE DATA SET REQUIRED. THE FORMAT APPROPRIATE TO THE INTENDED USE CAN THEN BE DETERMINED AND THE DATA PRESENTED ACCORDINGLY.

3 How to access the data

The latest hourly wave data measurements (over the past seven days) from the NSW Wave Climate Program and a variety wave data analysis documentation is available via the Manly Hydraulics Laboratory website:

www.mhl.nsw.gov.au/Data-Wave

Quality controlled wave data and other wave information can be requested by contacting Manly Hydraulics Laboratory by email via:

data-request@mhl.nsw.gov.au

All wave data requests are provided in digital format with accompanying conditions for data use and a descriptive summary of wave statistics.

For automated wave data services please contact MHL via the above email.

Use and presentation of the data on all occasions must include an acknowledgment to the NSW Department of Climate Change, Energy, the Environment and Water - Conservation Programs, Heritage and Regulation (DCCEEW CPHR) as owner of the data and Manly Hydraulics Laboratory for the collection and provision of the data.

4 Wave climate program summary 2023-2024

4.1 Data capture

Based on offshore wave data capture achieved by Manly Hydraulics Laboratory over the past 25 years, the target average annual data capture for all offshore Waverider buoy stations is 85%. Where the data capture percentage is defined as the total number of good quality control data points divided by the total number of continuous hours for the annual monitoring period.

During normal operations this target is readily achieved by the Waverider buoy network. Any data loss longer than one week is usually due to loss or damage to Waverider buoys by ship collisions. During 2023–2024 the overall average data capture percentage for all Waverider buoy stations was 90%. The monthly percentage data capture during 2023–2024 for each Waverider buoy station is provided in **Table 4.1**.

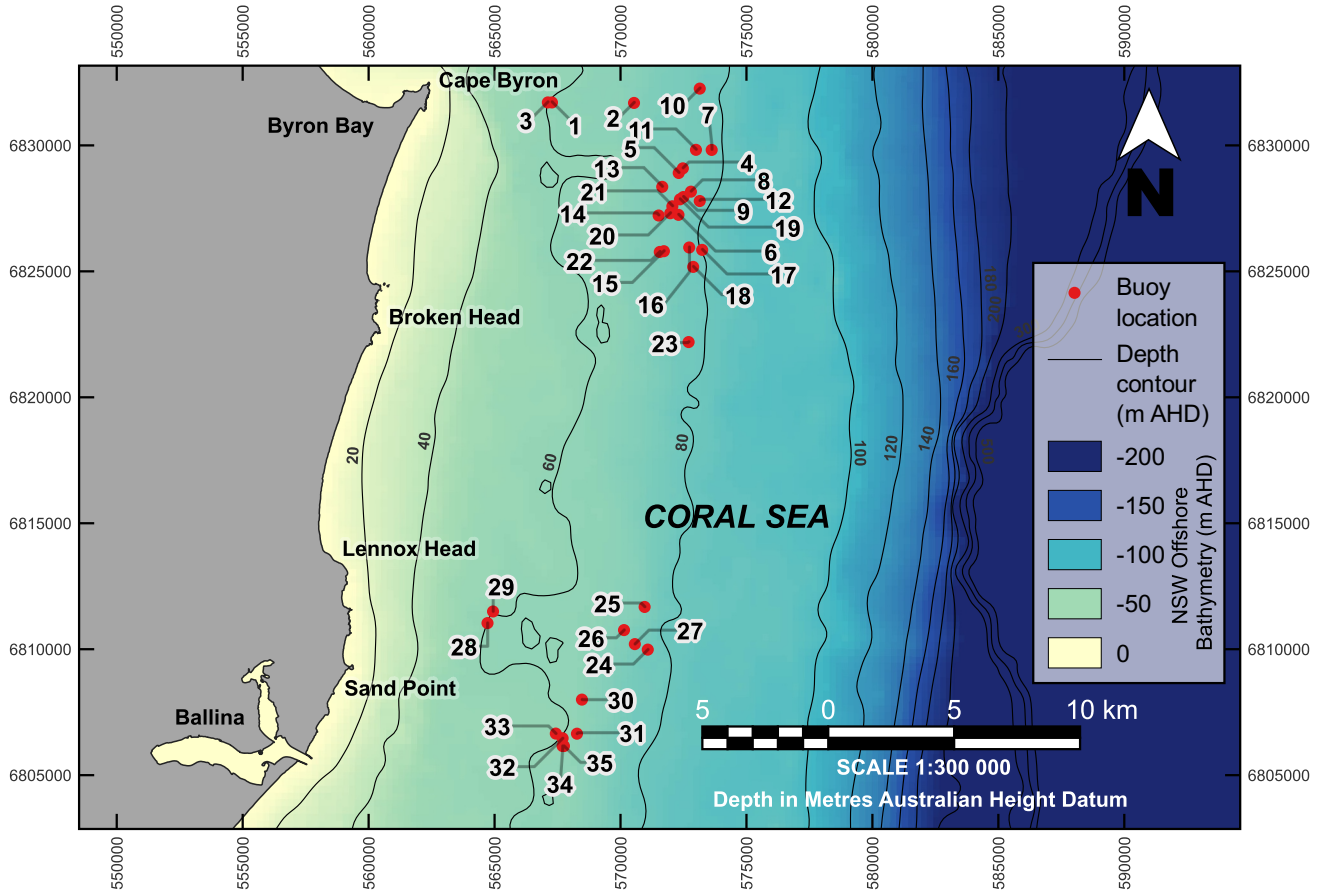
Table 4.1 New South Wales wave climate: 2023–2024 data capture

Waverider site	Data capture (%)												Total year
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
Byron Bay	98	88	9	92	98	88	94	89	74	59	30	84	**75**
Coffs Harbour	91	100	100	100	100	96	83	100	100	100	99	95	**97**
Crowdy Head	89	43	85	100	100	100	100	100	100	99	95	90	**92**
Sydney	94	99	96	99	99	86	99	95	99	97	99	94	**96**
Port Kembla	98	93	99	100	93	100	100	93	98	93	94	94	**96**
Batemans Bay	98	97	99	99	99	79	94	100	97	99	97	94	**96**
Eden	93	98	36	68	90	90	83	98	18	86	98	94	**79**
Total Months	**94**	**88**	**75**	**94**	**97**	**91**	**93**	**96**	**84**	**90**	**87**	**92**	**90**

Data capture at two Waverider stations during 2023–2024 was below the target 85%. Periods of extended data loss at these stations were due to:

- Byron Bay – the Waverider buoy went adrift on 28 August 2023 resulting in data loss until the buoy was replaced on 28 September 2023. The adrift buoy was recovered from Noosa North Shore in mid-April 2024. From March to June 2024, data anomalies occurred, possibly due to buoy damage via vessel collision. A replacement buoy was subsequently deployed.
- Eden – the Waverider buoy went adrift on 7 March 2024 due to mooring damage and has not been recovered. A replacement buoy was subsequently deployed on 4 April 2024.

Detailed station location information and data plots for 2023–2024 for all offshore sites are presented in **Figure 4.1** to **Figure 4.14** including data outage periods.



DEPLOYMENT LOCATION	LOCATION DETAILS				WATER DEPTH (m)	DEPLOYMENT PERIOD	
	Latitude (S)	Longitude (E)	MGA (Zone 56J) Easting	MGA (Zone 56J) Northing		First Date	Last Date
1	28° 38' 24"	153° 41' 18"	567280	6831690	64	14-Oct-76	7-Jun-78
2	28° 38' 24"	153° 43' 18"	570530	6831670	70	3-Aug-78	13-Jun-79
3	28° 38' 24"	153° 41' 12"	567110	6831690	62	8-Aug-79	9-Aug-83
4	28° 39' 48"	153° 44' 30"	572470	6829080	77	9-Aug-83	13-Dec-83
5	28° 39' 54"	153° 44' 24"	572310	6828890	77	7-Feb-84	25-Sep-84
6	28° 40' 48"	153° 44' 24"	572300	6827230	73	25-Sep-84	30-Jun-85
7	28° 39' 24"	153° 45' 12"	573620	6829810	80	27-Aug-85	22-Nov-85
8	28° 40' 18"	153° 44' 42"	572790	6828140	78	12-Dec-85	24-Mar-87
9	28° 40' 25"	153° 44' 31"	572480	6827950	78	24-Mar-87	19-Nov-87
10	28° 38' 05"	153° 44' 54"	573150	6832250	77	3-Dec-87	7-Apr-88
11	28° 39' 24"	153° 44' 49"	572980	6829800	77	18-May-88	7-Nov-88
12	28° 40' 30"	153° 44' 55"	573130	6827780	82	6-Dec-88	8-Dec-88
13	28° 40' 12"	153° 44' 00"	571650	6828350	72	10-Jan-89	5-Aug-89
14	28° 40' 49"	153° 43' 55"	571500	6827200	71	29-Aug-89	14-Dec-89
15	28° 41' 35"	153° 44' 03"	571730	6825790	74	7-Feb-90	6-Dec-90
16	28° 41' 30"	153° 44' 40"	572730	6825950	73	6-Dec-90	8-May-91
17	28° 41' 33"	153° 44' 59"	573240	6825840	78	29-May-91	14-May-92
18	28° 41' 55"	153° 44' 46"	572880	6825170	73	14-May-92	18-Jun-93
19	28° 40' 28"	153° 44' 26"	572360	6827850	73	23-Jun-93	21-Jul-93
20	28° 40' 46"	153° 44' 12"	571970	6827300	72	21-Jul-93	11-Nov-93
21	28° 40' 37"	153° 44' 15"	572060	6827570	72	1-Dec-93	20-Jul-94
22	28° 41' 36"	153° 43' 57"	571560	6825760	72	20-Jul-94	5-Feb-96
23	28° 43' 32"	153° 44' 40"	572700	6822180	72	5-Feb-96	28-Nov-00
24	28° 50' 09"	153° 43' 43"	571080	6809970	71	29-Nov-00	23-Jan-01
25	28° 49' 14"	153° 43' 38"	570950	6811670	71	10-Feb-01	29-Aug-03
26	28° 49' 44"	153° 43' 08"	570030	6810570	71	29-Aug-03	12-Aug-04
27	28° 50' 02"	153° 43' 24"	570570	6810200	71	12-Aug-04	1-Jan-05
28	28° 49' 36"	153° 39' 48"	564720	6811040	62	4-Feb-05	11-Dec-07
29	28° 49' 21"	153° 39' 56"	564940	6811500	62	11-Dec-07	20-Aug-09
30	28° 51' 14"	153° 42' 07"	568470	6808000	62	20-Aug-09	11-Feb-12
31	28° 51' 58"	153° 42' 00"	568270	6806650	62	11-Feb-12	5-Oct-12
32	28° 52' 04"	153° 41' 39"	567600	6806540	62	16-Oct-12	15-Nov-13
33	28° 51' 58"	153° 41' 29"	567430	6806650	62	15-Nov-13	29-May-14
34	28° 52' 14"	153° 41' 39"	567700	6806160	62	29-May-14	9-May-24
35	28° 52' 14"	153° 41' 41"	567750	6806157	61	9-May-24	Present

NSW GOVERNMENT

BYRON BAY WAVERIDER BUOY LOCATION HISTORY

NSW offshore bathymetry data obtained from Geoscience Australia 2009 and NSW OEH 2018 Marine LiDAR using methodology described by O'Grady, et al. (2021).

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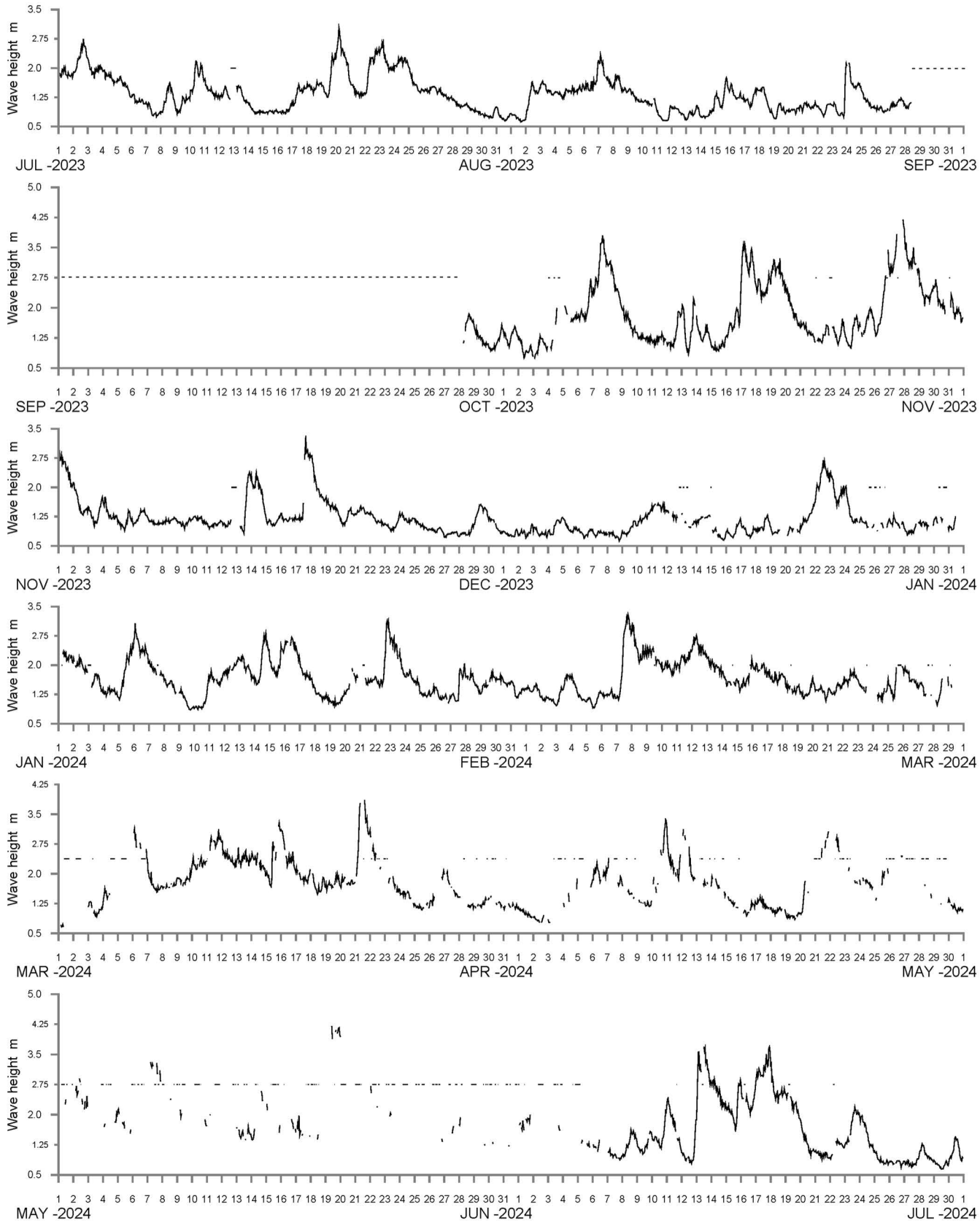
Report MHL3067
Figure
4.1

Dwg 3067-04-01



---------- DATA LOSS

NSW GOVERNMENT

BYRON BAY WAVERIDER BUOY
2023–2024 SIGNIFICANT WAVE HEIGHT TIME HISTORY

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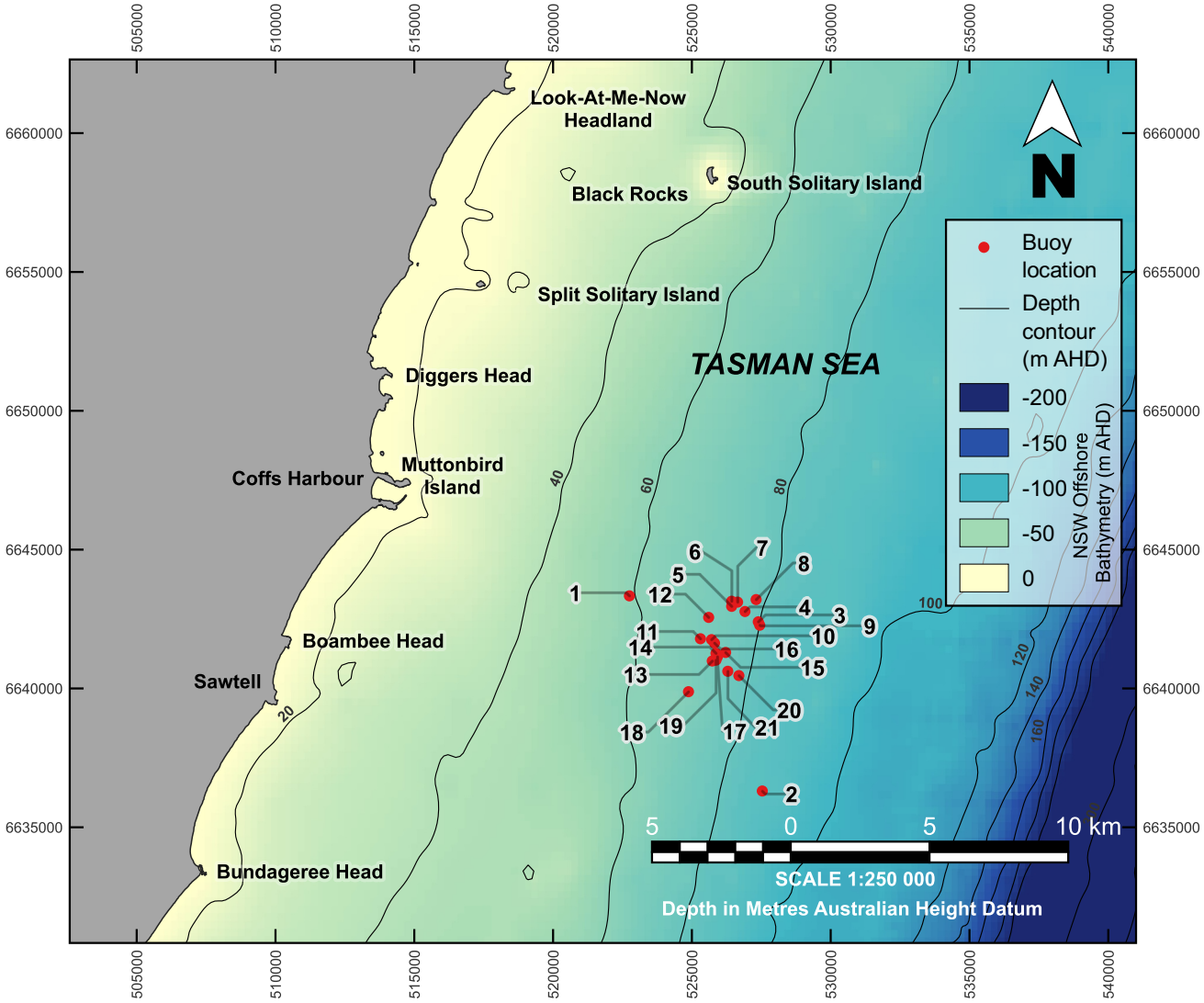
Report MHL3067
Figure
4.2

Dwg 3067-04-02



DEPLOYMENT LOCATION	LOCATION DETAILS				WATER DEPTH (m)	DEPLOYMENT PERIOD	
	Latitude (S)	Longitude (E)	MGA (Zone 56J) Easting	MGA (Zone 56J) Northing		First Date	Last Date
1	30° 20' 30"	153° 14' 12"	522750	6643320	60	26-May-76	18-Aug-83
2	30° 24' 18"	153° 17' 12"	527540	6636290	80	18-Aug-83	20-Dec-83
3	30° 21' 00"	153° 17' 06"	527390	6642380	80	20-Dec-83	7-Mar-84
4	30° 20' 48"	153° 16' 48"	526910	6642760	79	7-Mar-84	12-Apr-85
5	30° 20' 42"	153° 16' 30"	526430	6642940	77	12-Apr-85	9-Jul-85
6	30° 20' 36"	153° 16' 30"	526430	6643130	77	13-Aug-85	29-Oct-85
7	30° 20' 37"	153° 16' 38"	526640	6643100	77	5-Nov-85	8-Oct-87
8	30° 20' 34"	153° 17' 03"	527300	6643200	80	8-Oct-87	25-Sep-89
9	30° 21' 04"	153° 17' 08"	527450	6642250	82	25-Sep-89	6-Dec-89
10	30° 21' 21"	153° 16' 03"	525700	6641750	71	19-Dec-89	11-Apr-90
11	30° 21' 20"	153° 15' 48"	525300	6641770	73	11-Apr-90	22-Feb-91
12	30° 20' 55"	153° 15' 59"	525600	6642550	73	22-Feb-91	2-Jul-96
13	30° 21' 46"	153° 16' 04"	525730	6640970	74	26-Jul-96	6-Dec-97
14	30° 21' 37"	153° 16' 09"	525870	6641250	72	18-Jan-98	7-Nov-02
15	30° 21' 36"	153° 16' 22"	526210	6641280	72	23-Nov-02	11-Mar-05
16	30° 21' 25"	153° 16' 07"	525920	6641810	72	1-Apr-05	19-Oct-09
17	30° 21' 41"	153° 16' 11"	525920	6641140	72	19-Oct-09	13-Feb-12
18	30° 22' 22"	153° 15' 32"	524880	6639880	72	13-Feb-12	26-Oct-13
19	30° 21' 45"	153° 16' 09"	525870	6641010	72	26-Oct-13	18-Aug-16
20	30° 22' 03"	153° 16' 40"	526690	6640450	72	18-Aug-16	9-May-24
21	30° 21' 58"	153° 16' 25"	526291	6640613	76	9-May-24	Present

NSW GOVERNMENT

COFFS HARBOUR WAVERIDER BUOY LOCATION HISTORY

NSW offshore bathymetry data obtained from Geoscience Australia 2009 and NSW OEH 2018 Marine LiDAR using methodology described by O'Grady, et al. (2021).

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Report MHL3067
Figure
4.3

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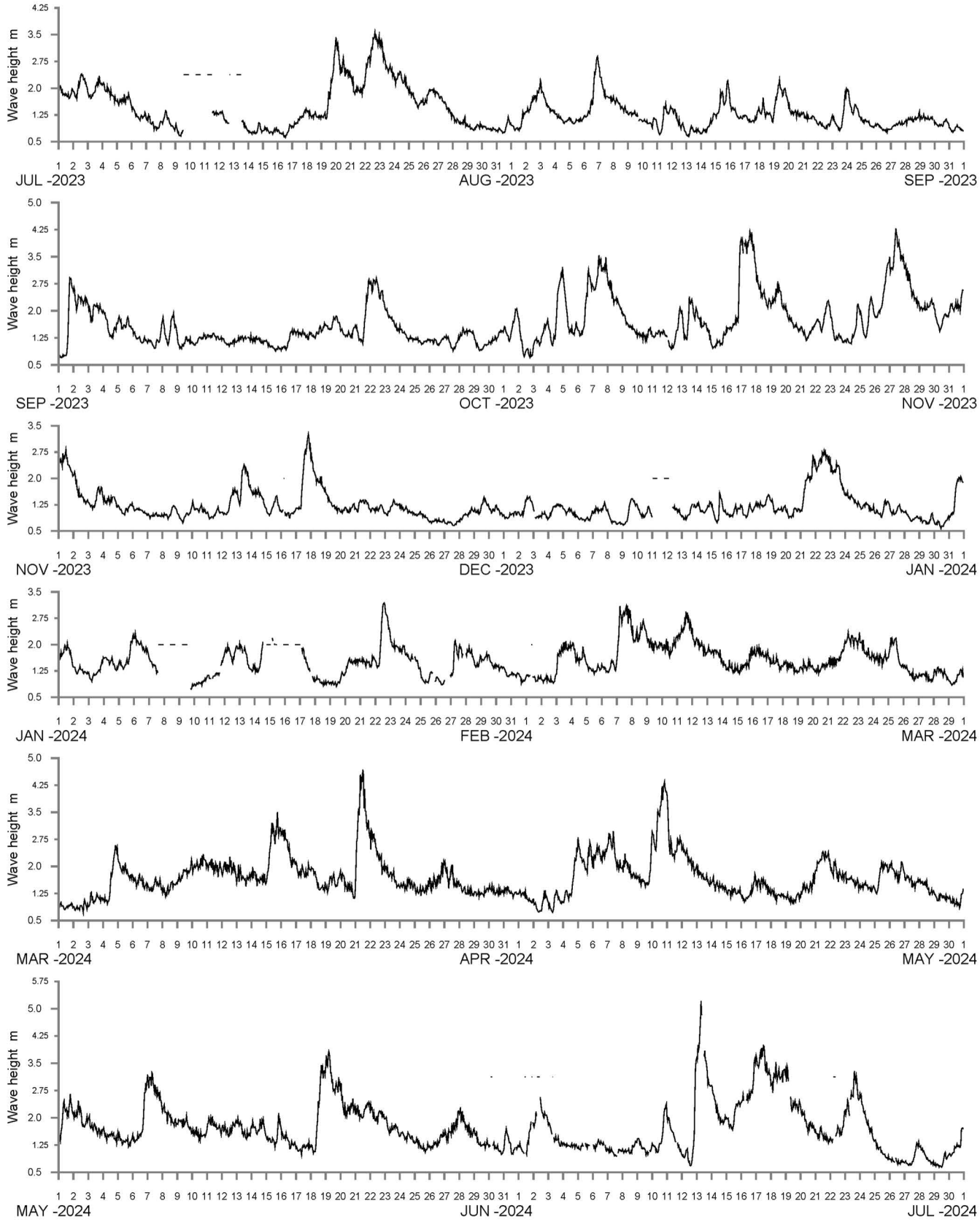

---------- DATA LOSS

NSW GOVERNMENT

COFFS HARBOUR WAVERIDER BUOY
2023–2024 SIGNIFICANT WAVE HEIGHT TIME HISTORY

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Report MHL3067
Figure
4.4

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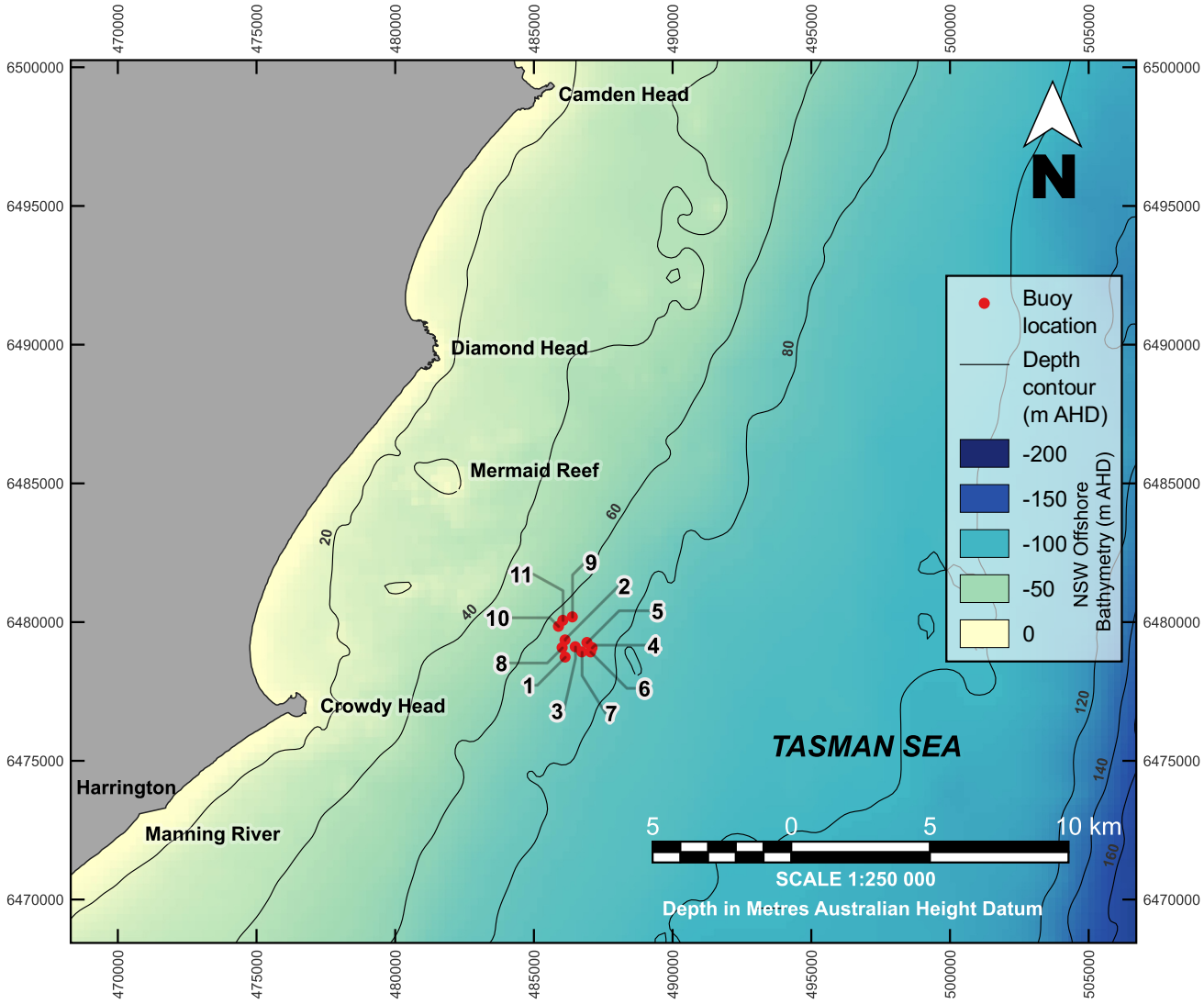

DEPLOYMENT LOCATION	LOCATION DETAILS				WATER DEPTH (m)	DEPLOYMENT PERIOD	
	Latitude (S)	Longitude (E)	MGA (Zone 56J) Easting	MGA (Zone 56J) Northing		First Date	Last Date
1	31° 49' 37"	152° 51' 12"	486110	6478730	77	10-Oct-85	11-Nov-86
2	31° 49' 17"	152° 51' 12"	486110	6479330	77	11-Nov-86	20-Oct-87
3	31° 49' 25"	152° 51' 26"	486480	6479100	80	20-Oct-87	8-Aug-89
4	31° 49' 26"	152° 51' 49"	487100	6479050	79	8-Aug-89	17-Jul-90
5	31° 49' 20"	152° 51' 42"	486900	6479250	77	17-Jul-90	20-Apr-93
6	31° 49' 31"	152° 51' 47"	487050	6478900	79	20-Apr-93	21-Nov-97
7	31° 49' 31"	152° 51' 35"	486720	6478910	79	21-Nov-97	31-Oct-12
8	31° 49' 26"	152° 51' 08"	485910	6479140	79	31-Oct-12	4-Jul-13
9	31° 48' 50"	152° 51' 22"	486380	6480180	79	10-Jul-13	20-May-21
10	31° 49' 01"	152° 51' 03"	485880	6479840	79	20-May-21	9-May-24
11	31° 48' 54"	152° 51' 09"	486039	6480060	64	9-May-24	Present

NSW GOVERNMENT

CROWDY HEAD WAVERIDER BUOY LOCATION HISTORY

NSW offshore bathymetry data obtained from Geoscience Australia 2009 and NSW OEH 2018 Marine LiDAR using methodology described by O'Grady, et al. (2021).

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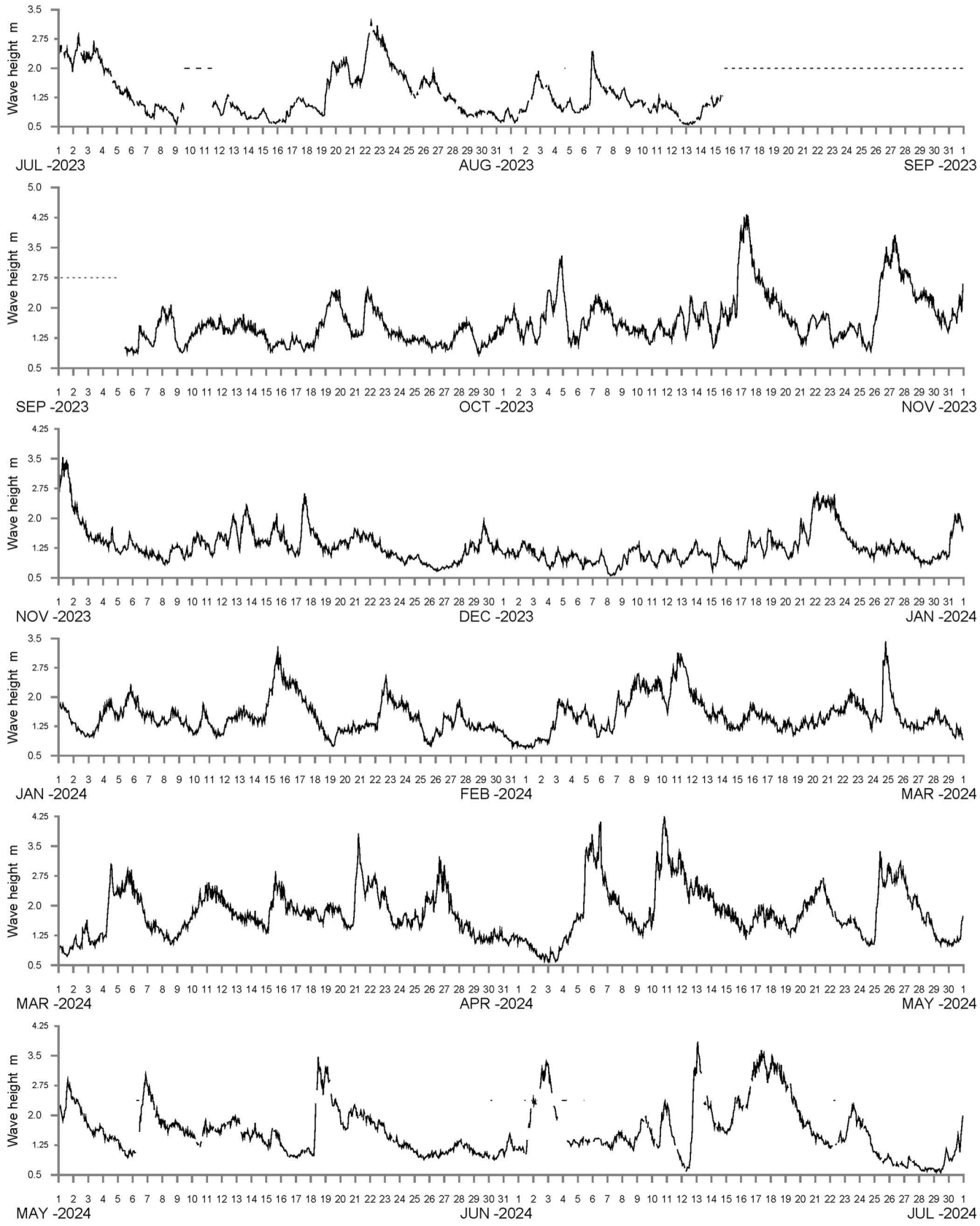
Report MHL3067
Figure
4.5

Dwg 3067-04-05



---------- DATA LOSS

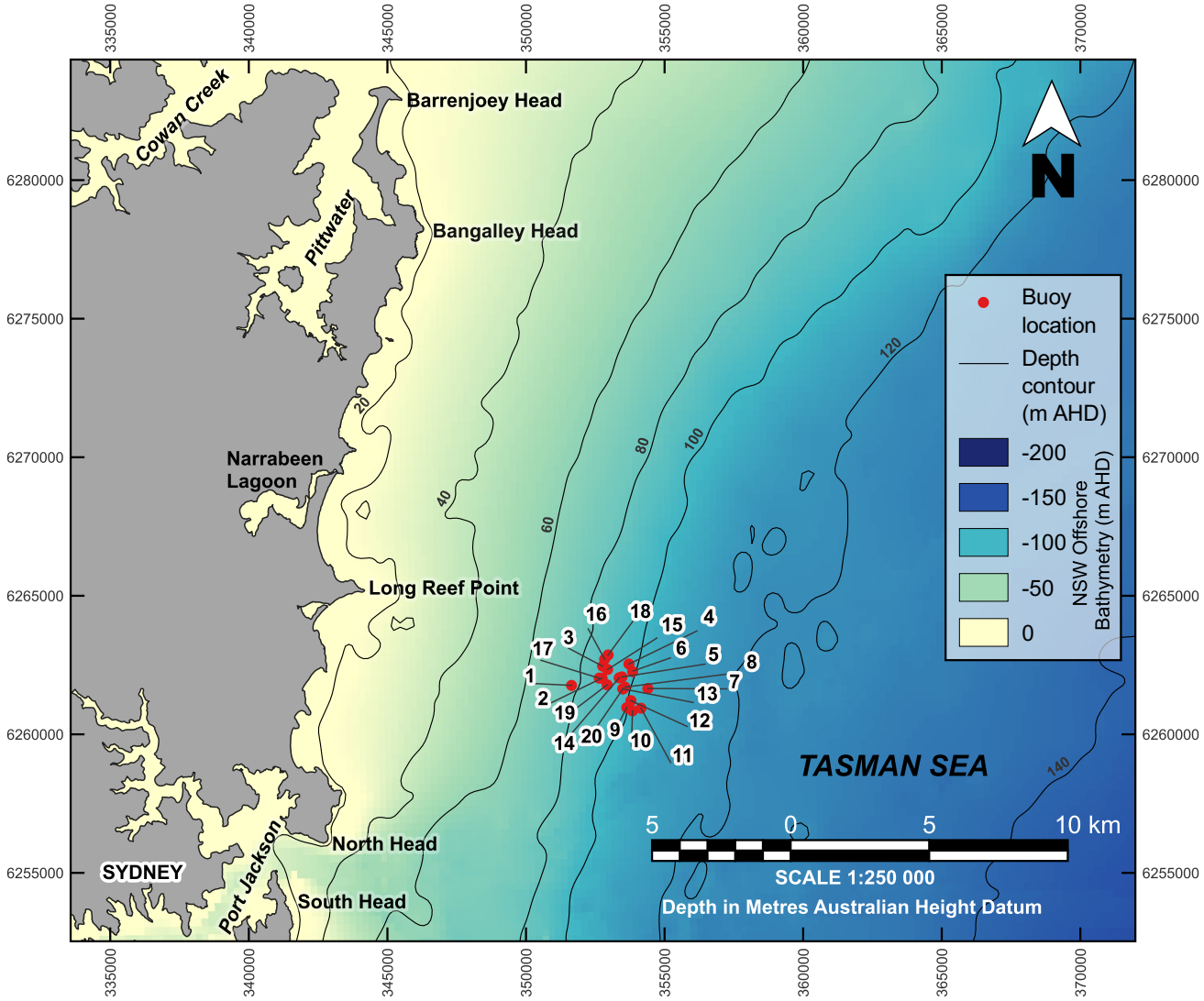
NSW GOVERNMENT

CROWDY HEAD WAVERIDER BUOY
2023–2024 SIGNIFICANT WAVE HEIGHT TIME HISTORY

Manly Hydraulics Laboratory

Report MHL3067
Figure
4.6

Dwg 3067-04-06



DEPLOYMENT LOCATION	LOCATION DETAILS				WATER DEPTH (m)	DEPLOYMENT PERIOD	
	Latitude (S)	Longitude (E)	MGA (Zone 56H) Easting	MGA (Zone 56H) Northing		First Date	Last Date
1	33° 46' 26"	151° 23' 52"	351650	6261750	82	3-Mar-92	5-Apr-93
2	33° 46' 18"	151° 24' 35"	352740	6262010	85	22-Jun-93	17-Nov-93
3	33° 46' 04"	151° 24' 36"	352760	6262440	85	17-Nov-93	1-Dec-93
4	33° 46' 02"	151° 25' 13"	353710	6262520	85	18-Dec-93	16-Feb-94
5	33° 46' 17"	151° 25' 03"	353460	6262050	85	22-Mar-94	25-Feb-95
6	33° 46' 11"	151° 25' 18"	353840	6262230	87	25-Feb-95	11-Feb-98
7	33° 46' 31"	151° 25' 39"	354400	6261640	87	11-Feb-98	1-Oct-98
8	33° 46' 29"	151° 25' 07"	353570	6261680	85	1-Oct-98	7-Feb-99
9	33° 46' 53"	151° 25' 09"	353630	6260940	85	26-Mar-99	23-Nov-00
10	33° 46' 57"	151° 25' 17"	353830	6260840	85	23-Nov-00	29-Jul-01
11	33° 46' 54"	151° 25' 29"	354160	6260930	85	11-Sep-01	18-May-04
12	33° 46' 45"	151° 25' 15"	353780	6261210	85	18-May-04	15-Jan-05
13	33° 46' 31"	151° 25' 04"	353490	6261620	85	15-Feb-05	13-Mar-08
14	33° 46' 18"	151° 24' 59"	353360	6262020	92	13-Mar-08	25-Nov-09
15	33° 46' 08"	151° 24' 43"	352940	6262340	92	25-Nov-09	21-Aug-12
16	33° 45' 56"	151° 24' 39"	352830	6262710	92	21-Aug-12	24-Apr-14
17	33° 46' 18"	151° 24' 31"	352630	6262020	90	24-Apr-14	30-Oct-14
18	33° 45' 51"	151° 24' 44"	352970	6262860	90	30-Oct-14	11-Feb-15
19	33° 46' 26"	151° 24' 42"	352920	6261800	90	11-Feb-15	9-May-24
20	33° 46' 31"	151° 25' 04"	353494	6261635	97	9-May-24	Present

NSW GOVERNMENT

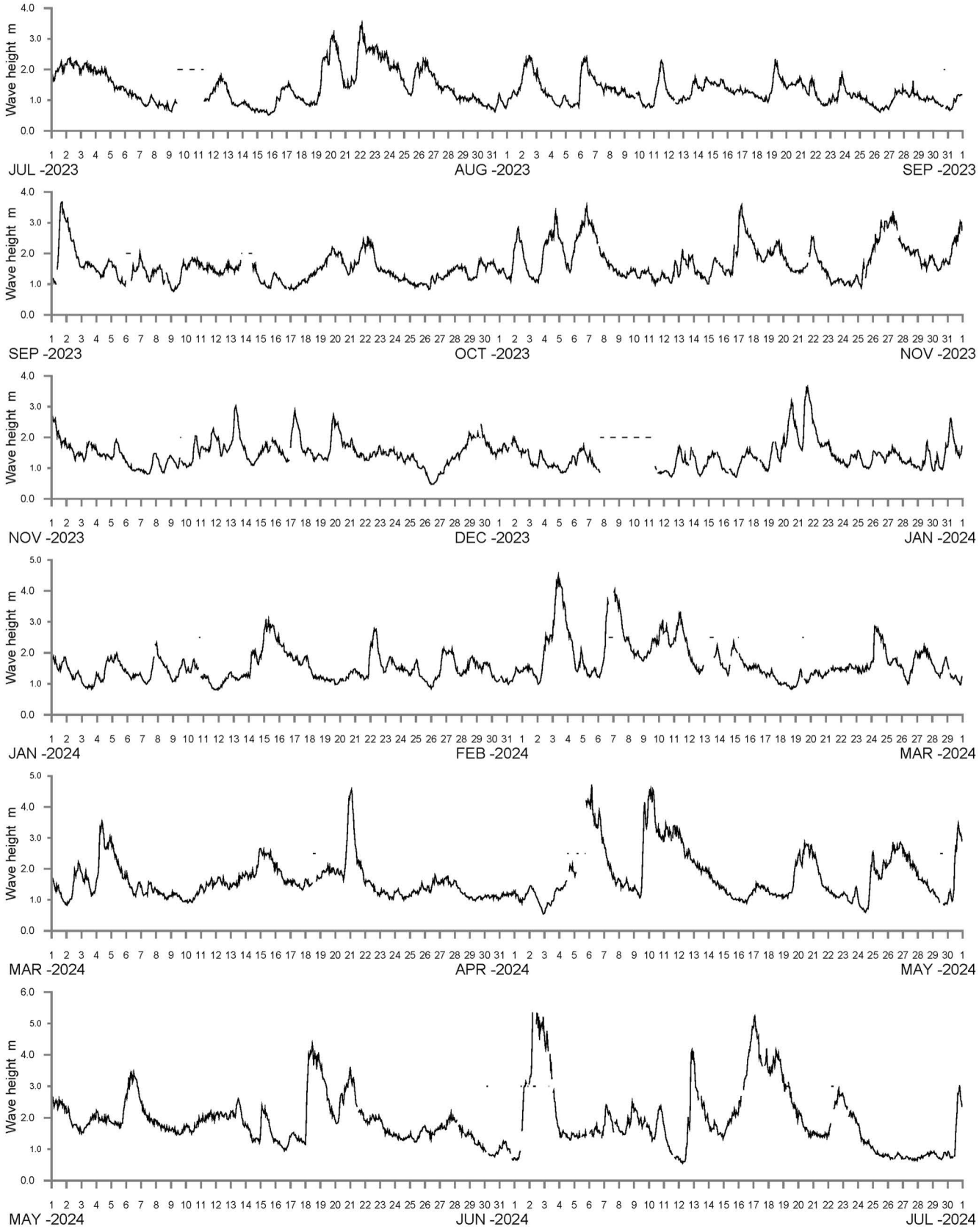
SYDNEY WAVERIDER BUOY LOCATION HISTORY

NSW offshore bathymetry data obtained from Geoscience Australia 2009 and NSW OEH 2018 Marine LiDAR using methodology described by O'Grady, et al. (2021).

Manly Hydraulics Laboratory

Report MHL3067
Figure
4.7

Dwg 3067-04-07



---------- DATA LOSS

NSW GOVERNMENT

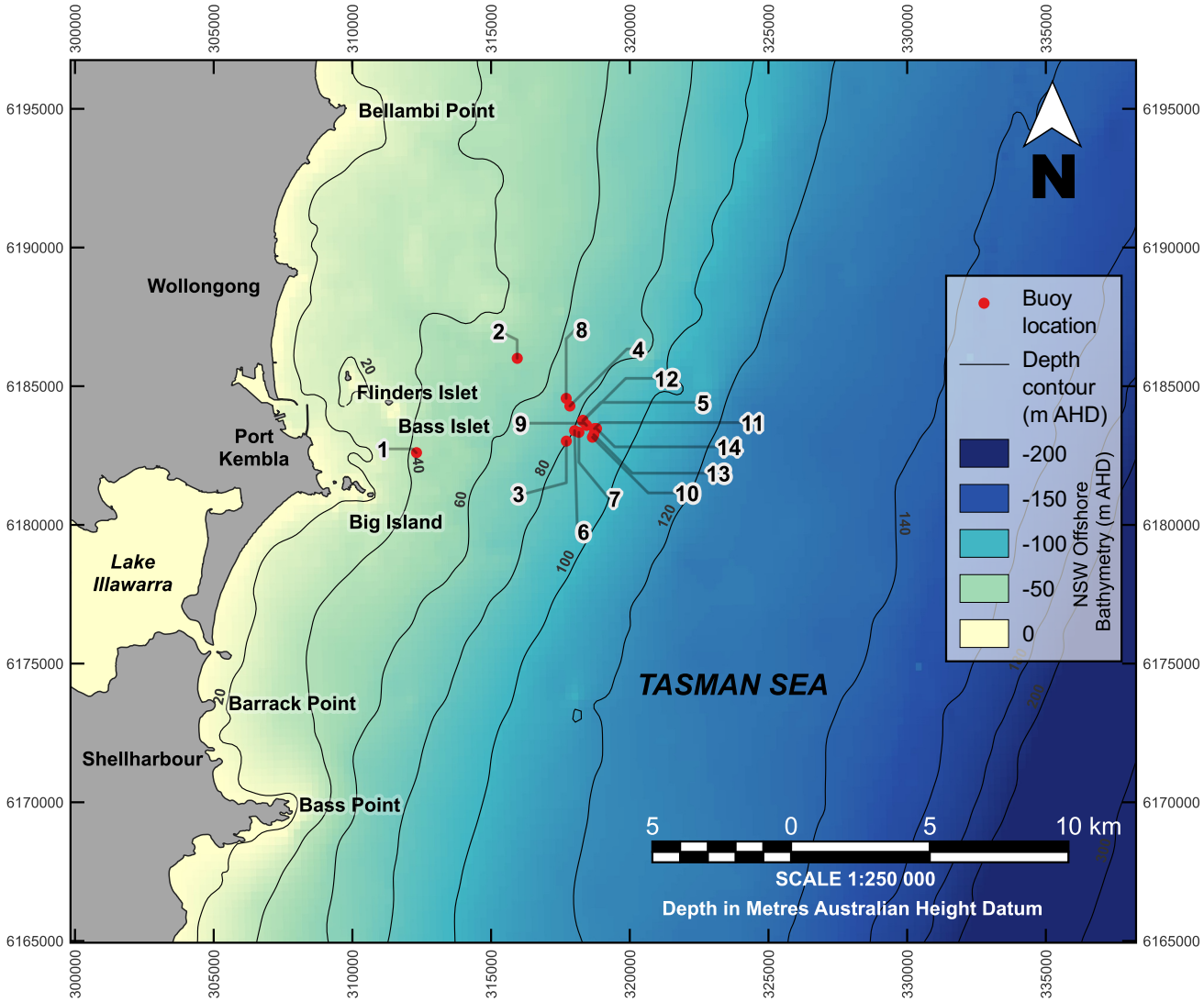
SYDNEY WAVERIDER BUOY
2023–2024 SIGNIFICANT WAVE HEIGHT TIME HISTORY

Manly Hydraulics Laboratory

Report MHL3067

Figure 4.8

Dwg 3067-04-08



DEPLOYMENT LOCATION	LOCATION DETAILS				WATER DEPTH (m)	DEPLOYMENT PERIOD	
	Latitude (S)	Longitude (E)	MGA (Zone 56H) Easting	MGA (Zone 56H) Northing		First Date	Last Date
1	34° 28' 52"	150° 57' 22"	312310	6182590	40	7-Feb-74	25-Oct-76
2	34° 27' 04"	150° 59' 47"	315940	6185990	50	25-Oct-76	16-Nov-83
3	34° 28' 42"	151° 00' 54"	317710	6183000	82	16-Nov-83	14-Jun-84
4	34° 28' 01"	151° 01' 00"	317850	6184280	76	14-Jun-84	27-May-88
5	34° 28' 18"	151° 01' 18"	318300	6183750	73	1-Jun-88	19-Dec-88
6	34° 28' 30"	151° 01' 06"	318000	6183380	73	19-Jan-89	25-Jan-90
7	34° 28' 32"	151° 01' 12"	318150	6183330	77	25-Jan-90	24-Oct-91
8	34° 27' 52"	151° 00' 55"	317700	6184550	82	24-Oct-91	24-Jun-92
9	34° 28' 24"	151° 01' 23"	318820	6183090	77	24-Jun-92	28-Jul-94
10	34° 28' 38"	151° 01' 31"	318650	6183150	78	28-Jul-94	10-Jun-03
11	34° 28' 28"	151° 01' 34"	318720	6183460	80	25-Jun-03	15-Jun-12
12	34° 28' 19"	151° 01' 18"	318310	6183740	80	15-Jun-12	7-Nov-14
13	34° 28' 35"	151° 01' 33"	318700	6183250	80	7-Nov-14	9-May-24
14	34° 28' 28"	151° 01' 37"	318798	6183470	87	9-May-24	Present

NSW GOVERNMENT

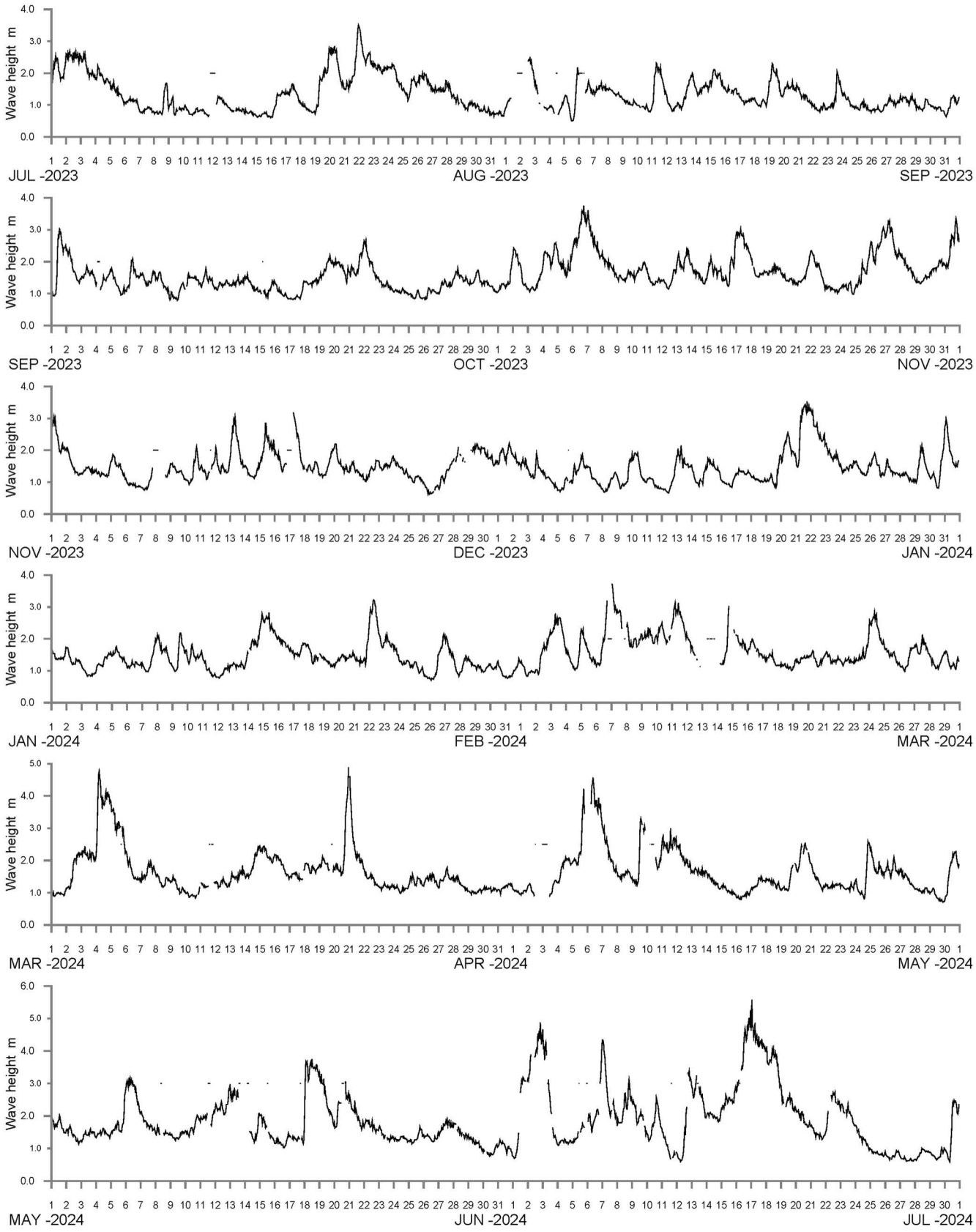
PORT KEMBLA WAVERIDER BUOY LOCATION HISTORY

NSW offshore bathymetry data obtained from Geoscience Australia 2009 and NSW OEH 2018 Marine LiDAR using methodology described by O'Grady, et al. (2021).

Manly Hydraulics Laboratory

Report MHL3067
Figure
4.9

Dwg 3067-04-09



---------- DATA LOSS

NSW GOVERNMENT

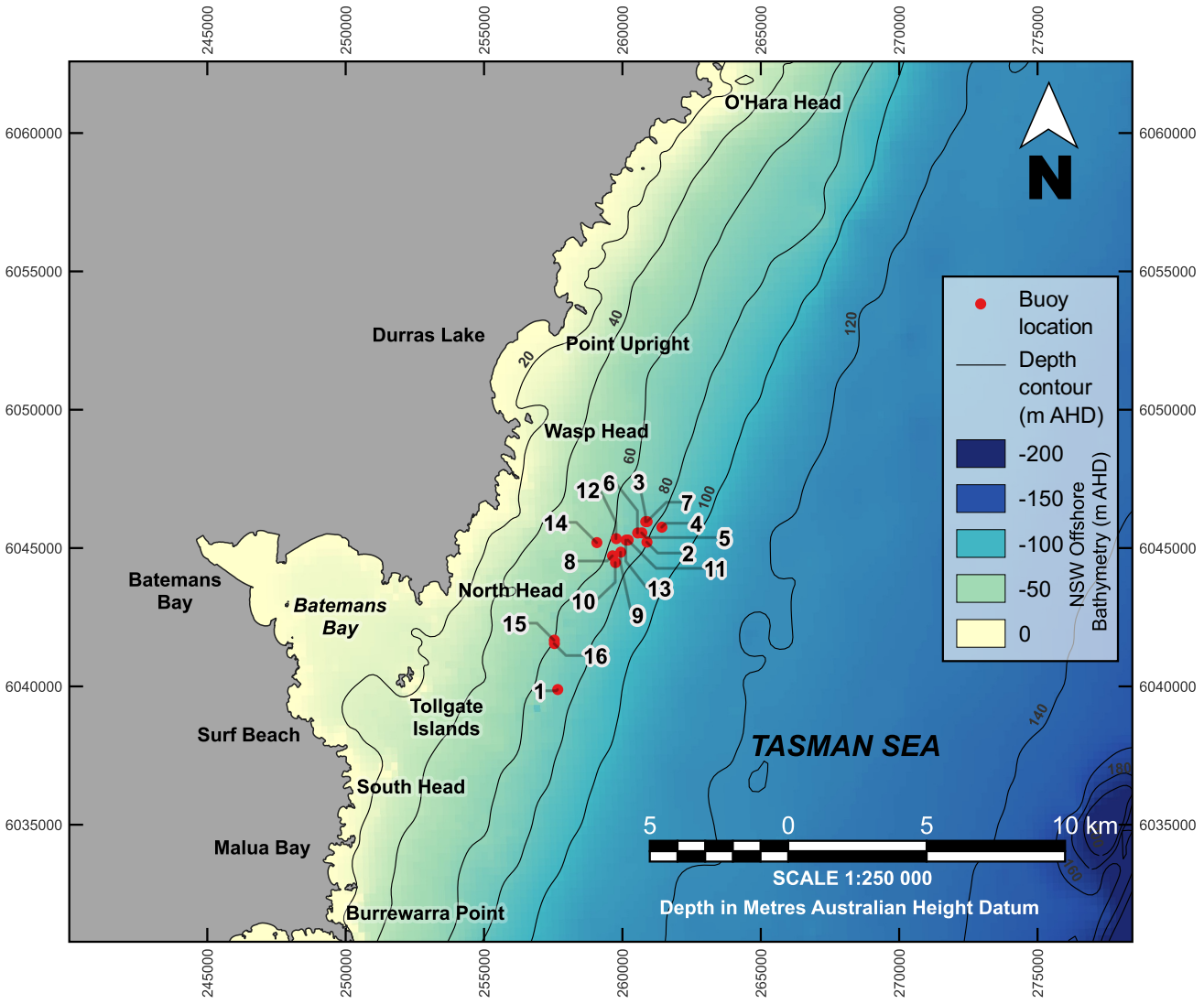
PORT KEMBLA WAVERIDER BUOY
2023–2024 SIGNIFICANT WAVE HEIGHT TIME HISTORY

Manly Hydraulics Laboratory

Report MHL3067

Figure 4.10

Dwg 3067-04-10



DEPLOYMENT LOCATION	LOCATION DETAILS				WATER DEPTH (m)	DEPLOYMENT PERIOD	
	Latitude (S)	Longitude (E)	MGA (Zone 56H) Easting	MGA (Zone 56H) Northing		First Date	Last Date
1	35° 45' 19"	150° 19' 11"	257650	6039860	79	27-May-86	2-Jun-86
2	35° 42' 29"	150° 21' 25"	260880	6045200	75	2-Jun-86	30-Sep-87
3	35° 42' 05"	150° 21' 24"	260850	6045950	75	1-Oct-87	29-Jun-88
4	35° 42' 12"	150° 21' 47"	261430	6045750	84	30-Jun-88	7-Feb-89
5	35° 42' 18"	150° 21' 18"	260700	6045530	80	7-Feb-89	19-Mar-89
6	35° 42' 18"	150° 21' 12"	260550	6045530	73	11-Apr-89	24-Oct-89
7	35° 42' 05"	150° 21' 26"	260900	6045950	75	25-Oct-89	9-Nov-89
8	35° 42' 44"	150° 20' 35"	259650	6044700	73	22-Nov-89	26-Apr-90
9	35° 42' 40"	150° 20' 47"	259950	6044830	73	9-May-90	19-Oct-90
10	35° 42' 52"	150° 20' 39"	259750	6044450	73	13-Nov-90	5-Jan-97
11	35° 42' 26"	150° 20' 58"	260200	6045270	75	5-Jan-97	28-Mar-98
12	35° 42' 24"	150° 20' 41"	259780	6045320	73	29-Apr-98	30-Jul-04
13	35° 42' 26"	150° 20' 55"	260030	6045090	73	30-Jul-04	18-Dec-07
14	35° 42' 28"	150° 20' 13"	259080	6045190	73	25-Jan-08	22-Feb-18
15	35° 44' 21"	150° 19' 08"	257540	6041540	65	22-Feb-18	9-May-24
16	35° 44' 25"	150° 19' 08"	257540	6043063	61	9-May-24	Present

NSW GOVERNMENT

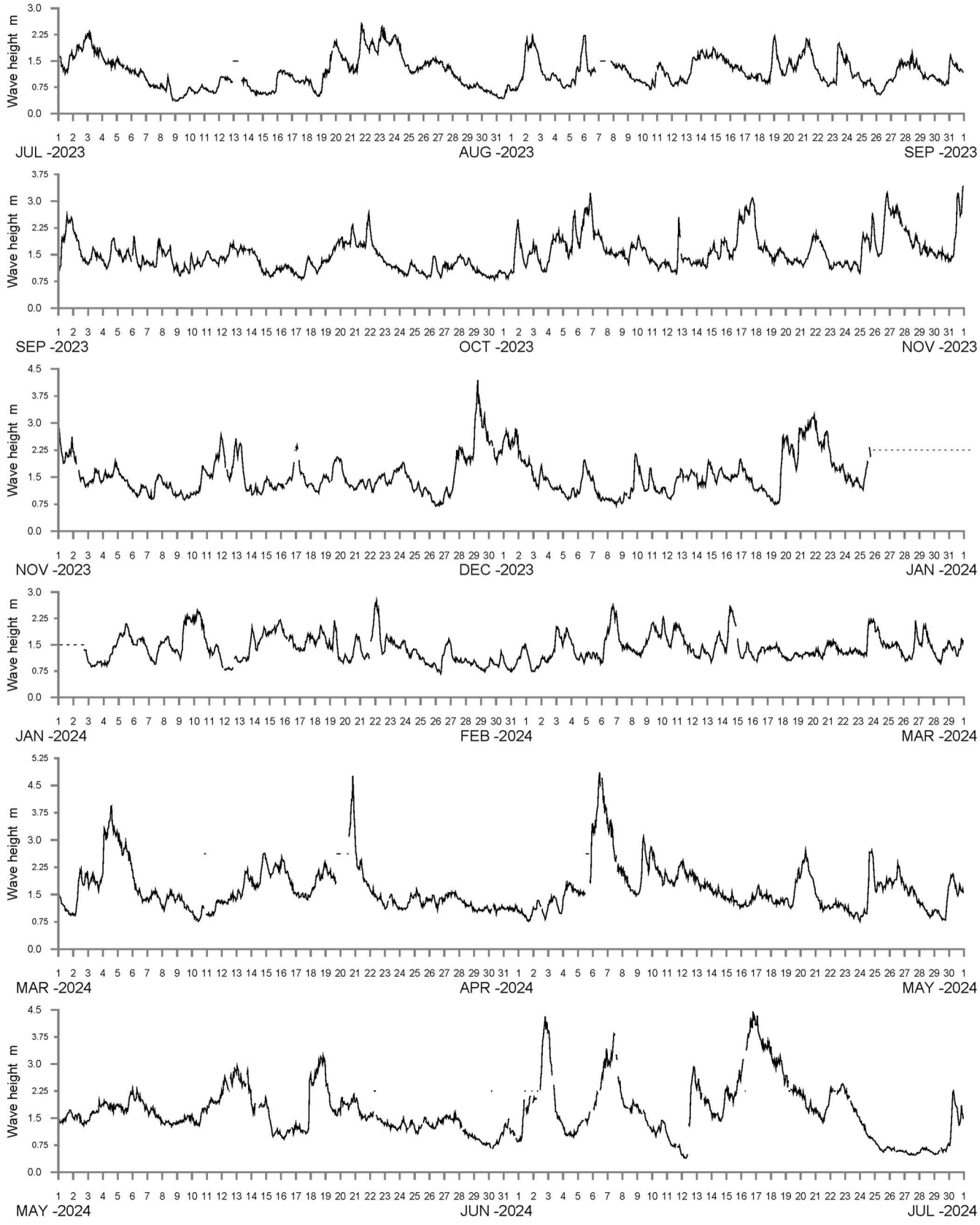
BATEMANS BAY WAVERIDER BUOY LOCATION HISTORY

NSW offshore bathymetry data obtained from Geoscience Australia 2009 and NSW OEH 2018 Marine LiDAR using methodology described by O'Grady, et al. (2021).

Manly Hydraulics Laboratory

Report MHL3067
Figure
4.11

Dwg 3067-04-11



---------- DATA LOSS

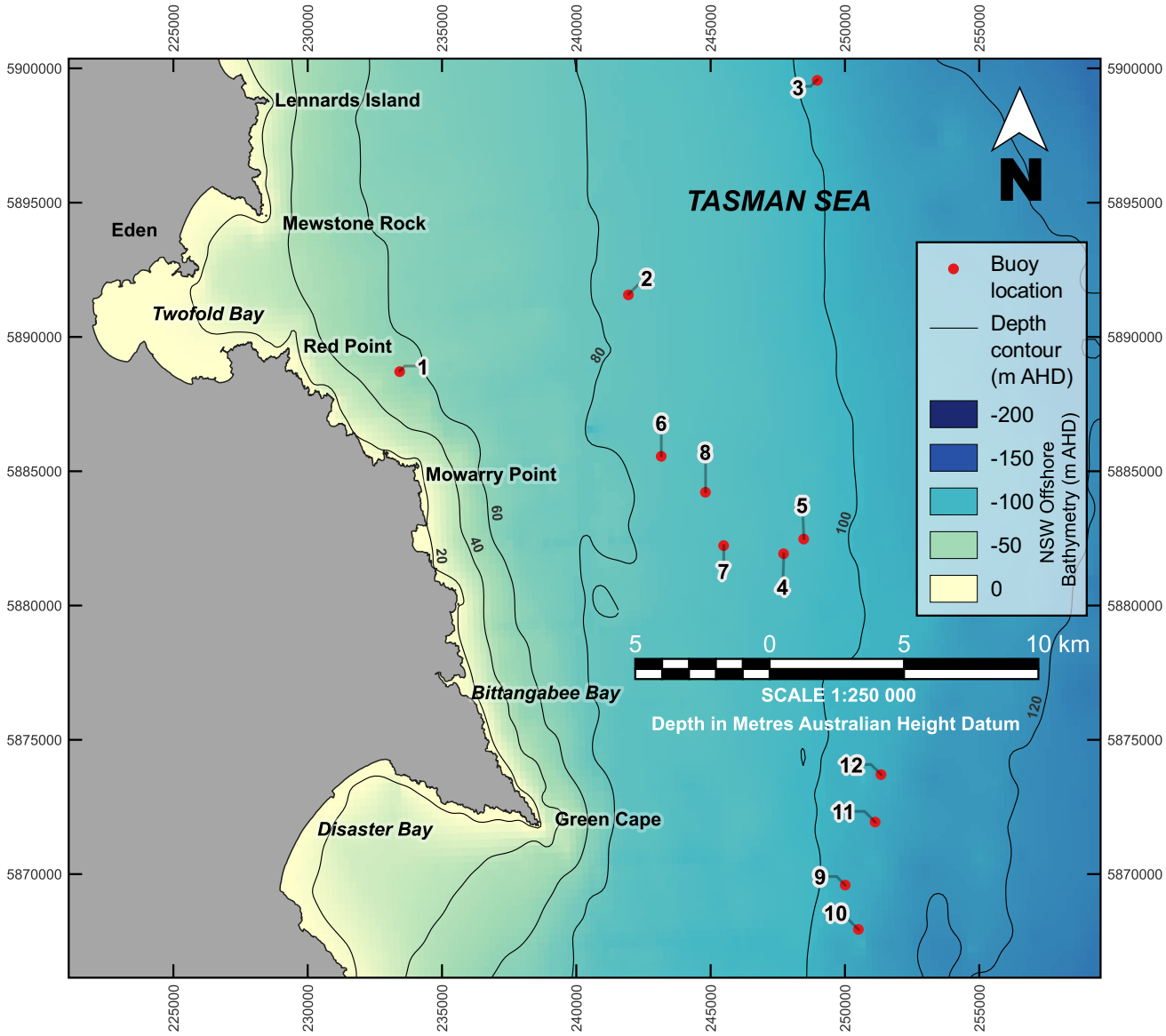
NSW GOVERNMENT

BATEMANS BAY WAVERIDER BUOY
2023–2024 SIGNIFICANT WAVE HEIGHT TIME HISTORY

Manly Hydraulics Laboratory

Report MHL3067
Figure
4.12

Dwg 3067-04-12



DEPLOYMENT LOCATION	LOCATION DETAILS				WATER DEPTH (m)	DEPLOYMENT PERIOD	
	Latitude (S)	Longitude (E)	MGA (Zone 56H) Easting	MGA (Zone 56H) Northing		First Date	Last Date
1	37° 06' 36"	150° 00' 00"	233420	5888700	55	8-Feb-78	21-Sep-83
2	37° 05' 12"	150° 05' 48"	241930	5891550	79	21-Sep-83	22-Sep-84
3	37° 01' 00"	150° 10' 42"	248960	5899540	104	10-Oct-84	23-Oct-84
4	37° 10' 30"	150° 09' 30"	247710	5881920	86	21-Mar-85	15-Oct-86
5	37° 10' 13"	150° 10' 01"	248450	5882450	95	15-Oct-86	4-Feb-87
6	37° 08' 28"	150° 06' 30"	243150	5885550	80	4-Feb-87	10-Feb-87
7	37° 10' 18"	150° 08' 00"	245480	5882220	90	23-Apr-87	4-Feb-88
8	37° 09' 13"	150° 07' 35"	244800	5884200	90	4-Feb-88	7-Mar-89
9	37° 17' 12"	150° 10' 48"	250000	5869580	110	7-Mar-89	14-Sep-00
10	37° 18' 06"	150° 11' 06"	250500	5866890	100	14-Sep-00	5-Jul-12
11	37° 15' 57"	150° 11' 36"	251120	5871940	100	20-Jul-12	9-May-24
12	37° 15' 00"	150° 11' 47"	251338	5873709	105	9-May-24	Present

NSW GOVERNMENT

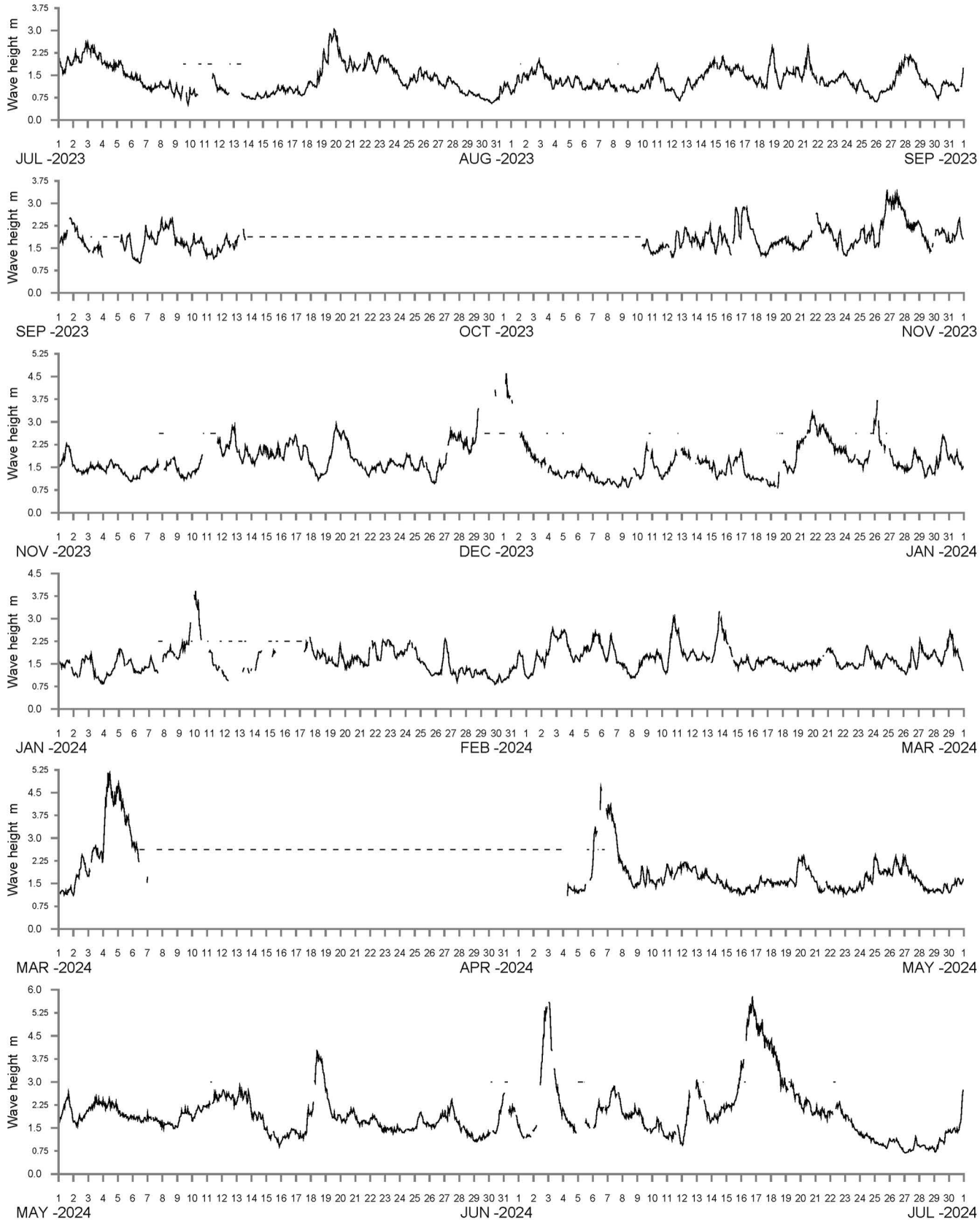
EDEN WAVERIDER BUOY LOCATION HISTORY

NSW offshore bathymetry data obtained from Geoscience Australia 2009 and NSW OEH 2018 Marine LiDAR using methodology described by O'Grady, et al. (2021).

Manly Hydraulics Laboratory

Report MHL3067
Figure
4.13

Dwg 3067-04-13



---------- DATA LOSS

NSW GOVERNMENT

EDEN WAVERIDER BUOY
2023–2024 SIGNIFICANT WAVE HEIGHT TIME HISTORY

Manly Hydraulics Laboratory

Report MHL3067
Figure
4.14

Dwg 3067-04-14

4.2 Storm events

Days on which the significant wave height exceeded 3 metres at each offshore Waverider buoy site are summarised on **Figure 4.15**.

4.3 System down time

A summary of system down time for periods longer than one day for each offshore site is presented on **Figure 4.15**.

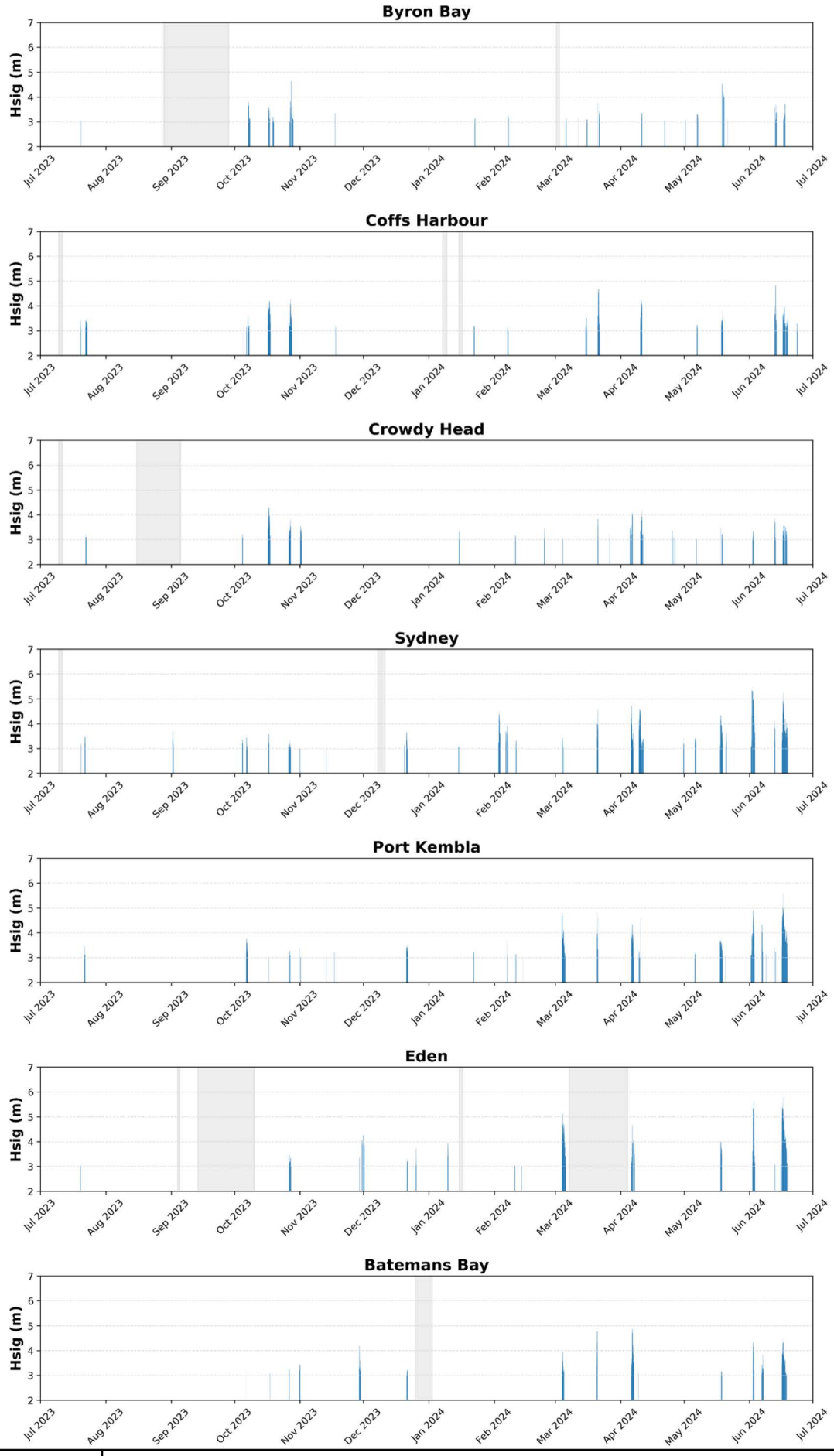
4.4 Significant developments 2023-2024

4.4.1 Waverider buoy tracking by GPS

Two types of GPS tracking units are utilized in monitoring Waverider buoys: one supplied by Pivotel®, and another by Geoforce®. Each buoy is equipped with one of these tracking units to ensure accurate up-to-date positional data of the buoy network and alerting for the recovery of adrift buoys.

Figure 4.16 displays the interface of the Pivotel Tracertrak SmartOne C. This unit features a predetermined watch-circle for each station, reporting daily when within this circle. If the unit exits the watch-circle, MHL receives notifications by SMS or email, with position updates every hour. Since their introduction in November 2015, the operation of these tracking units and software has led to the successful recovery of nine Waverider buoys that had drifted.

In July 2024, MHL commenced a trial of new Geoforce GT2s satellite trackers due to battery life limitations of the Pivotel Tracertrak SmartOne C devices. **Figure 4.17** shows the webpage interface of the Geoforce GT2s satellite tracker. This unit is designed to report GPS coordinates once or twice daily when the buoy remains stationary. Should the buoy's position shift by more than approximately 500 meters from its initial location, the GT2s switches to an hourly reporting mode and sends an automated email and SMS alert. The GT2s units are equipped with a long-life solar powered battery.



NSW GOVERNMENT

STORM HISTORY AND WAVE SYSTEM DOWNTIME SUMMARY 2023-2024

Manly Hydraulics Laboratory

Report MHL3067
Figure
4.15

Dwg 3067-04-15

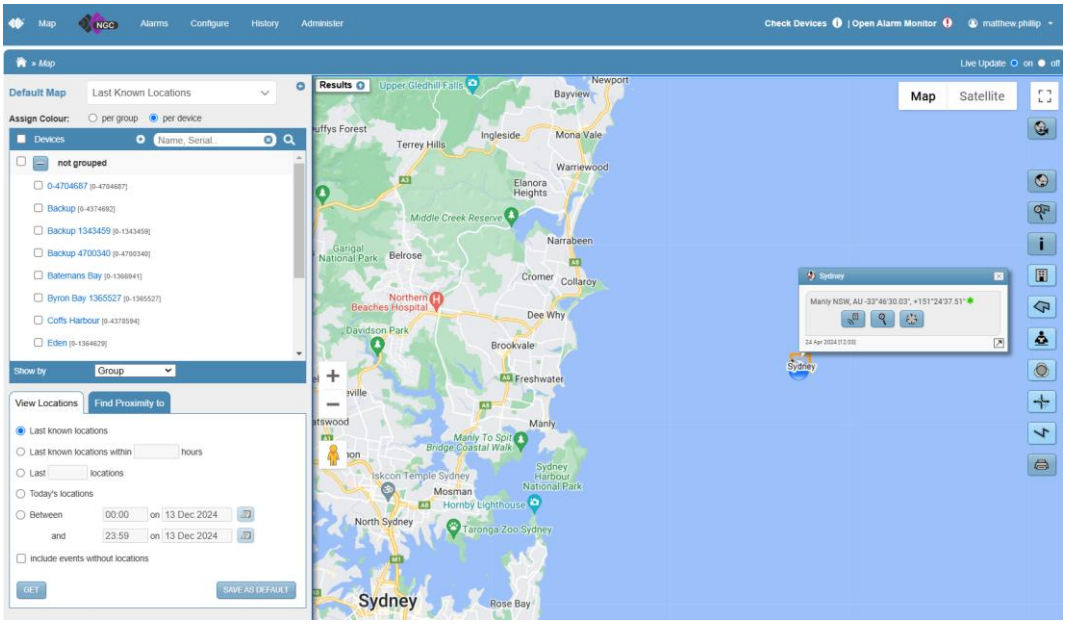


Figure 4.16: Pivotel Tracertrak GPS tracking webpage interface

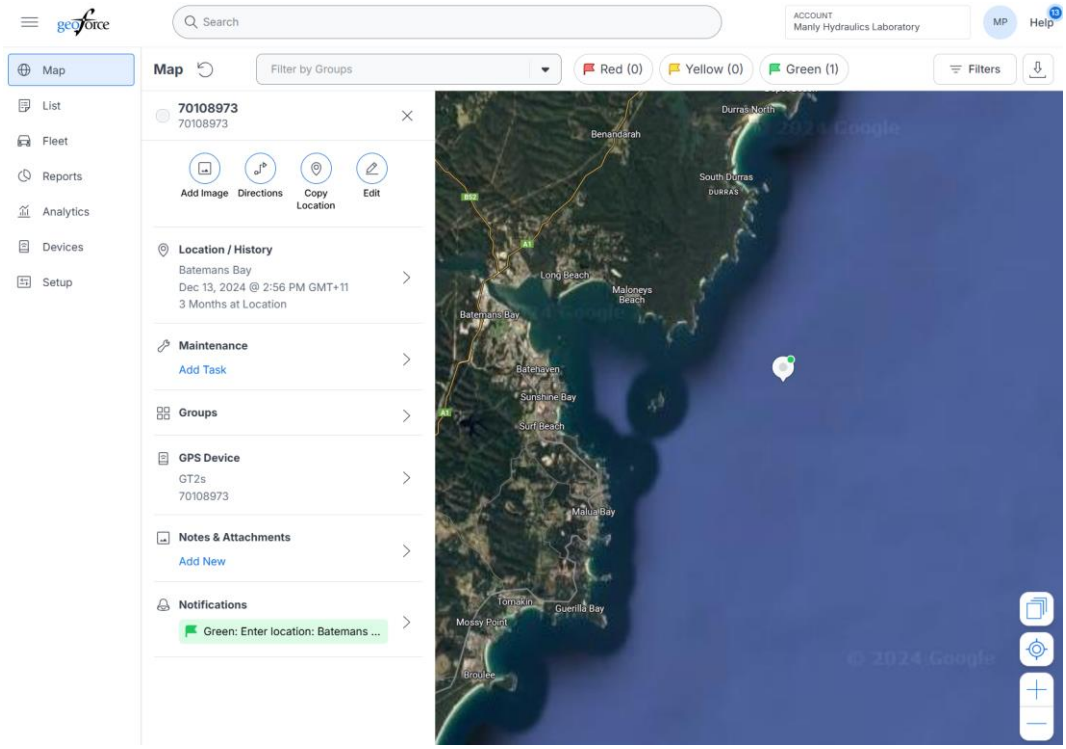


Figure 4.17: Geoforce GPS tracking webpage interface

4.4.2 NSW nearshore waves

The NSW Nearshore Wave Transformation Tool (**Figure 4.18**) provides transformation of offshore measured and forecast wave data (Bureau of Meteorology's AUSWAVE) into 10 m and 30 m nearshore water depths along the entire NSW coast. Offshore wave buoy data collected from the NSW Wave Climate Program is used to support this tool.

The NSW Nearshore Wave Transformation Tool can be accessed via the following webpage:

http://nearshore.waves.nsw.gov.au

Nearshore wave data requests can be submitted via:

https://nearshore.waves.nsw.gov.au/home/forecast/report

More information including Technical Reports associated with the development of the NSW Nearshore Wave Transformation Tool can be found here:

https://nearshore.waves.nsw.gov.au/home/about

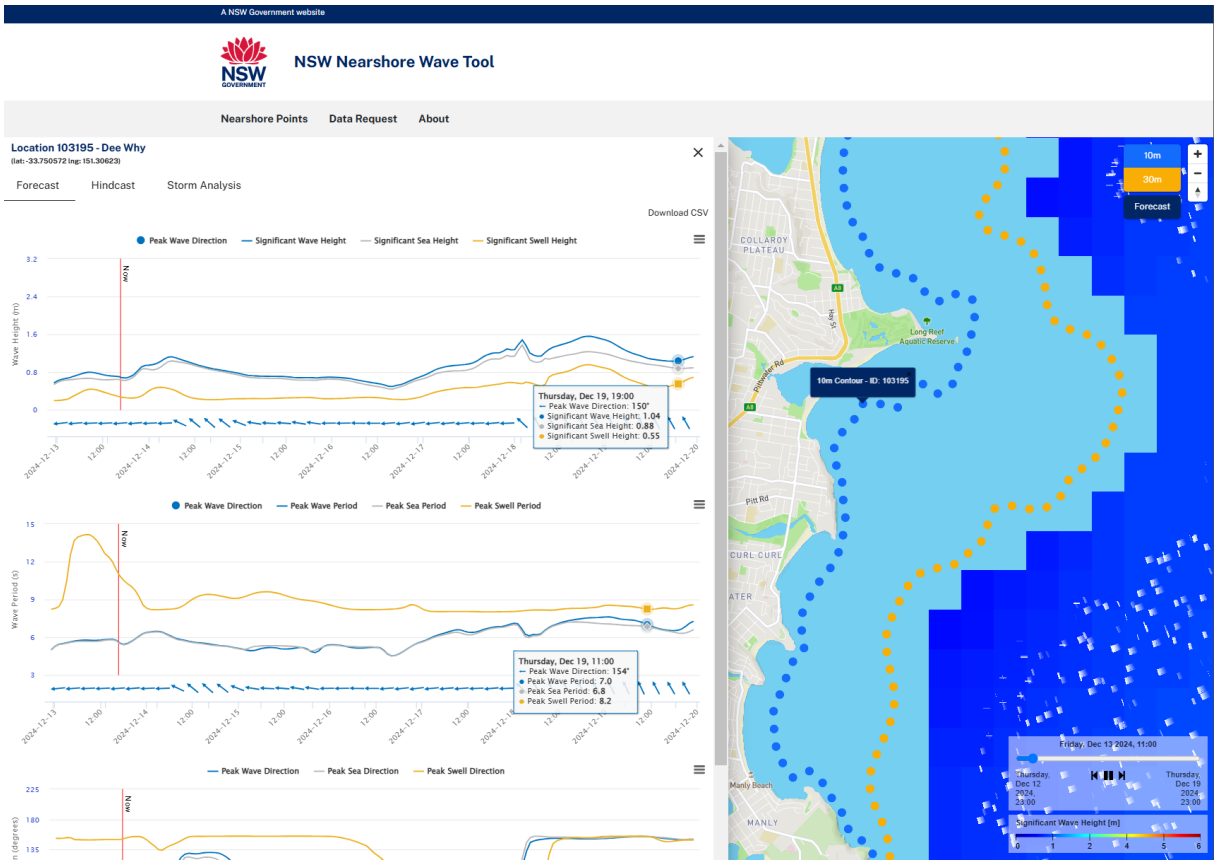


Figure 4.18: NSW Nearshore Wave Tool

5 Wave data capture and analysis

All analysed wave data from the offshore sites are archived in MHL's cloud environment. This data set includes selected hand-analysed results for installations operational before 1978 that recorded data on strip chart. Analysed data for all sites is resident in the cloud and raw time series data is archived in a separate cloud-storage system. If required, raw wave data can be recovered from the archive for further analysis.

5.1 Non-directional wave analysis

The first non-directional Waverider buoy was deployed by Manly Hydraulics Laboratory in February 1974 and initially recorded raw wave data traces on paper strip chart every six hours. In 1978 the introduction of the first electronic data loggers allowed more complete analysis but the record interval remained at six hours due to the limited memory capacity of these early loggers. In mid-1984 data logging and analysis was significantly enhanced with the introduction of the Manly Hydraulics Laboratory developed programmable LSI-11 data logger. The LSI-11 data logger software was upgraded for the introduction of Directional Waverider buoys in March 1992. After over 20 years of service the LSI-11 system was phased out between October 2005 and December 2007 and was replaced with the current MetOcean PC data logging, processing and telemetry system.

The recorded 2048-second bursts (34 minutes) at each site are digitised at 1.28 Hz (0.78 second) intervals and the data is conditioned to remove erroneous data points. The data is then analysed using the standard zero crossing and spectral methods. This section briefly outlines the terminology associated with these two methods.

5.1.1 Zero crossing analysis

A direct, repeatable and widely accepted method to extract representative statistics from the wave traces is the zero crossing method (**Figure 5.1**). For this method, a 'wave' is defined as the portion of record between two successive zero upcrossings. The waves are ranked (with their corresponding periods), and the following statistics computed:

H_{sig} : significant wave height = average height of the waves which comprise the top 33%

H_{10} : average height of the waves which comprise the top 10%

H_{max} : maximum wave height in a record

H_{rms} : root mean square wave height

H_{mean} : mean wave height

T_z : zero crossing period = mean period

T_{sig} : significant period = average period of the waves used to define H_{sig}

T_c : crest period = average time between successive crests (this involves a different definition of wave)

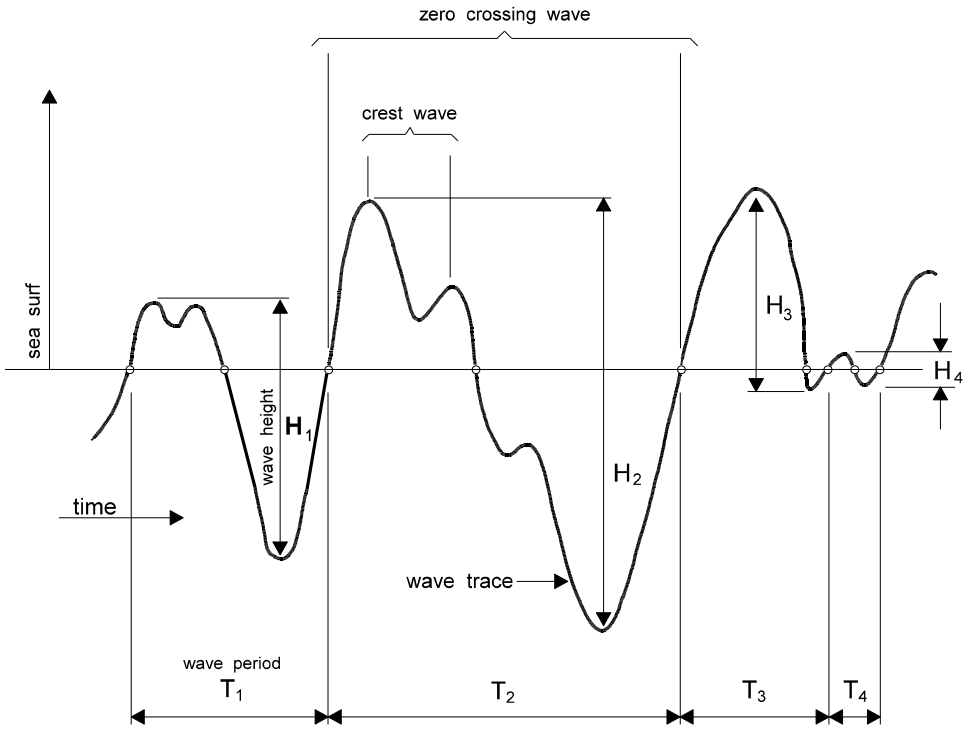


Figure 5.1 Zero crossing wave

5.1.2 Spectral analysis

The sea's motion at a point can be thought of as being composed of the sum of an infinite number of sine waves, each with its own amplitude (a), frequency (f) and phase (ϕ).

$$\eta(t) = \int_{o}^{oo} a\,(f)\,\sin\,[2\pi ft - \phi(f)]\,df$$

Spectral analysis using the Fast Fourier Transform technique provides estimates of the components. Rather than plotting the amplitudes, it is conventional to plot the energy density, E (effectively a^2/df).

For convenience, and because users are often interested in the shape of spectra, the values are scaled to give unity area.

The following statistics are computed from the spectrum:

T_{P1} : Period of highest peak

T_{P2} : Period of second highest peak

Y_{rms} : Root mean square surface vertical displacement

M_0, M_1, M_2, M_3 : Spectral moments - $M_n = \Sigma E f^n \Delta f$

These provide parameters describing the shape of the spectrum. Spectral moments can also be related statistically to the zero crossing parameters:

$$H_{rms} \approx 2\sqrt{2M_0} = 2\sqrt{2}Y_{rms}, \text{ where } M_0 = Y_{rms}^2$$

$$H_{sig} \approx 4\sqrt{M_0} = 4Y_{rms} = \sqrt{2}H_{rms}$$

$$H_{10} \approx 5.1\sqrt{M_0} = 5.1Y_{rms}$$

$$H_1 \approx 6.68\sqrt{M_0} = 6.68\ Y_{rms}$$

$$H_{mean} \approx 2.5\sqrt{M_0} = 2.5\ Y_{rms} = 0.886\ H_{rms}$$

An example of a spectral diagram is presented in **Figure 5.2**.

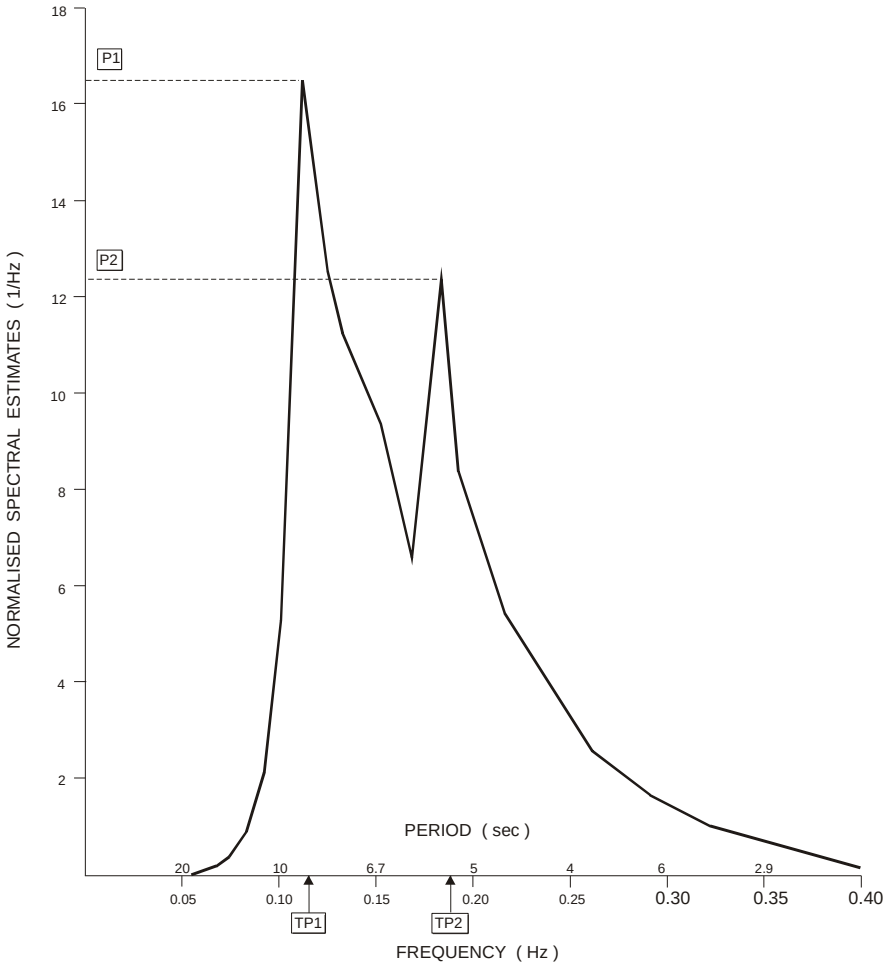


Figure 5.2 Spectral diagram

5.2 Directional wave analysis

5.2.1 The Directional Waverider buoy

Manly Hydraulics Laboratory uses Directional Waverider buoys to monitor wave height, period and direction at the seven NSW offshore wave monitoring stations. The original Mark I version of the Directional Waverider buoy was introduced by Datawell in early 1990, followed by the Mark II buoy in mid-1995. The Mark III Directional Waverider buoy, introduced in the mid-2000s, represented a significant upgrade and included a GPS receiver to continuously report its location to the shore station enabling the buoy location to be tracked should it go adrift. Mark III buoys are used in the NSW Waverider buoy network.

The Directional Waverider buoy utilises a heave-pitch-roll sensor, two fixed 'X' and 'Y' accelerometers and a three axis fluxgate compass to measure both vertical and horizontal motion at a sample rate of 1.28 Hz (0.78 seconds). A single point mooring is used, with horizontal freedom ensured by the inclusion of a 30 m rubber shock cord in the mooring system. An on-board processor converts the buoy motion to three orthogonal (vertical, north-south, east-west) translation signals that are telemetered to the shore station. The directional spectrum is also routinely calculated by the buoy and transmitted to the receiving station for reformatting and storage prior to transfer to MHL's cloud data storages via the internet.

Detailed information on the directional data analysis undertaken by the Directional Waverider buoy can be found in the *Datawell Waverider Reference Manual*, 2020.

5.2.2 Directional wave spectrum

Directional wave spectra plots have been developed by MHL to display the rich directional energy data now available from the NSW Waverider buoy network.

Going beyond the conventional reporting usually provided (wave heights, period and direction), directional spectra plots show information about the sea state in an easy to interpret graphical format, providing an overview of the wave conditions at a glance. An example of a directional spectrum plot is presented in **Figure 5.3**.

The directional spectra analysis takes the raw heave and X, Y displacement data collected by the buoys each hour and processes them to remove noise, before transformation into velocity vectors. These velocities are then fed into a custom implementation of the Directional WAve SPectrum analysis (DIWASP) software which produces the spectral plots for presentation on MHL's website along with key summary statistics.

The summary parameters displayed with the directional spectra plot are calculated over a 55 minute sampling period and include:

H_S : significant wave height in metres calculated as the average of the highest one-third waves recorded

T_p : wave period in seconds of the highest peak of the energy spectrum

D_{Tp} : the wave direction at the peak of the energy spectrum (Tp) measured in degrees clockwise from True North.

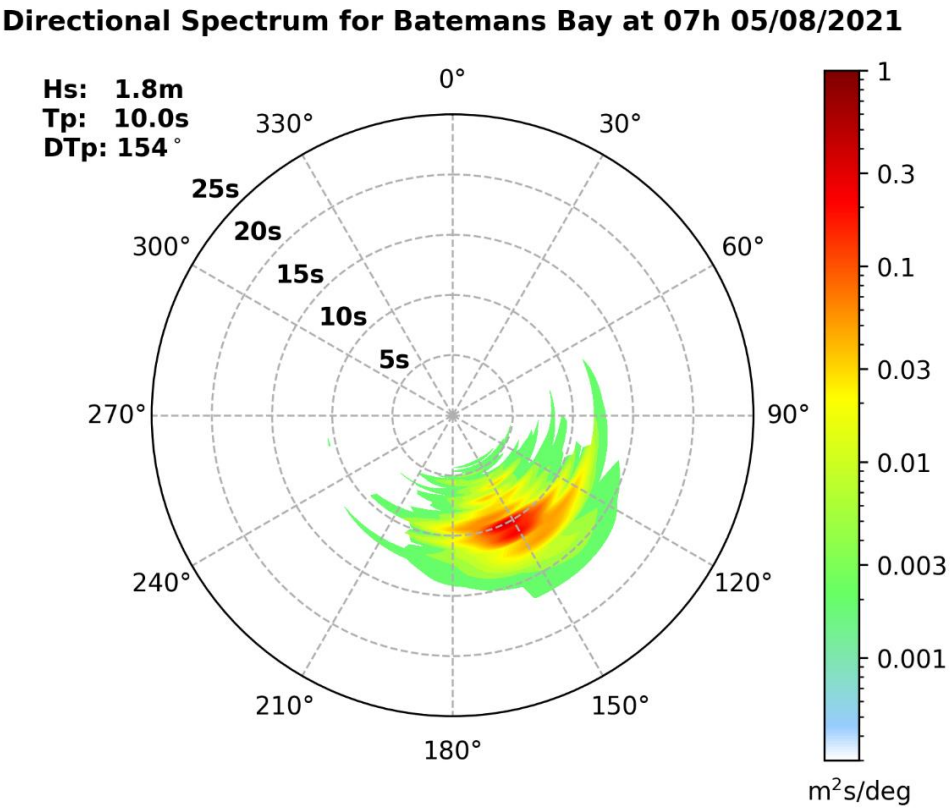


Figure 5.3 Directional spectrum plot

An example directional spectrum plot is shown in **Figure 5.3.** The colours in the Directional Spectrum plot show the distribution of measured wave energy from different directions and across different wave periods at the wave buoy. The more intense red areas on the plot show the directions and wave periods with the highest energy. These highlight the primary swell direction(s). Conversely the green or blue areas show directions and wave periods with lower wave energy. Long period waves (swell) are shown towards the outer edge of the plot and short period waves (sea) down to 2 seconds are near the centre of the plot. Direction is from which the waves are propagating are shown from 0° to 359°. Common swell directions for the NSW coast range from North-East (top right of plot) through to South (bottom of plot).

Sea states associated with high wind events appear as broad areas of colour near the centre of the plot as these events generate short period waves with wide directional spreading. Swell that is generated a long distance from the Waverider buoy is usually represented by small peaks in the middle of the plot (10 to 15 seconds) as it is typically associated with long period waves from a narrow direction.

One of the key features of the directional spectra plots is the capacity to represent more than one wave direction source, for example a southerly swell with a north-easterly sea can be depicted on one plot, but such information may be lost in the conventional plots of wave height, period and direction parameters.

The directional spectrum plots are generated hourly in line with the conventional wave height, period and direction graphs provided on the MHL website:

www.mhl.nsw.gov.au/Data-Wave

5.3 Supplementary wave data capture

It should be noted that in addition to the offshore network MHL undertakes site specific wave data capture programs associated with particular projects, such as breakwater design/ construction, harbour design/construction, beach erosion studies, etc. A range of instruments can be used to obtain wave information.

In general, the following instruments/applications are employed:

- Directional Waverider buoys in deep or intermediate water depth to provide wave height, period and direction spectral information. Smaller directional Waverider and Spotter buoys provide similar wave information in shallower nearshore water depths.
- Electromagnetic wave and tide monitoring systems (EWS) in shallow water to provide wave height, period, spectral and tidal information.
- From 1979 to 1989 Marsh McBirney and InterOcean S4 electromagnetic adaptive current meters were used to provide XY current information over the whole spectrum. The wave components are analysed and stored in a similar fashion to the Waverider and EWS data. Additionally, the current meters can provide wave direction information. When combined with an EWS or pressure sensor, estimates of the directional spectrum can be obtained.
- Teledyne RD Instruments Acoustic Doppler Current Profiler (ADCP) deployed on the seabed in shallow water to capture wave height, period and spectral information. The ADCP provides a comprehensive data set that can be processed to provide data on water level, wave conditions and current speed and direction through the water column above the instrument.

Site specific studies utilise the same software/hardware for record analysis as the offshore network and provide additional inshore information at specific sites. For this reason, a list of these study sites and their operational status has been included in **Section 5.3**.

6 Wave data index

Since 1974 wave data have been collected at over 40 locations along the NSW coast using a variety of wave motion sensors. This section includes a catalogue of all wave data stored on MHL's cloud storages. Details of analysed wave data available are presented in three tables grouped according to the following categories:

- **Table 6.1**: Offshore stations – Waverider buoys deployed to provide deepwater wave data. The buoys are typically moored in a water depth of 80 m between 6 km and 12 km from the shoreline. At the buoy location the water is sufficiently deep that wave refraction, diffraction, shoaling and friction attenuation effects are minimal
- **Table 6.2**: Site specific stations – wave data collected by a variety of sensors in intermediate or shallow water. These stations gather wave data for particular projects such as breakwater design/construction, harbour design/construction, beach erosion studies, etc. The wave characteristics at these inshore locations may be significantly affected by refraction, diffraction, shoaling and friction attenuation
- **Table 6.3**: Long wave stations – water level data collected at selected EWS stations are filtered and analysed to provide long wave statistics. Long waves have periods that range from 30 seconds to several minutes and are often associated with storm wave activity off the NSW coast.

All raw historical wave data is backed up on local servers on buoy retrieval and online via cloud storage. **Table 6.4** provides an index of raw data. Prior to mid-2006, at most sites raw data was normally saved twice per day at 0900 and 2100 hours and every second hour during storm events (Hsig greater than 3 m for offshore sites). Since 2006, with the introduction of the MetOcean system, raw data has been archived hourly for all wave data collection stations.

It should be noted that raw data is not available for all sites or before January 1981.

Table 6.1 Analysed wave data at MHL: offshore stations – June 2024

Wave data site	Instrument	MGA location (Zone 56)		Water depth	Data available		Record length	Data capture
		Easting	Northing	(m)	First date	Last date	(years)	(%)
Byron Bay	Waverider buoy	572 700	6 822 180	72	14-Oct-1976	26-Oct-1999	47.71	79.0
Byron Bay	Directional Waverider buoy	567 700	6 806 160	62	26-Oct-1999	Present		
Coffs Harbour	Waverider buoy	525 920	6 641 140	72	26-May-1976	13-Feb-2012	48.10	86.8
Coffs Harbour	Directional Waverider buoy	526 690	6 640 450	72	14-Feb-2012	Present		
Crowdy Head	Waverider buoy	486 720	6 478 910	79	10-Oct-1985	19-Aug-2011	38.72	87.9
Crowdy Head	Directional Waverider buoy	486 380	6 480 180	79	19-Aug-2011	Present		
Sydney	Waverider buoy	353 490	6 261 200	85	17-Jul-1987	04-Oct-2000	13.23	92.2
Sydney Directional	Directional Waverider buoy	352 920	6 261 800	90	03-Mar-1992	Present	32.33	88.3
Port Kembla	Waverider buoy	318 720	6 183 460	80	07-Feb-1974	14-May-2012	50.39	85.4
Port Kembla	Directional Waverider buoy	318 700	6 183 250	80	20-Jun-2012	Present		
Batemans Bay	Waverider buoy	259 780	6 045 320	73	27-May-1986	23-Feb-2001	38.09	90.2
Batemans Bay	Directional Waverider buoy	257 540	6 041 540	65	23-Feb-2001	Present		
Eden	Waverider buoy	250 500	5 866 890	100	08-Feb-1978	16-Dec-2011	46.39	85.4
Eden	Directional Waverider buoy	251 120	5 871 940	100	16-Dec-2011	Present		

Table 6.2 Analysed wave data at MHL: site specific stations – June 2024

Wave data site	Instrument	MGA location (Zone 56)		Water depth	Data available		Record length	Data capture
		Easting	Northing	(m)	First date	Last date	(years)	(%)
Tweed River	EWS	553 860	6 883 725	4	20-Jan-1995	27-Nov-2008	13.86	68.4
Tweed Heads Inshore	Waverider buoy	555 294	6 883 017	13	21-Apr-1989	08-Nov-1989	0.55	97.0
Tweed Heads	Marsh McBirney	555 294	6 883 017	13	09-Jun-1988	10-Oct-1989	1.34	61.6
Cook Island	Marsh McBirney / S4	556 003	6 881 182	12	09-Jun-1988	25-Oct-1989	1.38	40.8
Fingal Head	Marsh McBirney / S4	556 079	6 879 564	12	09-Jun-1988	25-Oct-1989	1.38	30.7
Coffs Harbour Entrance	Marsh McBirney	514 665	6 646 863	9	04-Dec-1986	31-Oct-1987	0.91	52.9
Coffs Harbour Jetty	EWS	513 840	6 647 148	7	05-Nov-1986	15-Jan-1996	9.20	83.7
Coffs Harbour Jetty MMcB	Marsh McBirney	513 840	6 647 148	7	04-Dec-1986	20-Jan-1987	0.13	97.2
Coffs Harbour Boat Ramp	Marsh McBirney	513 674	6 646 699	6	21-Jan-1987	08-Mar-1987	0.13	90.6
Coffs Harbour Quarry	Marsh McBirney	514 163	6 646 618	6	10-Mar-1987	27-Apr-1987	0.13	84.1
Muttonbird Island West	Marsh McBirney	514 110	6 647 040	6	29-Apr-1987	17-Jun-1987	0.13	81.6
Coffs Inner Hbr Entrance	Marsh McBirney	513 790	6 647 313	4	19-Jun-1987	04-Aug-1987	0.13	89.2
Muttonbird Island East	Marsh McBirney	514 790	6 647 105	11	14-Aug-1987	06-Oct-1987	0.15	62.1
Muttonbird Island South	Marsh McBirney	514 415	6 647 000	7	07-Oct-1987	31-Oct-1987	0.07	96.0
Coffs Harbour Central	Marsh McBirney	513 927	6 646 790	8	05-Nov-1987	25-Nov-1987	0.06	96.4
Coffs Inner Harbour	EWS	513 920	6 647 470	4	16-Jan-1996	08-Oct-2011	15.74	83.8
Crowdy Head Harbour	EWS	476 318	6 477 138	2	07-Nov-1986	16-Jul-2012	25.71	75.5
Jimmys Beach	EWS	421 665	6 383 610	3	16-Dec-1983	08-Oct-1985	1.82	86.0
Nelson Bay	EWS	419 720	6 379 447	6	20-Jan-1981	18-Jun-1986	4.92	36.1
Nelson Bay West Point	EWS	419 470	6 379 465	5	19-Jun-1986	20-Apr-1988	1.84	87.6
Swansea	EWS	375 079	6 338 043	2	17-Dec-1987	12-Apr-1991	3.32	98.6
Wamberal Beach	Direction Waverider	356 089	6 299 724	11	05-Aug-2011	16-Mar-2012	0.61	92.7
Wamberal Beach	Spotter Wave Buoy	355 940	6 299 639	10	22-Dec-2022	03-Feb-2023	0.12	100
Broken Bay	Waverider buoy	346 190	6 285 235	24	30-Jan-1981	02-Jun-1983	2.34	53.1
Palm Beach	Marsh McBirney	345 650	6 281 755	24	19-Jun-1981	14-Sep-1982	1.24	41.1
Broken Bay Current	Marsh McBirney	346 190	6 284 795	24	23-Nov-1979	15-Feb-1983	3.23	71.7
Mackerel Beach	EWS	342 270	6 281 775	2	17-Aug-1988	15-Oct-1989	1.16	97.1
Narrabeen Beach	Direction Waverider	342 875	6 267 444	10	27-Jul-2011	14-Nov-2011	0.30	96.4
Long Reef	Waverider buoy	344 749	6 266 181	21	27-Jul-2011	14-Nov-2011	0.30	98.9
Melrose Park	EWS	321 365	6 255 975	2	24-Mar-1988	20-Jul-1988	0.32	81.7
Chiswick	EWS	327 650	6 253 076	2	28-Mar-1988	20-Jul-1988	0.31	74.6
Port Hacking Seaward	EWS	328 830	6 227 575	3	06-Sep-1983	04-Jan-2014	30.33	77.8
Deeban Spit	EWS	327 850	6 227 474	2	15-Sep-1983	03-Oct-1986	3.05	51.4
Port Hacking S'ward MMcB	Marsh McBirney	328 830	6 227 575	3	06-Sep-1983	17-Nov-1986	3.20	56.6
Deeban Spit MMcB	Marsh McBirney	327 850	6 227 474	2	06-Sep-1983	28-May-1985	1.73	60.5
Burraneer Point MMcB	Marsh McBirney	327 763	6 227 931	6	06-Sep-1983	16-Dec-1985	2.28	53.8
Port Kembla Inshore	Waverider buoy	307 990	6 184 970	18	31-May-1978	26-Jul-1982	4.16	72.3
Jervis Bay North	EWS	287 850	6 120 050	6	11-Nov-1981	03-Jul-1989	7.65	62.4
Jervis Bay South	EWS	288 500	6 118 800	8	01-Sep-1981	18-Oct-1983	2.13	35.4
Batemans Bay Inshore	EWS	247 792	6 043 097	7	26-Feb-1987	08-Dec-1990	3.78	94.1
Eden Inshore *	Waverider buoy	758 230	5 892 820	9	24-Nov-1984	11-May-1987	2.46	75.8
Eden Harbour *	EWS	758 324	5 892 999	4	24-Nov-1984	13-Nov-2012	27.97	85.1

* Location is relative to origin of Zone 55

Table 6.3 Analysed wave data at MHL: long wave stations – June 2024

Wave data site	Instrument	MGA location (Zone 56)		Water depth (m)	Data available		Record length (years)	Data capture (%)
		Easting	Northing		First date	Last date		
Tweed River	EWS	553 860	6 883 725	4	20-Jan-1995	02-May-2005	10.29	78.8
Coffs Harbour Jetty	EWS	513 840	6 647 148	7	13-Jul-1987	15-Jan-1996	8.52	86.6
Coffs Inner Harbour	EWS	513 920	6 647 470	4	16-Jan-1996	04-Apr-2006	10.22	87.5
Crowdy Head Harbour	EWS	476 318	6 477 138	2	24-Jul-1987	07-Jan-2004	16.47	83.9
Swansea	EWS	375 079	6 338 043	2	09-Sep-1988	12-Apr-1991	2.59	98.3
Mackerel Beach	EWS	342 270	6 281 775	2	17-Aug-1988	15-Oct-1989	1.16	96.4
Port Hacking	EWS	328 830	6 227 575	3	20-Nov-1987	13-Apr-2004	16.41	87.6
Jervis Bay North	EWS	287 850	6 120 050	6	30-Jul-1987	03-Jul-1989	1.93	87.0
Batemans Bay	EWS	247 792	6 043 097	7	26-Aug-1987	08-Dec-1990	3.29	95.3
Eden Harbour *	EWS	758 324	5 892 999	4	28-Jul-1987	28-Feb-2006	18.60	90.4

* Location is relative to origin of Zone 55

Table 6.4 Raw wave data at MHL: time series data – June 2024

Wave data site	Instrument	Site category	Available analysed data		Available raw data	
			First data	Last date	First date	Last date
Tweed River	EWS	Inshore	20-Jan-1995	27-Nov-2008	20-Jan-1995	27-Nov-2008
Tweed Heads Inshore	Waverider buoy	Inshore	21-Apr-1989	08-Nov-1989	21-Apr-1989	08-Nov-1989
Byron Bay	Waverider buoy	Offshore	14-Oct-1976	26-Oct-1999	12-Aug-1983	26-Oct-1999
Byron Bay	Direct'n Waverider	Offshore	26-Oct-1999	Present	26-Oct-1999	Present
Coffs Harbour	Waverider buoy	Offshore	26-May-1976	13-Feb-2012	29-Jul-1983	13-Feb-2012
Coffs Harbour	Direct'n Waverider	Offshore	14-Feb-2012	Present	14-Feb-2012	Present
Coffs Harbour Jetty	EWS	Inshore	05-Nov-1986	15-Jan-1996	05-Nov-1986	15-Jan-1996
Coffs Inner Harbour	EWS	Inshore	16-Jan-1996	08-Oct-2011	16-Jan-1996	08-Oct-2011
Crowdy Head	Waverider buoy	Offshore	10-Oct-1985	19-Aug-2011	10-Oct-1985	19-Aug-2011
Crowdy Head	Direct'n Waverider	Offshore	19-Aug-2011	Present	19-Aug-2011	Present
Crowdy Head Harbour	EWS	Inshore	07-Nov-1986	16-Jul-2012	07-Nov-1986	16-Jul-2012
Jimmys Beach	EWS	Inshore	16-Dec-1983	08-Dec-1985	16-Dec-1983	19-Sep-1985
Nelson Bay	EWS	Inshore	20-Jan-1981	18-Jun-1986	20-Jan-1981	18-Jun-1986
Nelson Bay West Point	EWS	Inshore	19-Jun-1986	20-Apr-1988	19-Jun-1986	20-Apr-1988
Swansea	EWS	Inshore	17-Dec-1987	12-Apr-1991	17-Dec-1987	11-Apr-1991
Wamberal Beach	Direct'n Waverider	Inshore	05-Aug-2011	16-Mar-2012	05-Aug-2011	16-Mar-2012
Wamberal Beach	Spotter Wave Buoy	Inshore	22-Dec-2022	03-Feb-2023	22-Dec-2022	03-Feb-2023
Mackerel Beach	EWS	Inshore	17-Aug-1988	15-Oct-1989	17-Aug-1988	14-Oct-1989
Narrabeen Beach	Direct'n Waverider	Inshore	27-Jul-2011	14-Nov-2011	27-Jul-2011	14-Nov-2011
Long Reef	Waverider buoy	Inshore	27-Jul-2011	14-Nov-2011	27-Jul-2011	14-Nov-2011
Sydney	Waverider buoy	Offshore	17-Jul-1987	04-Oct-2000	17-Jul-1987	04-Oct-2000
Sydney Directional	Direct'n Waverider	Offshore	03-Mar-1992	Present	03-Mar-1992	Present
Melrose Park (Parramatta R)	EWS	River	24-Mar-1988	20-Jul-1988	24-Mar-1988	20-Jul-1988
Chiswick (Parramatta River)	EWS	River	28-Mar-1988	20-Jul-1988	28-Mar-1988	20-Jul-1988
Port Hacking Seaward	EWS	Inshore	06-Sep-1983	04-Jan-2014	06-Sep-1983	04-Jan-2014
Deeban Spit	EWS	Inshore	15-Sep-1983	03-Oct-1986	15-Sep-1983	03-Oct-1986
Port Hacking Seaward MMcB	Marsh McBirney	Inshore	06-Sep-1983	17-Nov-1986	06-Sep-1983	17-Sep-1986
Deeban Spit MMcB	Marsh McBirney	Inshore	06-Sep-1983	28-May-1985	06-Sep-1983	27-May-1985
Burraneer Point MMcB	Marsh McBirney	Inshore	06-Sep-1983	16-Dec-1985	06-Sep-1983	04-Sep-1985
Port Kembla	Waverider buoy	Offshore	07-Feb-1974	14-May-2012	31-Jul-1983	14-May-2012

Wave data site	Instrument	Site category	Available analysed data		Available raw data	
			First data	Last date	First date	Last date
Port Kembla	Direct'n Waverider	Offshore	20-Jun-2012	Present	20-Jun-2012	Present
Jervis Bay North	EWS	Inshore	11-Nov-1981	03-Jul-1989	27-Dec-1982	03-Jul-1989
Jervis Bay South	EWS	Inshore	01-Sep-1981	18-Oct-1983	04-Jan-1983	18-Oct-1983
Batemans Bay	Waverider buoy	Offshore	27-May-1986	23-Feb-2001	27-May-1986	23-Feb-2001
Batemans Bay	Direct'n Waverider	Offshore	23-Feb-2001	Present	23-Feb-2001	Present
Batemans Bay Inshore	EWS	Inshore	26-Feb-1987	08-Dec-1990	26-Feb-1987	08-Dec-1990
Eden	Waverider buoy	Offshore	08-Feb-1978	16-Dec-2011	26-Jul-1983	16-Dec-2011
Eden	Direct'n Waverider	Offshore	16-Dec-2011	Present	16-Dec-2011	Present
Eden Inshore	Waverider buoy	Inshore	24-Nov-1984	11-May-1987	24-Nov-1984	11-May-1987
Eden Harbour	EWS	Inshore	24-Nov-1984	13-Nov-2012	24-Nov-1984	13-Nov-2012

Appendix A Web data presentation formats

Examples of long-term data analysis data presentation formats available from the Manly Hydraulics Laboratory wave data station webpages are presented in this appendix. The following data analysis information for each Waverider buoy station is available to download:

Significant wave height exceedance table

- Wave period occurrence table
- Wave direction occurrence table
- Joint wave height / wave period table
- Significant wave height / wave direction rose – all data
- Seasonal significant wave height / wave direction roses
- Storm history table

The data analysis information for each Waverider buoy station is available via the ***Station Documents*** links on the following webpages:

Byron Bay	https://www.mhl.nsw.gov.au/Station-BYRBOW
Coffs Harbour	https://www.mhl.nsw.gov.au/Station-COFHOW
Crowdy Head	https://www.mhl.nsw.gov.au/Station-CRHDOW
Sydney	https://www.mhl.nsw.gov.au/Station-SYDDOW
Port Kembla	https://www.mhl.nsw.gov.au/Station-PTKMOW
Batemans Bay	https://www.mhl.nsw.gov.au/Station-BATBOW
Eden	https://www.mhl.nsw.gov.au/Station-EDENOW

Manly Hydraulics Laboratory

Significant Wave Height Statistics

Site Name: BATEMANS BAY
Site Code: BATBOW

Nominated Start/Finish: 27-May-1986 to 30-June-2024, Record Length: 38.1 years

Creation Date: 26-November-2024

Percentage Exceedance for Hsig (m)

Monthly Exceedance Probability													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hsig (m)													
0.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	**100.000**
0.50	99.99	100.00	99.99	99.72	98.33	97.53	97.76	97.96	99.63	99.66	99.95	99.96	**99.203**
1.00	85.44	85.69	84.38	77.64	69.91	69.52	66.19	65.10	75.69	79.08	80.90	80.80	**76.713**
1.50	37.32	40.41	39.35	37.26	36.74	40.18	34.93	32.99	33.30	36.65	36.68	36.20	**36.883**
2.00	12.16	16.80	16.89	15.97	16.22	19.82	17.28	15.25	12.83	13.94	14.16	12.85	**15.383**
2.50	3.90	6.13	6.85	6.33	6.95	10.51	7.96	7.06	5.39	5.23	5.64	4.50	**6.396**
3.00	1.33	2.10	2.72	2.70	2.81	4.62	4.32	3.32	2.06	2.15	2.54	1.33	**2.683**
3.50	0.48	0.77	0.85	1.41	1.08	2.08	2.28	1.77	0.82	1.00	1.24	0.36	**1.182**
4.00	0.16	0.33	0.25	0.68	0.32	0.97	1.20	0.94	0.35	0.49	0.62	0.07	**0.535**
4.50	0.05	0.09	0.09	0.23	0.10	0.48	0.50	0.51	0.17	0.25	0.30	0.00	**0.232**
5.00	0.00	0.01	0.03	0.14	0.05	0.18	0.26	0.22	0.07	0.13	0.12	0.00	**0.101**
5.50	0.00	0.00	0.00	0.07	0.00	0.03	0.08	0.10	0.04	0.05	0.05	0.00	**0.036**
6.00	0.00	0.00	0.00	0.03	0.00	0.00	0.02	0.04	0.02	0.02	0.01	0.00	**0.012**
6.50	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	**0.004**
7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.001**
7.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.000**
Monthly Statistics													
Minimum	0.47	0.54	0.48	0.42	0.30	0.26	0.32	0.30	0.36	0.30	0.40	0.43	**0.26**
Average	1.45	1.51	1.51	1.46	1.41	1.48	1.41	1.37	1.40	1.44	1.46	1.43	**1.45**
Maximum	4.79	5.10	5.29	6.96	5.50	5.98	6.25	7.19	7.01	6.57	6.62	4.55	**7.19**
Number of Data Points Used for Statistical Analysis													
No. Points	25,919	23,558	26,331	23,684	25,917	25,570	26,127	25,034	24,538	25,452	24,334	24,784	**301,248**
Percent Capture Based on Nominated Start/Finish													
% Capture	91.68	91.40	93.13	86.56	91.28	91.06	92.33	88.55	89.69	90.03	88.94	87.66	**90.20**

Wave data collected under the NSW Coastal Data Network Program managed by the NSW Department of Climate Change, Energy, the Environment and Water – Biodiversity, Conservation and Science (DCCEEW BCS)

Manly Hydraulics Laboratory

Peak Wave Period Occurrence Statistics

Site Name: BATEMANS BAY
Site Code: BATBOW

Nominated Start/Finish: 27-May-1986 to 30-June-2024, Record Length: 38.10 years

Creation Date: 26-November-2024

Percentage Occurrence for Peak Wave Period

Monthly Occurrence Probability													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Tp1 (s)													
2.00- 3.99	0.17	0.15	0.13	0.10	0.31	0.33	0.46	0.43	0.29	0.35	0.38	0.31	**0.285**
4.00- 5.99	9.35	7.97	6.40	4.82	3.22	2.97	2.24	4.04	6.17	8.04	10.09	10.45	**6.282**
6.00- 7.99	30.93	25.89	21.46	15.69	12.19	10.95	10.21	14.43	20.06	23.21	29.28	28.57	**20.169**
8.00- 9.99	32.88	34.11	30.63	31.42	29.15	26.99	27.97	29.22	33.27	34.38	33.16	32.66	**31.278**
10.00-11.99	18.08	20.99	23.96	28.02	30.67	32.43	33.75	29.69	24.36	21.45	18.20	19.59	**25.160**
12.00-13.99	7.63	9.67	15.47	18.19	21.74	23.21	22.17	19.55	13.86	11.28	8.18	7.89	**14.975**
14.00-15.99	0.70	1.00	1.62	1.51	2.19	2.41	2.60	2.14	1.46	0.85	0.48	0.39	**1.457**
16.00-17.99	0.25	0.22	0.35	0.25	0.51	0.65	0.57	0.50	0.50	0.41	0.21	0.11	**0.381**
18.00-19.99	0.00	0.00	0.00	0.00	0.01	0.06	0.02	0.01	0.02	0.02	0.00	0.02	**0.013**
Monthly Statistics													
Minimum	2.60	3.40	3.10	2.40	2.30	2.30	2.30	2.40	2.60	2.20	2.70	2.70	**2.20**
Average	8.68	8.98	9.46	9.80	10.16	10.32	10.34	9.99	9.44	9.09	8.66	8.67	**9.47**
Maximum	17.44	17.44	17.44	17.44	19.70	19.70	19.70	19.70	19.10	19.10	17.44	19.10	**19.70**
Number of Data Points Used for Statistical Analysis													
No. Points	25,919	23,558	26,331	23,684	25,917	25,570	26,127	25,034	24,538	25,452	24,334	24,784	**301,248**
Percent Capture Based on Nominated Start/Finish													
% Capture	91.68	91.40	93.13	86.56	91.28	91.06	92.33	88.55	89.69	90.03	88.94	87.66	**90.20**

Wave data collected under the NSW Coastal Data Network Program managed by the NSW Department of Climate Change, Energy, the Environment and Water – Biodiversity, Conservation and Science (DCCEEW BCS)

Manly Hydraulics Laboratory

Wave Direction Occurrence Statistics

Site Name: BATEMANS BAY
Site Code: BATBOW

Nominated Start/Finish: 23-February-2001 to 30-June-2024, Record Length: 23.35 years

Creation Date: 04-December-2024

Percentage Occurrence for Wave Direction

Monthly Occurrence Probability														
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Principal Wave Direction (°TN)														
N	*(348.75 - 11.24)*	0.01	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.01	0.01	0.00	0.01	**0.010**
NNE	*(11.25 - 33.74)*	0.06	0.05	0.06	0.07	0.02	0.03	0.09	0.09	0.13	0.06	0.03	0.10	**0.066**
NE	*(33.75 - 56.24)*	4.26	1.81	1.71	1.35	1.27	1.02	1.27	2.22	3.53	2.78	2.85	3.32	**2.261**
ENE	*(56.25 - 78.74)*	17.68	11.69	10.65	6.61	4.38	4.48	5.02	6.51	11.28	12.20	13.73	13.89	**9.784**
E	*(78.75 -101.24)*	17.39	16.59	15.28	14.68	9.91	9.54	9.37	6.40	9.30	9.95	11.57	11.35	**11.787**
ESE	*(101.25 -123.74)*	12.35	16.32	14.48	14.46	13.36	13.14	14.73	9.71	9.75	9.67	10.66	12.07	**12.586**
SE	*(123.75 -146.24)*	16.55	17.53	20.08	26.31	25.79	24.26	28.04	24.57	18.55	19.00	19.39	18.05	**21.562**
SSE	*(146.25 -168.74)*	22.35	23.79	25.24	28.18	38.89	38.79	35.39	41.61	37.05	33.81	29.29	28.44	**31.923**
S	*(168.75 -191.24)*	8.75	11.52	11.42	7.88	5.94	7.85	5.54	8.06	9.92	11.80	11.71	11.92	**9.329**
SSW	*(191.25 -213.74)*	0.55	0.68	1.07	0.41	0.36	0.41	0.27	0.45	0.31	0.62	0.66	0.81	**0.553**
SW	*(213.75 -236.24)*	0.01	0.02	0.01	0.01	0.01	0.03	0.03	0.05	0.03	0.01	0.04	0.04	**0.024**
WSW	*(236.25 -258.74)*	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.01	0.01	0.00	**0.005**
W	*(258.75 -281.24)*	0.01	0.00	0.00	0.00	0.03	0.05	0.02	0.03	0.02	0.01	0.01	0.01	**0.016**
WNW	*(281.25 -303.74)*	0.00	0.00	0.00	0.01	0.02	0.17	0.10	0.14	0.05	0.03	0.01	0.01	**0.045**
NW	*(303.75 -326.24)*	0.00	0.00	0.00	0.01	0.01	0.14	0.07	0.09	0.04	0.04	0.01	0.00	**0.036**
NNW	*(326.25 -348.74)*	0.01	0.00	0.00	0.01	0.00	0.06	0.01	0.01	0.02	0.02	0.01	0.00	**0.013**
Monthly Statistics														
Average		117.49	124.94	127.34	129.27	134.75	136.06	133.25	136.50	130.45	130.60	127.62	126.59	**129.61**
Number of Data Points Used for Statistical Analysis														
No. Points		15,332	14,605	16,398	14,721	16,379	15,768	15,352	14,747	14,189	15,411	15,088	14,385	**182,375**
Percent Capture Based on Nominated Start/Finish														
% Capture		89.60	92.77	91.83	85.19	91.73	91.25	89.59	86.18	85.68	90.06	91.11	84.06	**89.10**

Wave data collected under the NSW Coastal Data Network Program managed by the NSW Department of Climate Change, Energy, the Environment and Water – Biodiversity, Conservation and Science (DCCEEW BCS)

Manly Hydraulics Laboratory

Significant Wave Height vs Peak Wave Period Joint Occurrence Statistics

Site Name: BATEMANS BAY
Site Code: BATBOW

Nominated Start/Finish: 27-May-1986 to 30-June-2024, Record Length: 38.10 years

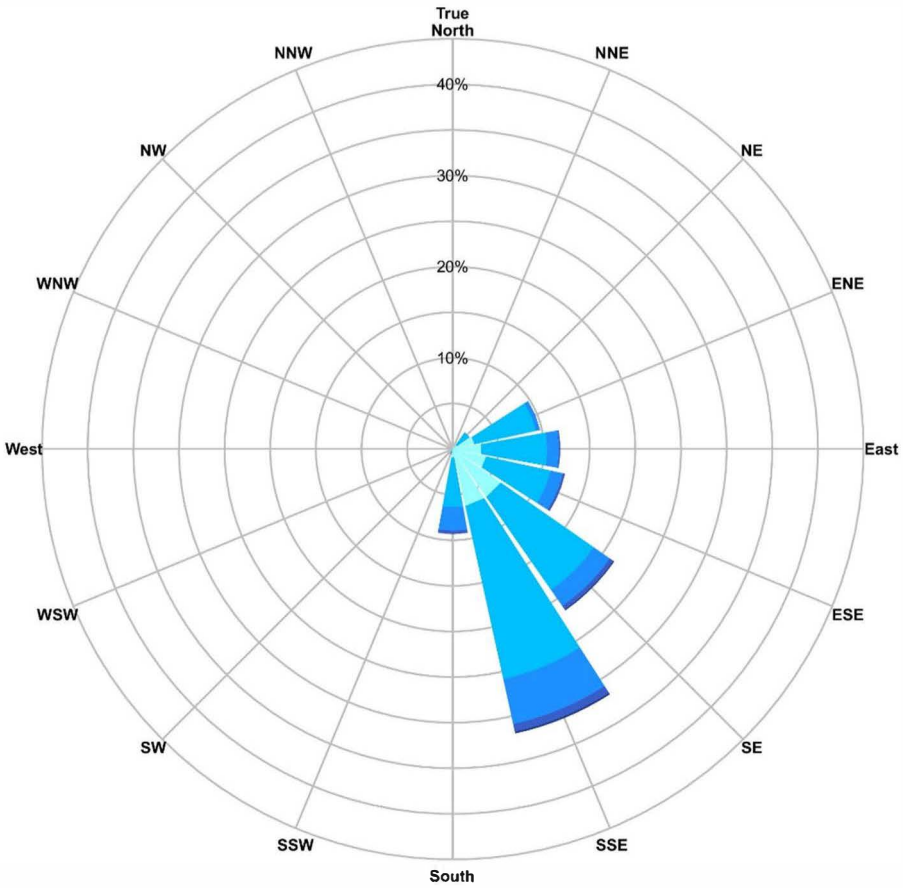
Total Number of Records Used for Analysis: 301,248
Recovery Rate Based on Nominated Start/Finish: 90.20%

Creation Date: 27-November-2024

Percentage Joint Occurrence for Significant Wave Height and Peak Wave Period

	Tp1 (s)									
	2.00 to 3.99	4.00 to 5.99	6.00 to 7.99	8.00 to 9.99	10.00 to 11.99	12.00 to 13.99	14.00 to 15.99	16.00 to 17.99	18.00 to 19.99	Total
Hsig (m)										
0.00 to 0.49	0.01	0.01	0.06	0.23	0.25	0.22	0.03	0.01	0.00	**0.82**
0.50 to 0.99	0.22	1.44	3.84	7.10	5.59	3.80	0.38	0.11	0.00	**22.48**
1.00 to 1.49	0.06	3.63	8.47	12.73	9.03	5.27	0.50	0.14	0.01	**39.84**
1.50 to 1.99	0.00	1.12	5.09	6.68	5.41	2.86	0.28	0.07	0.00	**21.51**
2.00 to 2.49	0.00	0.09	2.06	2.79	2.64	1.28	0.10	0.03	0.00	**8.99**
2.50 to 2.99	0.00	0.00	0.55	1.16	1.21	0.70	0.07	0.02	0.00	**3.71**
3.00 to 3.49	0.00	0.00	0.08	0.41	0.59	0.37	0.04	0.01	0.00	**1.50**
3.50 to 3.99	0.00	0.00	0.01	0.13	0.25	0.23	0.03	0.00	0.00	**0.65**
4.00 to 4.49	0.00	0.00	0.00	0.04	0.11	0.13	0.02	0.00	0.00	**0.30**
4.50 to 4.99	0.00	0.00	0.00	0.01	0.05	0.06	0.01	0.00	0.00	**0.13**
5.00 to 5.49	0.00	0.00	0.00	0.00	0.02	0.04	0.00	0.00	0.00	**0.06**
5.50 to 5.99	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	**0.02**
6.00 to 6.49	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	**0.01**
6.50 to 6.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
7.00 to 7.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Total Percentage										
Total %	0.29	6.29	20.16	31.28	25.16	14.98	1.46	0.39	0.01	**100.00**

Wave data collected under the NSW Coastal Data Network Program managed by the NSW Department of Climate Change, Energy, the Environment and Water – Biodiversity, Conservation and Science (DCCEEW BCS)



Significant Wave Height vs. Direction Rose

Site: Batemans Bay

Start: 23 February 2001 Finish: 30 June 2024

Record Length (yrs): 23.35

No. of Hourly Records: 182,375

Significant Wave Height (m)

- 4 – 7
- 3 – 4
- 2 – 3
- 1 – 2
- 0 – 1

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SAMPLE WEB PAGE DOCUMENT
SIGNIFICANT WAVE HEIGHT/WAVE DIRECTION ROSE

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Report MHL3067
Figure
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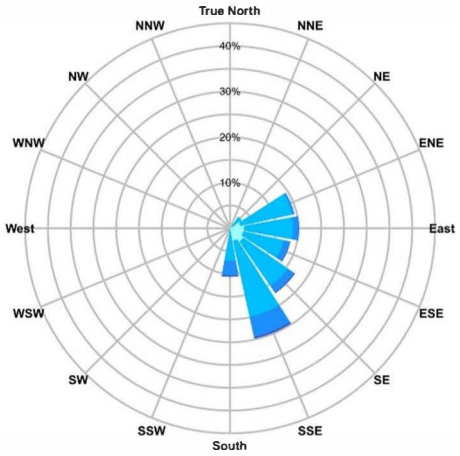
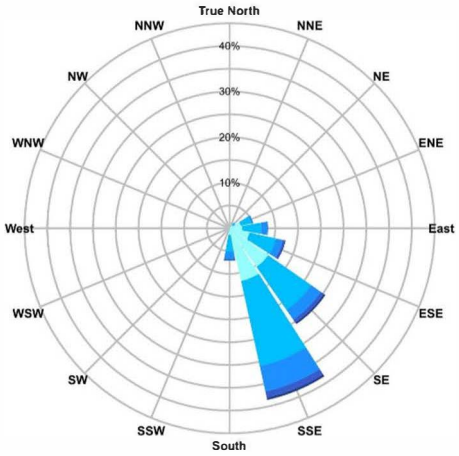
SUMMER



WINTER



Significant Wave Height vs. Direction Roses

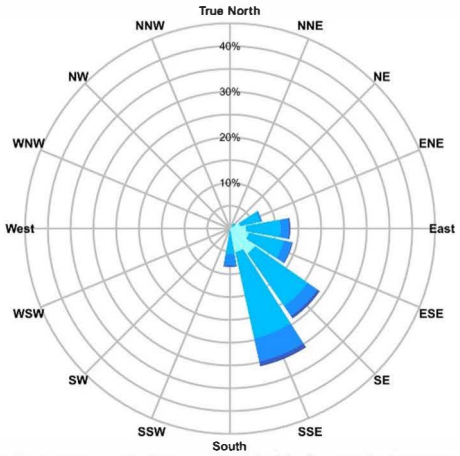
Site: Batemans Bay

Start: 23 February 2001 Finish: 30 June 2024

Record Length (yrs): 23.35

No. of Hourly Records: 182,375

AUTUMN



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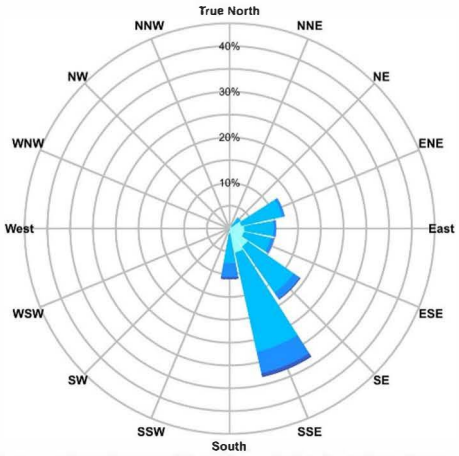

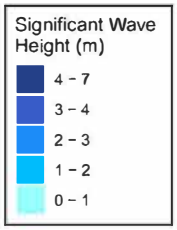

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SAMPLE WEB PAGE DOCUMENT
SEASONAL SIGNIFICANT WAVE HEIGHT/
WAVE DIRECTION ROSE

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Report MHL3067
Figure
A6

Dwg 3067-A6

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NSW Wave Climate

Batemans Bay Waverider Buoy Storm History

Site Commissioned: 27-May-86

Date Capture: 90.2%

Storm Date		Storm Duration (Hours) of Hsig (m) greater than:											Peak Hsig	Mean Hsig	Peak Hmax	Mean Tsig	Mean TP1	Peak Power	Mean Power	Deepwater Wave Direction	
Start	Finish	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	(m)	(m)	(m)	(s)	(s)	(kW/m)	(kW/m)	(° TN)	(Compass)
30-Jun-86	1-Jul-86	14	0	0	0	0	0	0	0	0	0	0	3.4	3.1	6.3	11.2	12.6	74.1	62.8	135	SE
10-Jul-86	11-Jul-86	19	2	0	0	0	0	0	0	0	0	0	3.7	3.3	6.6	10.4	11.6	84.1	61.6	157	SSE
25-Jul-86	26-Jul-86	17	4	1	0	0	0	0	0	0	0	0	4.2	3.4	6.9	10.7	12.4	104.2	71.1	180	S
5-Aug-86	11-Aug-86	100	80	71	53	15	3	0	0	0	0	0	5.6	4.4	11.2	10.1	11.7	180.9	110.3	90	E
15-Aug-86	15-Aug-86	3	0	0	0	0	0	0	0	0	0	0	3.4	3.3	5.9	7.3	7.5	47.8	44.3	45	NE
14-Sep-86	15-Sep-86	18	1	0	0	0	0	0	0	0	0	0	3.5	3.2	6.1	8.9	10.0	62.2	49.4	157	SSE
18-Nov-86	21-Nov-86	60	55	52	42	22	9	1	0	0	0	0	6.0	4.8	10.3	10.5	11.7	221.1	139.0	180	S
29-Nov-86	30-Nov-86	13	8	4	0	0	0	0	0	0	0	0	4.2	3.7	7.3	9.8	12.3	97.0	75.9	157	SSE
9-Dec-86	9-Dec-86	3	0	0	0	0	0	0	0	0	0	0	3.3	3.1	5.9	8.4	10.8	51.4	46.3	157	SSE
4-Jan-87	5-Jan-87	3	0	0	0	0	0	0	0	0	0	0	3.0	3.0	5.7	9.1	10.2	46.9	44.5	67	ENE
3-Mar-87	3-Mar-87	1	0	0	0	0	0	0	0	0	0	0	3.0	3.0	5.5	9.8	12.2	46.8	46.8	135	SE
8-Apr-87	9-Apr-87	2	0	0	0	0	0	0	0	0	0	0	3.0	3.0	5.1	7.5	9.2	40.7	37.2	157	SSE
3-May-87	3-May-87	2	0	0	0	0	0	0	0	0	0	0	3.1	3.1	5.9	9.8	10.2	47.3	47.1	90	E
18-May-87	19-May-87	28	9	1	0	0	0	0	0	0	0	0	4.0	3.4	7.4	10.4	11.5	87.2	64.3	180	S
19-Aug-87	20-Aug-87	16	2	0	0	0	0	0	0	0	0	0	3.6	3.3	6.5	8.1	8.0	59.3	51.6	90	E
1-Sep-87	2-Sep-87	28	11	5	1	0	0	0	0	0	0	0	4.7	3.5	7.1	11.3	12.5	151.2	78.2	157	SSE
30-Sep-87	30-Sep-87	3	1	0	0	0	0	0	0	0	0	0	3.5	3.3	6.3	7.7	8.1	50.0	44.8	180	S
21-Oct-87	21-Oct-87	2	0	0	0	0	0	0	0	0	0	0	3.2	3.2	5.5	7.4	8.0	42.0	38.4	157	SSE
24-Nov-87	24-Nov-87	5	1	0	0	0	0	0	0	0	0	0	3.7	3.3	6.2	8.9	10.0	61.3	51.2	180	S
2-Dec-87	4-Dec-87	35	4	0	0	0	0	0	0	0	0	0	3.8	3.3	6.4	9.8	11.3	81.4	56.9	180	S
19-Dec-87	19-Dec-87	1	0	0	0	0	0	0	0	0	0	0	3.0	3.0	4.9	7.2	7.3	33.7	33.7	112	ESE
21-Dec-87	23-Dec-87	5	0	0	0	0	0	0	0	0	0	0	3.3	3.1	7.0	7.7	10.0	52.0	44.7	157	SSE
17-Jan-88	17-Jan-88	2	0	0	0	0	0	0	0	0	0	0	3.1	3.1	6.4	5.7	7.8	61.5	51.6	180	S

31-Jan-88	31-Jan-88	4	0	0	0	0	0	0	0	0	0	0	3.3	3.2	5.7	7.8	8.5	45.9	42.0	180	S
8-Feb-88	10-Feb-88	29	20	14	1	0	0	0	0	0	0	0	4.5	3.8	7.9	9.6	11.3	114.5	79.5	157	SSE
14-Feb-88	14-Feb-88	5	0	0	0	0	0	0	0	0	0	0	3.3	3.1	5.9	7.7	8.7	43.9	39.4	157	SSE
19-Feb-88	19-Feb-88	3	0	0	0	0	0	0	0	0	0	0	3.2	3.1	5.0	7.9	8.7	40.5	39.7	112	ESE
7-Mar-88	8-Mar-88	22	4	0	0	0	0	0	0	0	0	0	3.7	3.3	6.7	12.9	15.4	111.4	86.8	90	E
14-Mar-88	14-Mar-88	1	0	0	0	0	0	0	0	0	0	0	3.0	3.0	5.4	7.4	7.7	36.9	36.9	157	SSE
8-Apr-88	10-Apr-88	43	29	17	1	0	0	0	0	0	0	0	4.5	3.8	8.5	9.2	11.4	106.5	74.5	180	S
16-Apr-88	16-Apr-88	5	0	0	0	0	0	0	0	0	0	0	3.4	3.2	6.0	7.6	8.2	46.4	42.1	157	SSE
28-Apr-88	2-May-88	69	48	18	0	0	0	0	0	0	0	0	4.4	3.7	8.1	9.5	11.4	206.9	79.2	90	E
24-May-88	26-May-88	29	17	8	1	0	0	0	0	0	0	0	4.5	3.6	8.3	9.8	11.4	106.5	71.7	157	SSE
16-Jun-88	18-Jun-88	4	0	0	0	0	0	0	0	0	0	0	3.1	3.1	5.7	10.9	12.3	61.6	56.5	90	E
6-Jul-88	7-Jul-88	23	16	8	3	0	0	0	0	0	0	0	4.8	3.8	8.5	9.0	10.2	123.9	73.1	90	E
8-Aug-88	9-Aug-88	37	12	2	0	0	0	0	0	0	0	0	4.2	3.4	7.2	9.4	11.3	86.5	61.8	157	SSE
16-Sep-88	16-Sep-88	5	0	0	0	0	0	0	0	0	0	0	3.3	3.1	6.0	8.4	10.1	49.0	45.0	67	ENE
5-Nov-88	5-Nov-88	2	1	0	0	0	0	0	0	0	0	0	3.5	3.4	6.2	6.6	8.5	46.4	44.5	157	SSE
16-Nov-88	16-Nov-88	4	0	0	0	0	0	0	0	0	0	0	3.3	3.2	6.2	7.1	8.0	43.6	40.4	135	SE
26-Dec-88	27-Dec-88	6	2	0	0	0	0	0	0	0	0	0	3.8	3.4	6.4	5.2	9.1	64.5	52.4	180	S
1-Feb-89	1-Feb-89	1	0	0	0	0	0	0	0	0	0	0	3.0	3.0	5.5	7.3	9.5	36.1	36.1	157	SSE
21-Feb-89	21-Feb-89	1	0	0	0	0	0	0	0	0	0	0	3.0	3.0	5.0	10.1	12.2	51.6	51.6	112	ESE
16-Mar-89	17-Mar-89	14	0	0	0	0	0	0	0	0	0	0	3.4	3.2	6.1	9.4	12.4	66.7	58.5	135	SE
31-May-89	1-Jun-89	26	15	4	0	0	0	0	0	0	0	0	4.3	3.6	7.8	9.6	10.9	98.3	68.6	157	SSE
11-Jun-89	12-Jun-89	8	0	0	0	0	0	0	0	0	0	0	3.4	3.2	6.2	9.0	10.5	54.2	50.8	180	S
19-Jun-89	21-Jun-89	22	5	0	0	0	0	0	0	0	0	0	3.6	3.3	7.5	8.4	10.3	59.8	49.8	180	S
23-Jun-89	24-Jun-89	19	6	0	0	0	0	0	0	0	0	0	3.8	3.4	6.8	11.9	13.1	98.2	77.0	67	ENE
11-Jul-89	13-Jul-89	55	27	8	3	0	0	0	0	0	0	0	4.8	3.6	8.0	10.7	12.3	160.2	78.6	180	S
24-Jul-89	26-Jul-89	49	32	15	5	0	0	0	0	0	0	0	4.9	3.8	8.9	9.3	10.7	127.5	72.9	112	ESE
11-Aug-89	12-Aug-89	19	4	0	0	0	0	0	0	0	0	0	3.7	3.3	7.2	9.3	11.7	78.5	57.5	157	SSE
2-Sep-89	2-Sep-89	5	0	0	0	0	0	0	0	0	0	0	3.3	3.2	6.2	7.6	8.2	46.5	42.9	180	S
25-Sep-89	26-Sep-89	4	0	0	0	0	0	0	0	0	0	0	3.3	3.2	6.1	7.2	7.9	42.7	39.0	180	S
2-Oct-89	2-Oct-89	4	0	0	0	0	0	0	0	0	0	0	3.2	3.2	5.2	9.3	11.0	54.5	51.3	180	S
28-Oct-89	29-Oct-89	11	3	0	0	0	0	0	0	0	0	0	3.8	3.3	6.6	9.9	12.6	76.6	62.2	180	S
14-Dec-89	14-Dec-89	1	0	0	0	0	0	0	0	0	0	0	3.3	3.3	5.6	9.1	10.2	51.1	51.1	180	S
4-Jan-90	4-Jan-90	3	0	0	0	0	0	0	0	0	0	0	3.3	3.2	5.8	7.5	8.5	43.3	41.2	157	SSE
26-Jan-90	27-Jan-90	2	0	0	0	0	0	0	0	0	0	0	3.2	3.1	5.4	11.2	12.3	63.9	61.0	90	E

NSW GOVERNMENT

SAMPLE WEB PAGE DOCUMENT
STORM HISTORY TABLE

Manly Hydraulics Laboratory

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Figure
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Appendix B Glossary of terms

Average H_{sig}	:	average significant wave height recorded during a storm event. See H_{sig}.
Average T_{P1}	:	average spectral peak period recorded during a storm event. See T_{P1}.
Average T_{sig}	:	average significant wave period recorded during a storm event. See T_{sig}.
Average Wave Power	:	average wave power recorded during a storm event. See Wave Power.
Data Capture / Data Recovery	:	number of records collected divided by total number of possible records. Normally expressed as a percentage.
Date / Time	:	for start of record.
Deep Water	:	water sufficiently deep that surface waves are little affected by the ocean bottom. Generally, water deeper than one-half the surface wave length is considered deep water.
Diffraction	:	the 'spreading' of waves into the lee of obstacles such as breakwaters by the transfer of wave energy along wave crests. Diffracted waves are lower in height than the incident waves.
Directional Waverider Buoy	:	a floating device used to measure ocean wave height, period and direction. It is a registered trademark of the Dutch company Datawell.
Effective Record Length	:	total record length multiplied by the data capture rate.
Electromagnetic Current Meter	:	a device that measures current and water pressure variations. If deployed in shallow water current and pressure data can be converted to wave height, period and direction. Current meters manufactured by the American companies Marsh McBirney and InterOcean are used by Manly Hydraulics Laboratory to collect wave data.
Electromagnetic Wave and Tide Monitoring System (EWS)	:	linear electromagnetic gauge fixed to a structure used to measure water level variations caused by waves and tides.
Fetch	:	the horizontal distance over which a wind blows in generating waves.

Hindcast	:	the prediction of wave characteristics using meteorological information as opposed to the measurements of these features.
H_1	:	average height of the waves which comprise the top 1%.
H_{10}	:	average height of the waves which comprise the top 10%.
H_{max}	:	maximum wave height.
H_{mean}	:	mean wave height.
H_{rms}	:	root mean square wave height.
H_{sig}	:	significant wave height = average height of the waves which comprise the top 33%.
Logger	:	device for recording digitised data.
Long Wave	:	waves with periods greater than 30 seconds. Often associated with storm wave activity along the NSW coast.
M_0, M_1, M_2, M_3	:	Spectral Moments - $M_n = \Sigma\ E\ f^n\ \Delta f$. These provide parameters describing the shape of the spectrum.
MS	:	Mean Square displacement (= Y_{rms}^2 = M_0).
Peak H_{max}	:	highest maximum wave height recorded during a storm event.
Peak H_{sig}	:	highest significant wave height recorded during a storm event.
Peak Wave Power	:	maximum wave power level recorded during a storm event.
Percentage Exceedance	:	percentage of time that a given value is exceeded.
Percentage Occurrence	:	percentage of time that given value (or range of values) occurs.
Receiver	:	shore-based device for receiving incoming wave signals.
Record	:	burst of data from the wave measuring device (usually 2048 seconds for Manly Hydraulics Laboratory instruments).

Record Interval	:	time between records (usually 1 hour). Prior to June 1984 the standard for wave data collection by Manly Hydraulics Laboratory was 6 hours.
Refraction	:	the tendency of wave crests to become parallel to bottom contours as waves move into shallower waters. This effect is caused by the shoaling process which slows down waves in shallower waters.
Sample Increment	:	time between sample points measured by the transducer. Sample points are spaced at 0.78 second intervals for directional ocean wave measurement.
Sea Waves	:	waves in coastal waters resulting from the interaction of different wave trains and locally generated waves. Typically, sea waves are of short wave length and of disordered appearance.
Shallow Water	:	water of such a depth that surface waves are noticeably affected by bottom topography. Generally, water depth less than one-half the surface wave length is considered shallow water.
Shoaling	:	the influence of the seabed on wave behaviour. Such effects only become significant in water depths of 60 m or less. Manifested as a reduction in wave speed, a shortening in wave length and an increase in wave height.
Storm Event	:	period of high wave activity. For the NSW coastline is normally defined as the time when a H_{sig} greater than 3 metres is recorded at an offshore wave recording station.
Swell Waves	:	wind waves remote from the area of generation (fetch) having a uniform and orderly appearance characterised by regularly spaced wave crests.
Total Record Length	:	elapsed period from the date of commission to the end of data collection at a recording site.
T_c	:	crest period = average time between successive crests.
T_{P1}	:	peak period of the energy spectrum.
T_{P2}	:	period corresponding to the second biggest peak of the energy spectrum.
T_{sig}	:	significant period = average period of the waves used to define H_{sig}.
T_z	:	zero crossing period = mean period.

Wave Direction	:	the direction from which ocean waves approach a location. Generally, the principal wave direction is represented by the direction that corresponds to the peak period of the energy spectrum (T_{P1}).
Wave Height	:	the vertical distance between a wave trough and wave crest.
Wave Length	:	the distance between consecutive wave crest or wave troughs.
Wave Period	:	the time taken for consecutive wave crests or wave troughs to pass a given point.
Wave Power	:	the rate at which wave energy is transmitted in the direction of wave propagation. Normally expressed in watts per metre of wave crest length.
Waverider Buoy	:	a floating device used to measure water level variations caused by ocean waves. It is a registered trademark of the Dutch company Datawell.
Wind Waves	:	the waves initially formed by the action of wind blowing over the sea surface. Wind waves are characterised by a range of heights, periods and wave lengths. As they leave the area of generation (fetch), wind waves develop a more ordered and uniform appearance and are referred to as swell or swell waves.
Y_{rms}	:	root mean square amplitude (not to be confused with H_{rms}).

Appendix C Bibliography

1. Wave data collection and analysis – general

Barstow, S.F. and Kollstad, T., Field trials of the Directional Waverider, *First International Offshore and Polar Engineering Conference,* Edinburgh, United Kingdom, August 1991.

Borgman, L.E., Confidence Intervals for Ocean Wave Spectra, *13th International Coastal Engineering Conference,* Vancouver, 1972.

Coastal Impacts Unit, *Mk4 Datawell Wave Buoy Analysis and Comparison – A Comparison between the Mk4 and Mk3 Datawell Directional Waverider buoys*, Queensland Department of Science, Information Technology and Innovation, November 2017.

Coastal Impacts Unit, *Wave Monitoring Equipment Comparison – An Evaluation of Current and Emerging In-situ Ocean Wave Monitoring Technology*, Queensland Department of Environment and Science, April 2019.

CSIR, *Comparative field tests of a Datawell Directional Waverider and an Electromagnetic Current Meter Pressure Sensor Instrument*, CSIR Report EMAS-T93003, Stellenbosch, February 1993.

CSIRO, *A wave climatology for the Australian Region*, Australian Greenhouse Office, Department of Environment and Water Resources, June 2007.

CSIRO, *Variability and trends in the Australian wave climate and consequent coastal vulnerability*, Department of Climate change Surface Ocean Wave Variability Project, September 2008.

Datawell b.v., *Warec - PC Software*, Datawell b.v. - Laboratory for Instrumentation, October 1992.

Datawell b.v., *Manual of the Digital Waverider Receiver type DIWAR,* Datawell b.v. - Laboratory for Instrumentation, February 1998.

Datawell b.v., *Manual for the Wave Direction Receiver 'WAREC'*, Datawell b.v. - Laboratory for Instrumentation, April 1998.

Datawell b.v., *Datawell Directional Waverider Manual Mark II*, Datawell b.v. – Laboratory for Instrumentation, June 2004.

Datawell b.v., *Datawell Waverider Installation Guide,* Datawell b.v. - Laboratory for Instrumentation, June 2005.

Datawell b.v., *Datawell Waverider Receiver Manual RX-D type 2,* Datawell b.v. - Laboratory for Instrumentation, November 2005.

Datawell b.v., *Datawell Waverider Reference Manual (including FB2 electronics unit) WR-SG, DWR-MkIII*, Datawell b.v. – Laboratory for Instrumentation, June 2011.

Datawell b.v., *Datawell Waverider Reference Manual, WR-SG, DWR-MkIII, DWR-G*, Datawell BV, February 2020.

Draper L., The Analysis and Presentation of Wave Data - A Plea for Uniformity, *10th International Coastal Engineering Conference,* Japan, September 1966.

Goda, Y., Wave Measurements and Utilisation of Wave Data, *6th Australian Conference on Coastal*

and Ocean Engineering, Brisbane, Institution of Engineers, Australia, July 1983.

Hamilton, L.J*., Bibliography of Wind-Wave Data and Publications for the Coastal Regions of Australia*, Department of Defence, Defence Science and Technology Organisation, Report DSTO-GD-0116, February 1997.

Harris, D.L., Analysis of Wave Records, *12th International Coastal Engineering Conference,* Washington, September 1970.

Harris, D.L., Finite Spectrum Analysis of Wave Records, *International Symposium on Ocean Wave Measurement and Analysis*, New Orleans, September 1974.

Kuik, A.J. and Holthuijsen, L.H., Buoy Observation of Directional Wave Parameters, *Conference on Directional Wave Spectra Applications,* Berkeley, California, American Society of Civil Engineers, September 1981.

Kuik, A.J. and van Vledder, G., Proposed Method for the Routine Analysis of Pitch-Roll Buoy Data, *Symposium on Description and Modelling of Directional Seas*, Denmark, Danish Hydraulic Institute and Danish Maritime Institute, June 1984.

Lawson, N.V., Rice, R.A. and Szylkarski, S.P., World Satellite Altimeter Wave Data Base, *11th Australasian Conference on Coastal and Ocean Engineering*, Townsville, Institution of Engineers, Australia, August 1993.

MacLaren Plansearch Limited, *Evaluation/Validation of the new Datawell Directional Waverider Buoy*, Report 05889SRE.001, Nova Scotia, Canada, 1991.

Mansard, E.P.D. and Funke, E.R., A Comprehensive Wave Data Analysis Package, *International Conference on Measuring Techniques of Hydraulic Phenomena in Offshore, Coastal and Inland Waters,* London, BHRA, The Fluid Engineering Centre, April 1986.

Morim, J., Cartwright, N., Etemad-Shahidi, A., Strauss, D. and Hemer, M., *Wave energy resource assessment along the Southeast coast of Australia on the basis of a 31-year hindcast*, Applied Energy 184 276-297, 2016.

NOAA, *Nondirectional and Directional Wave Data Analysis Procedures*, National Data Buoy Center, NDBC Technical Document 96-01, January 1996.

Oceanographic Company of Norway A/S., *Field Trials of the Directional Waverider*, Trondheim, Norway.

Pitt, E.C. Pascall, R.W. and van Heteren, J., A Comparison of the Measurements made by two Pitch-Roll Buoys during the NURWEC Project*, Ocean-Data Conference - Evaluation, Comparison and Calibration of Ocean Instruments*, London, 1985.

Reid, J.S., Some Comments on Ocean Wave Statistics, *9th Australasian Conference on Coastal and Ocean Engineering,* Adelaide, Institution of Engineers, Australia, December 1989.

Siefert, W., Shallow Water Wave Characteristics, *13th International Coastal Engineering Conference,* Vancouver, 1972.

Tremarfon Pty Ltd, *Ocean Wave Data Collection System Software Guide*, Tremarfon Pty Ltd for Manly Hydraulics Laboratory, September 2010.

Thompson, W.G., Swell and Storm Characteristics from Coastal Wave Records, *12th International Coastal Engineering Conference,* Washington, September 1970.

Tucker, M.J., *Waves in Ocean Engineering, measurement, analysis and interpretation*, Ellis Horwood Limited, 1991.

Tucker, M.J., *Recommended Standard for Wave Data Sampling and Near Real-time Processing*, Oil Industry International Exploration and Production Forum, London, Report No. 3.14/186, June 1992.

van der Vlugt, A.J.M., Kuik, A.J. and Holthuijsen, The Wavec Directional Buoy under Development, *Conference on Directional Wave Spectra Applications*, Berkeley, California, American Society of Civil Engineers, September 1981.

van der Vlugt, A.J.M., The Wavec Buoy for Routinely Measuring the Direction of Sea Waves, *International Conference on Wave and Wind Directionality Applications to the Design of Structures,* Paris, September 1981.

van der Vlugt, A.J.M., Experience with the Wavec Buoy, *Symposium on Description and Modelling of Directional Seas*, Denmark, Danish Hydraulic Institute and Danish Maritime Institute, June 1984.

Wang, S. and Le Mehaute, B., Duration of Measurements and Long-Term Wave Statistics, *Journal of Waterway Port Coastal and Ocean Engineering,* Vol. 109 No. 2, American Society of Civil Engineers, May 1983.

Waters, C.B., Experiences in the Operation of Waverider Buoys, *16th Congress International Association for Hydraulic Research,* Brazil, 1975.

Wilson, J.R. and Baird, W.F., A Discussion of Some Measured Wave Data, *13th International Coastal Engineering Conference,* Vancouver, 1972.

2. Wave data collection and analysis – New South Wales

Abernethy, C.L. and Lawson, N.V., Statistical Distributions of Wave Parameters off Botany Bay, *1st Australian Conference on Coastal Engineering*, Sydney, Institution of Engineers, Australia, May 1973.

Allan, A.J., Bolton, A.W. and Webb, A.T., A Second Generation Wave Recording Network, *International Conference on Measuring Techniques of Hydraulic Phenomena in Offshore, Coastal and Inland Waters,* London. BHRA, The Fluid Engineering Centre, April 1986.

Australian Water and Coastal Studies Pty Ltd, *DWAVE - Wave Data Software Wave Power Statistics User's Guide,* Report No. 90/07, July 1990.

Australian Water and Coastal Studies Pty Ltd, *Wave Power Study for Selected Sites along the New South Wales Coastline,* Report No. 91/08, May 1991.

Australian Water and Coastal Studies Pty Ltd, *Sydney Deepwater Outfalls Environmental Monitoring Program, Post Commissioning Phase, An Examination of Ocean Reference Station Wind and Wave Data*, Interim Report 93/01/14, December 1995.

Coghlan, I., Mole, M., Shand, T., Carley, J., Peirson, W., Miller, B., Kulmar, M., Couriel, E., Modra, B. and You, Z.J., *High Resolution Wave Modelling (HI-WAM) for Batemans Bay Detailed Wave Study*, Coasts and Ports 2011 Conference, Perth, Australia, September 2011.

Department of Finance and Services, *Batemans Bay Wave Climate Study*, Manly Hydraulics Laboratory, Report MHL2003, December 2010.

Department of Public Works and Services, *New South Wales Central Coast 1995 Wave Data Analysis*, Manly Hydraulics Laboratory, Report MHL754, June 1997.

Department of Public Works and Services, *New South Wales Coast May 1997 Storm Analysis*, Manly Hydraulics Laboratory, Report MHL886, December 1997.

Foster, D., Gordon, A.D. and Lawson, N.V., The Storms of May-June 1974, Sydney, NSW, *2nd Australian Conference on Coastal and Ocean Engineering,* Gold Coast, Institution of Engineers, Australia, April 1975.

Gordon, A.D., Beach Fluctuations and Shoreline Change, *8th Australasian Conference on Coastal and Ocean Engineering,* Launceston, Institution of Engineers, Australia, December 1987.

Glatz, M., Fitzhenry, M. and Kulmar, M., It's Time for an Update – Extreme Waves and Directional Distributions along the New South Wales Coastline, *26th NSW Coastal Conference*, Port Stephens, Port Stephens Council, November 2017.

Jayewardene, I.F.W., Haradasa, D.K.C. and Tainsh, J., Analysis of Wave Groupiness, *11th Australasian Conference on Coastal and Ocean Engineering,* Townsville, Institution of Engineers, Australia, August 1993.

Kemp, R., Gage, B., Moodie, N. and Kulmar, M., Climatology of Large Wave Events and Associated Weather Systems Along the NSW Coast, *16th Australasian Coastal and Ocean Engineering Conference*, Institution of Engineers, Australia, Auckland, NZ, September 2003.

Kulmar, M.A., Wave Direction Distributions off Sydney, New South Wales, *12th Australasian Coastal and Ocean Engineering Conference*, Melbourne, Institution of Engineers, Australia, May 1995.

Kulmar, M., Lord, D. and Sanderson, B., Future Directions for Wave Data Collection in New South Wales, *17th Australasian Conference on Coastal and Ocean Engineering*, Adelaide, Engineers Australia, September 2005.

Kulmar, M., Modra, B. and Fitzhenry, M., The New South Wales Wave Climate – Improved Understanding through the Introduction of Directional Wave Monitoring Buoys, *2013 Australasian Coasts and Ports Conference*, Sydney, Engineers Australia, September 2013.

Lawson, N.V. and Abernethy, C.L., Long Term Wave Statistics off Botany Bay, *2nd Australian Conference on Coastal and Ocean Engineering,* Gold Coast, Institution of Engineers, Australia, April 1975.

Lawson, N.V., McCowan, A.D. and Treloar, P.D., Inter-Relationships between Wave Periods for the NSW, Australia Coast, *8th Australasian Conference on Coastal and Ocean Engineering,* Launceston, Institution of Engineers, Australia, December 1987.

Lawson, N.V. and Youll, P.H., Storm Duration and Return Interval for Waves off the Central NSW Coast, *3rd Australian Conference on Coastal and Ocean Engineering,* Melbourne, Institution of Engineers, Australia, April 1977.

Lawson, N.V. and Youll, P.H., Realtime Wave Analysis, Newcastle, Australia, *17th International Conference on Coastal Engineering,* Sydney, Institution of Engineers, Australia, March 1980.

Lord, D. and Kulmar, M.A., The 1974 Storms Revisited: 25 years Experience in Ocean Wave Measurement along the South-East Australian Coast, *27th International Conference on Coastal Engineering*, Sydney, Institution of Engineers, Australia, July 2000.

McMonagle, C.J. and Fidge, B.L., A Study of Extreme Values of Water Level and Wave Height at Coffs Harbour, *5th Australian Conference on Coastal and Ocean Engineering,* Perth, Institution of Engineers, Australia, November 1981.

NSW Public Works, *Waverider User Manual*, Manly Hydraulics Laboratory, Version 3.4, June 1993.

NSW Public Works, *Wave Direction Study - Satellite Imagery Progress Report No.2*, Manly Hydraulics Laboratory, Report MHL641, March 1993.

NSW Public Works, *Sydney Directional Waverider Buoy*, Manly Hydraulics Laboratory, Interim Report MHL656, April 1995.

NSW Public Works, *Batemans Bay Wave Climate Study*, Manly Hydraulics Laboratory, Draft Report MHL2003, October 2010.

Public Works Department, NSW, *Wave Data Collection at Manly Laboratory,* Manly Hydraulics Laboratory, Report MHL311, April 1982.

Public Works Department, NSW, *Wave Statistics for Port Kembla,* Manly Hydraulics Laboratory, Report MHL416, August 1984.

Public Works Department, NSW, *Comparison of Wave Statistics between Byron Bay and Coffs Harbour,* Manly Hydraulics Laboratory, Report MHL422, November 1984.

Public Works Department, NSW, *DWAVE Data Presentation,* Manly Hydraulics Laboratory, Report MHL427, September 1985.

Public Works Department, NSW, *Wave Data Conditioning,* Manly Hydraulics Laboratory, Report MHL436, August 1985.

Public Works Department, NSW, *Hand Reduction of Wave Data for Port Kembla, 1974-1983,* Manly Hydraulics Laboratory, Report MHL442, November, 1985.

Public Works Department, NSW, *Elevated Ocean Levels - Storms Affecting the NSW Coast 1880-1980,* Coastal Branch, Report No. 85041, December 1985.

Public Works Department, NSW, *Development of a Radar Facility to Measure Wave Direction and Currents,* Manly Hydraulics Laboratory, Report MHL456, April 1986.

Public Works Department, NSW, *Elevated Ocean Levels - Storms Affecting the NSW Coast 1980-1985,* Coastal Branch, Report No. 86026, August 1986.

Public Works Department, NSW, *DWAVE - Wave Data Software*, Manly Hydraulics Laboratory, Report MHL399, July 1987.

Public Works Department, NSW, *Zwarts User's Manual*, Manly Hydraulics Laboratory, Report MHL406, Revised Edition, July 1987.

Public Works Department, NSW, *Jervis Bay Wave and Tide Data,* Manly Hydraulics Laboratory, Report MHL476, June 1988.

Public Works Department, NSW, *Nelson Bay Wave Data,* Manly Hydraulics Laboratory, Report MHL543, July 1988.

Public Works Department, NSW, *Eden Wave Data Collection Network,* Manly Hydraulics Laboratory, Report MHL542, November 1988.

Public Works Department, NSW, *Batemans Bay Oceanographic and Meteorological Data 1986-89*, Manly Hydraulics Laboratory, Report MHL556, August 1990.

Public Works Department, NSW, *Storm Surges Monitored along the NSW Coast March - April 1990,* Manly Hydraulics Laboratory, Report MHL591, November 1991.

Short, A.D., *Beaches of the New South Wales Coast - a Guide to their Nature, Characteristics, Surf and Safety*, Australian Beach Safety and Management Program, 1993.

Tremarfon Pty Ltd, *Ocean Wave Data Collection System Software Guide*, September 2010.

Trenaman, N.L. and Short, A.D., *Deepwater and Breaker Wave Climate of the Sydney Region New South Wales 1971-1985,* Coastal Studies Unit, The University of Sydney, Report No. 87/1, December 1987.

University of New South Wales, *NSW Coastal Inundation Hazard Study: Coastal Storms and Extreme Waves,* Water Research Laboratory and Macquarie University, WRL Technical Report 2010/16, January 2011.

Watson, P., Lord, D., Kulmar, M., McLuckie, D. and James, J., Analysis of a Storm – June 2007, *16th NSW Coastal Conference,* Yamba, Clarence Valley Council, November 2007.

Webb, A.T., Wave Climate of the New South Wales Coast, *6th Australian Conference on Coastal and Ocean Engineering,* Gold Coast, Institution of Engineers, Australia, July 1983.

Webb, A.T. and Bolton, A.W., Wave Data on Tap, *8th Australasian Conference on Coastal Engineering,* Launceston, Institution of Engineers, Australia, December 1987.

Webb, A.T. and Kulmar, M.A., Coastal Wave Climate of New South Wales - An Update, *9th Australasian Conference on Coastal and Ocean Engineering,* Adelaide, Institution of Engineers, Australia, December 1989.

Wyllie, S.J., Kulmar, M.A. and Davidson, P.J., Development of Design Offshore Wave and Ocean Level Conditions for the New South Wales Coastal Zone, *2nd Coastal Management Conference,* Kiama, Kiama Municipal Council, November 1992.

Wyllie, S.J. and Kulmar, M.A., Coastal Wave Monitoring, *Australian Marine Data Collection and Management Guidelines Workshop*, Hobart, Environmental Resources Information Network, December 1995.

Willoughby, M.A., NSW Central Coast Wave Climate - 1995 Update, *12th Australasian Coastal and Ocean Engineering Conference*, Melbourne, Institution of Engineers, Australia, May 1995.

You, Z.J. and Jayewardene, I., The Occurrence of Extreme Coastal Storms Along the NSW Coast, *National Environment Conference*, Brisbane, 2003.

You, Z.J. and Lord, D., Influence of the El Nino Southern Oscillation on the NSW Coastal Storm Severity, *Journal of Coastal Research*, 24: 203-207, 2008.

You, Z.J., Extrapolation of extreme wave height with a proper probability distribution function, *Australasian Coasts and Ports Conference*, 17-20 July, Melbourne, 2008.

Youll, P.H., Botany Bay Waverider System - Ten Years of Records, *5th Australian Conference on Coastal and Ocean Engineering,* Perth, Institution of Engineers, Australia, November 1981.

3. New South Wales wave climate annual summaries

Public Works Department, NSW, *New South Wales Wave Climate Annual Summary 1985/86*, Manly Hydraulics Laboratory, Report MHL465, September 1986.

Public Works Department, NSW, *New South Wales Wave Climate Annual Summary 1986/87*, Manly Hydraulics Laboratory, Report MHL520, October 1987.

Public Works Department, NSW, *New South Wales Wave Climate Annual Summary 1987/88*, Manly Hydraulics Laboratory, Report MHL547, October 1988.

Public Works Department, NSW, *New South Wales Wave Climate Annual Summary 1988/89*, Manly Hydraulics Laboratory, Report MHL560, November 1989.

Public Works Department, NSW, *New South Wales Wave Climate Annual Summary 1989/90*, Manly Hydraulics Laboratory, Report MHL581, October 1990.

Public Works Department, NSW, *New South Wales Wave Climate Annual Summary 1990/91*, Manly Hydraulics Laboratory, Report MHL600, September 1991.

Public Works Department, NSW, *New South Wales Wave Climate Annual Summary 1991/92*, Manly Hydraulics Laboratory, Report MHL627, October 1992.

NSW Public Works, *New South Wales Wave Climate Annual Summary 1992/93,* Manly Hydraulics Laboratory, Report MHL655, September 1993.

NSW Public Works, *New South Wales Wave Climate Annual Summary 1993/94,* Manly Hydraulics Laboratory, Report MHL695, October 1994.

Department of Public Works and Services, *New South Wales Wave Climate Annual Summary 1994/95,* Manly Hydraulics Laboratory, Report MHL733, November 1995.

Department of Public Works and Services, *New South Wales Wave Climate Annual Summary 1995/96,* Manly Hydraulics Laboratory, Report MHL779, August 1996.

Department of Public Works and Services, *New South Wales Wave Climate Annual Summary 1996-97,* Manly Hydraulics Laboratory, Report MHL877, September 1997.

Department of Public Works and Services, *New South Wales Wave Climate Annual Summary 1997-98*, Manly Hydraulics Laboratory, Report MHL948, October 1998.

Department of Public Works and Services, *New South Wales Wave Climate Annual Summary 1998-99*, Manly Hydraulics Laboratory, Report MHL1016, September 1999.

Department of Public Works and Services, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 1999-2000*, Manly Hydraulics Laboratory, Report MHL1072, October 2000.

Department of Public Works and Services, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2000-2001*, Manly Hydraulics Laboratory, Report MHL1132, October 2001.

Department of Public Works and Services, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2001-2002*, Manly Hydraulics Laboratory, Report MHL1208, March 2003.

Department of Commerce, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2002-2003*, Manly Hydraulics Laboratory, Report MHL1279, October 2003.

Department of Commerce, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2003-2004*, Manly Hydraulics Laboratory, Report MHL1349, October 2004.

Department of Commerce, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2004-2005*, Manly Hydraulics Laboratory, Report MHL1425, November 2005.

Department of Commerce, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2005-2006*, Manly Hydraulics Laboratory, Report MHL1514, March 2007.

Department of Commerce, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2006-2007*, Manly Hydraulics Laboratory, Report MHL1766, March 2008.

Department of Commerce, *New South Wales Wave Climate and Coastal Air Pressure* Annual Summary 2007-2008, Manly Hydraulics Laboratory, Report MHL1850, September 2008.

Department of Commerce, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2008-2009*, Manly Hydraulics Laboratory, Report MHL1935, November 2009.

Department of Services, Technology and Administration, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2009-2010*, Manly Hydraulics Laboratory, Report MHL2012, November 2010.

Department of Finance and Services, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2010-2011*, Manly Hydraulics Laboratory, Report MHL2091, December 2011.

Department of Finance and Services, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2011-2012*, Manly Hydraulics Laboratory, Report MHL2160, November 2012.

Department of Finance and Services, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2012-2013*, Manly Hydraulics Laboratory, Report MHL2221, November 2013.

Office of Finance and Services, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2013-2014*, Manly Hydraulics Laboratory, Report MHL2294, March 2015.

Department of Finance, Services and Innovation, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2014-2015*, Manly Hydraulics Laboratory, Report MHL2386, March 2016.

Department of Finance, Services and Innovation, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2015-2016*, Manly Hydraulics Laboratory, Report MHL2477, November 2016.

Department of Finance, Services and Innovation, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2016-2017*, Manly Hydraulics Laboratory, Report MHL2576, November 2017.

Department of Finance, Services and Innovation, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2017-2018*, Manly Hydraulics Laboratory, Report MHL2620, March 2019.

Department of Planning, Industry and Environment, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2018-2019*, Manly Hydraulics Laboratory, Report MHL2695, January 2020.

Department of Planning, Industry and Environment, *New South Wales Wave Climate and Coastal Air Pressure Annual Summary 2019-2020*, Manly Hydraulics Laboratory, Report MHL2772, March 2021.

Department of Planning, Industry and Environment, *New South Wales Wave Climate Annual Summary 2020-2021*, Manly Hydraulics Laboratory, Report MHL2858, February 2022.

Department of Planning and Environment, *New South Wales Wave Climate Annual Summary 2021-2022*, Manly Hydraulics Laboratory, Report MHL2909, May 2023.

Department of Climate Change, Energy, the Environment and Water, *New South Wales Wave Climate Annual Summary 2022-2023*, Manly Hydraulics Laboratory, Report MHL2909, May 2024.

Manly
Hydraulics
Laboratory

110B King Street

Manly Vale NSW 2093