COMPARISON OF CONTEMPORANEOUS WAVE MEASUREMENTS WITH A SAAB WAVERADAR REX AND A DATAWELL DIRECTIONAL WAVERIDER BUOY

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MOTIVATION

- Investigate why such a significant difference (~5%) exists between nearby offshore wave heights measured with a DWR and SAAB.
- Better understand the differences and limitations of the two different instruments.
- To attend this conference.

This study compares DWR and SAAB measured data for:

- Total, sea and swell waves;
- For operational and limited tropical cyclone storm conditions; and
- For omni-directional, easterly and westerly conditions.

STUDY METHODOLOGY

The methodology used for this study was as follows:

- A 2 year period (2008 to 2010) of continuous overlapping DWR and SAAB raw wave profile data, was chosen for operational analyses;
- Also, from the 4.8 year total period (2006 to 2011) of overlapping DWR and SAAB wave data, 12 tropical cyclone events were chosen for storm analysis;
- All individual logged raw wave profiles from the DWR and SAAB were visually inspected and QC'd;
- Similar data sampling schemes for the DWR and SAAB were chosen to allow for better data comparison.
- Spectral analysis was conducted on the QC'd DWR and SAAB wave profiles to produce total, sea and swell wave parameters for comparison;
- Correlation and ambient statistical analyses were conducted on the DWR and SAAB wave parameters;
- Results of the analyses were interpreted and conclusions were made.

SUMMARY OF CONCLUSIONS

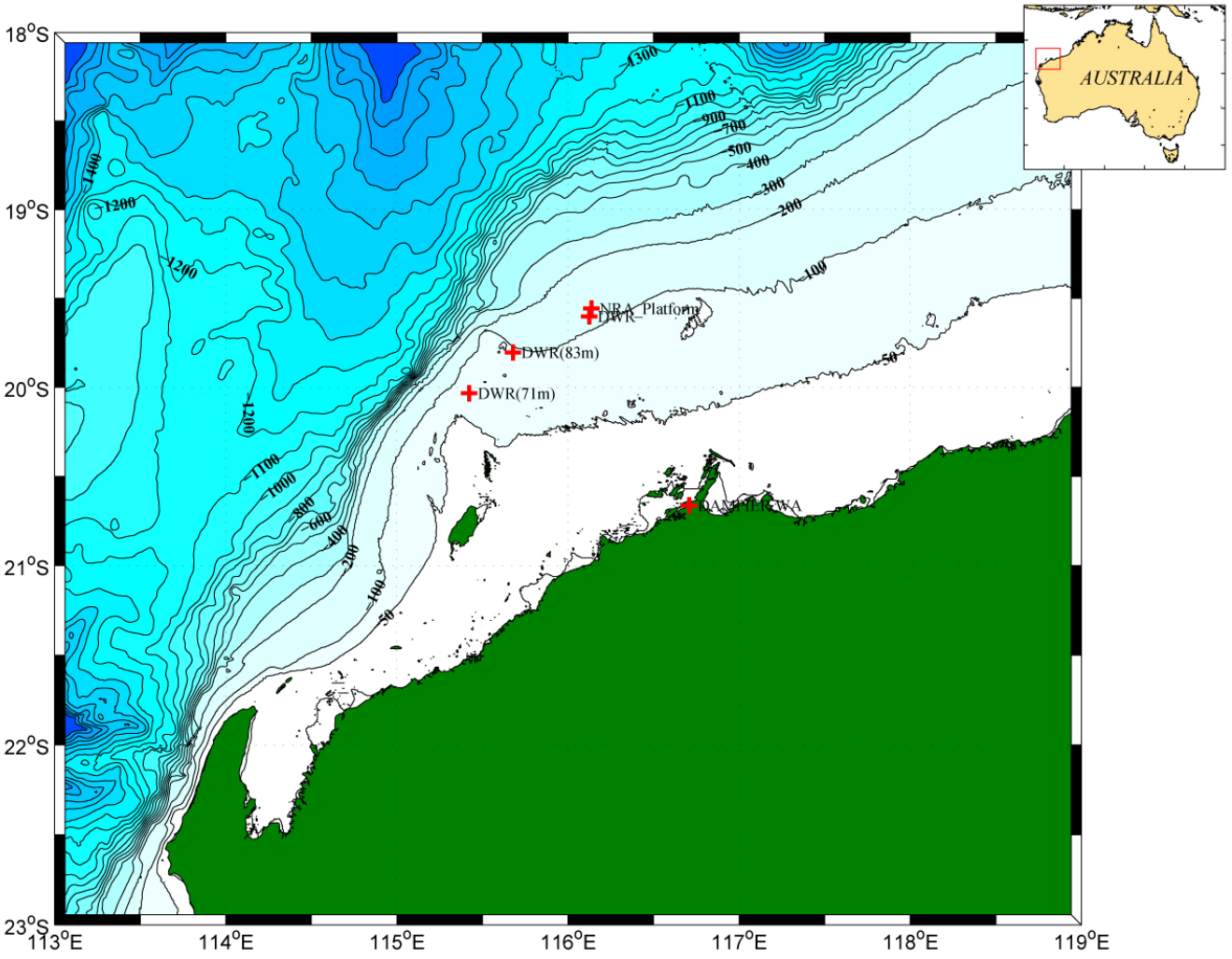
The following conclusions were reached as a result of this study:

- Compared to the DWR, the SAAB under estimates total and sea wave heights during both ambient and tropical cyclone storm conditions (from 4 to10%);
- SAAB under estimation increases as the wave heights increase;
- Worst at the peak of the 12 storms, with an average under estimation of ~16% (as much as 25% under the largest storm);
- Wave direction makes no significant difference to the comparison results, with correlation slopes typically within +/- 1%, for omni-directional, easterly and westerly waves;
- SAAB and DWR measured essentially the same for swell wave heights (slopes typically within 1%) under both ambient and storm conditions; and
- SAAB and DWR compared quite well for wave periods (slopes typically within +/- 4%).

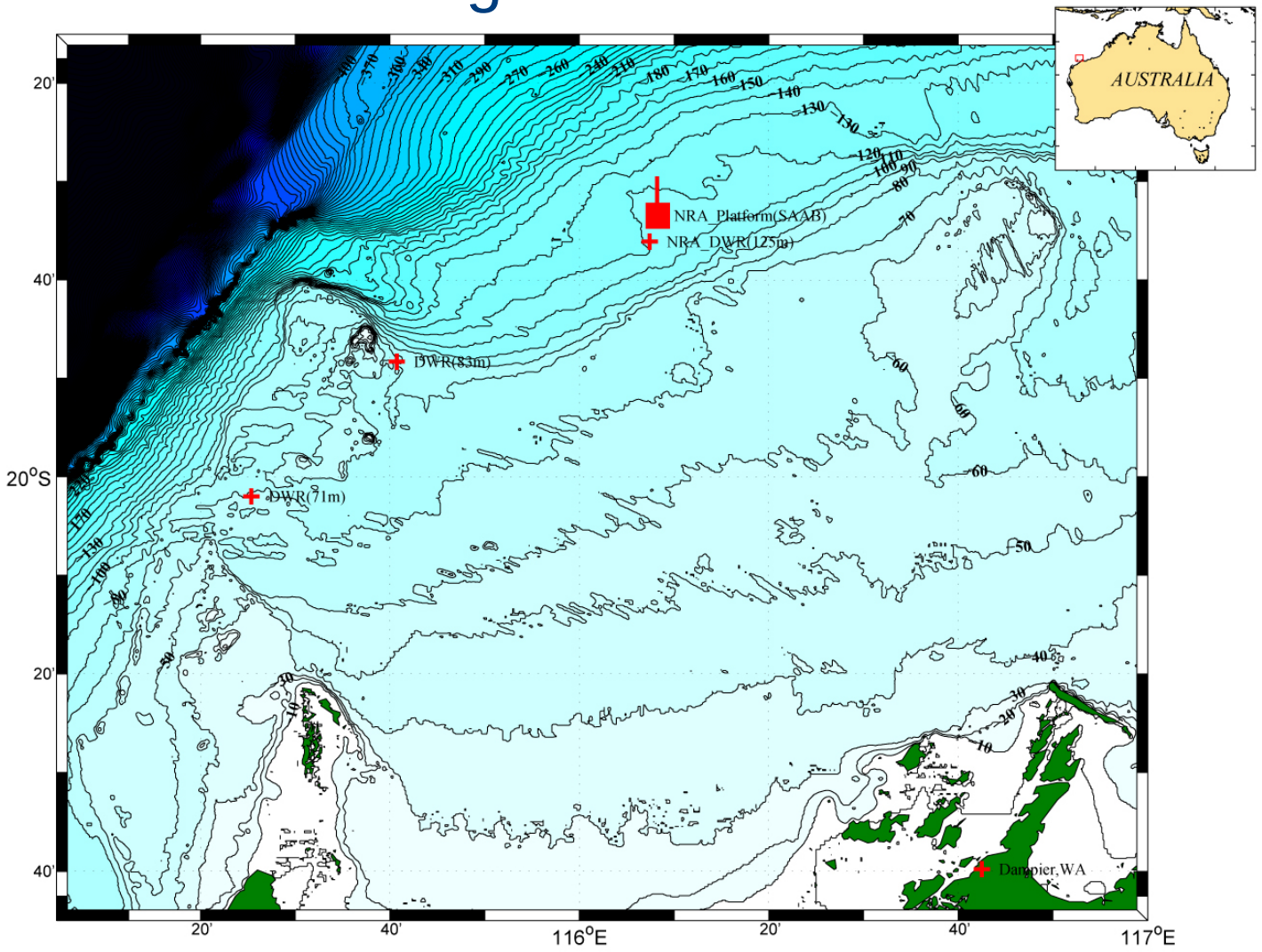
STUDY BACKGROUND

- A previous study, compared the NRA DWR (125 m) waves against another DWR (83 m) located about 50 km to the WSW;
- For the period of interest there was a gap in the NRA DWR wave data, so the NRA SAAB wave data was used to fill the gap;
- SAAB data had not previously been used for any wave analysis, so a brief comparison was conducted (with 2.5 months of data);
- It showed that the SAAB total waves were ~5% less than those measured by the nearby (<3 km away) DWR;
- Result was somewhat surprising, as from previous work we had found that:
  - Total waves from the NRA DWR (125 m) only differed by 5 to 6% from a DWR (83 m) ~50 km away and a second DWR (71 m) ~90 km away.

Study Area ~135 km Offshore Dampier, WA on the Southern North West Shelf



Wave measurement sites offshore, where total wave heights are within 5 - 6%

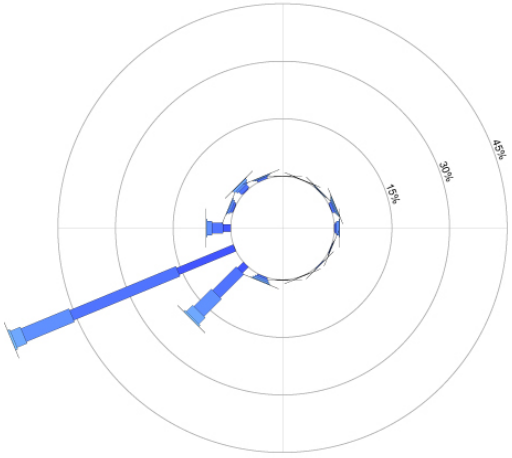


LOCAL WAVE CLIMATE AND CYCLONES

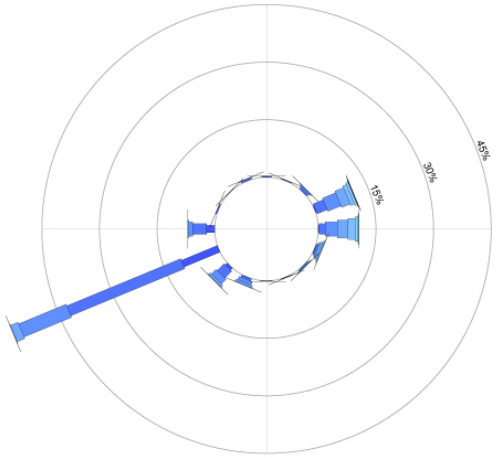
- Total seastate is strongly dominated by the long period WSW swell from the Southern Indian Ocean;
- Ambient seas alternate, approaching mostly from the WSW and SW in the summer (Sep to Mar) and from the WSW, ENE and E in the winter (Apr to Aug);
- Main swell direction is from the WSW throughout the year (~75%); with peak periods of 14 seconds or more occurring about 1/3rd of the time;
- Tropical cyclones (2 to 3 per season) occur in the months of Dec to Apr;
- Cyclones approach mostly from the N – E directions (~90%) and occasionally from the NW (~10%);
- Majority of tropical cyclone generated waves (~50%) will approach the NRA platform from a roughly NE direction.

DWR WAVE COMPASS ROSES

Total Wave Roses

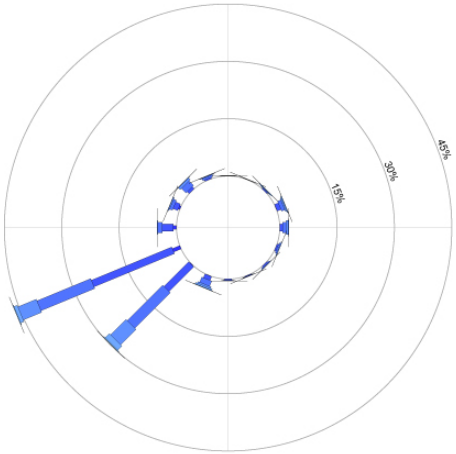


Summer
(Sep Oct Nov Dec Jan Feb Mar)

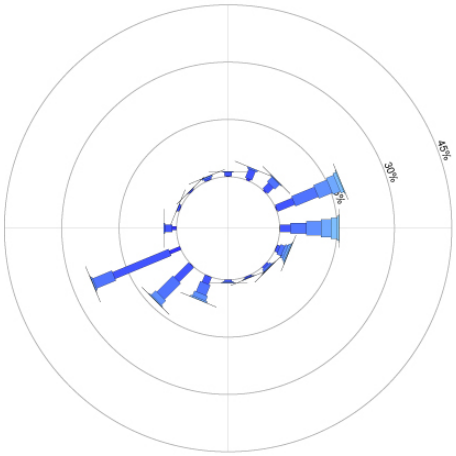


Winter
(Apr May Jun Jul Aug Sep)

Sea

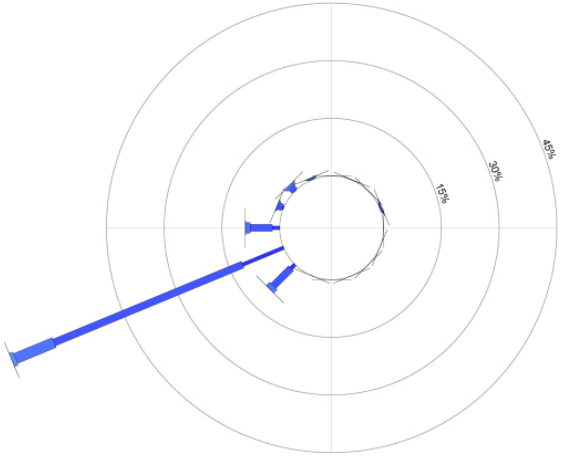


Summer
(Sep Oct Nov Dec Jan Feb Mar)

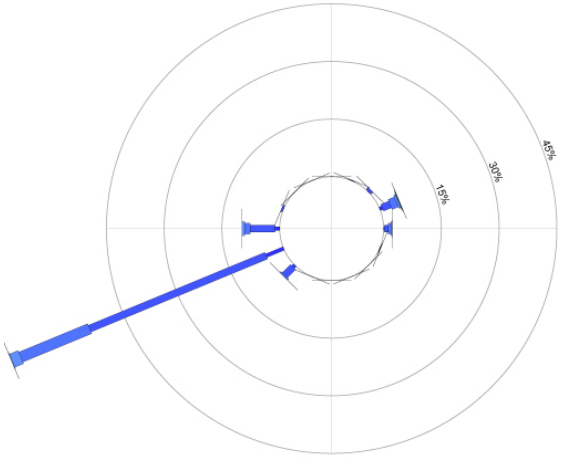


Winter
(Apr May Jun Jul Aug Sep)

Swell

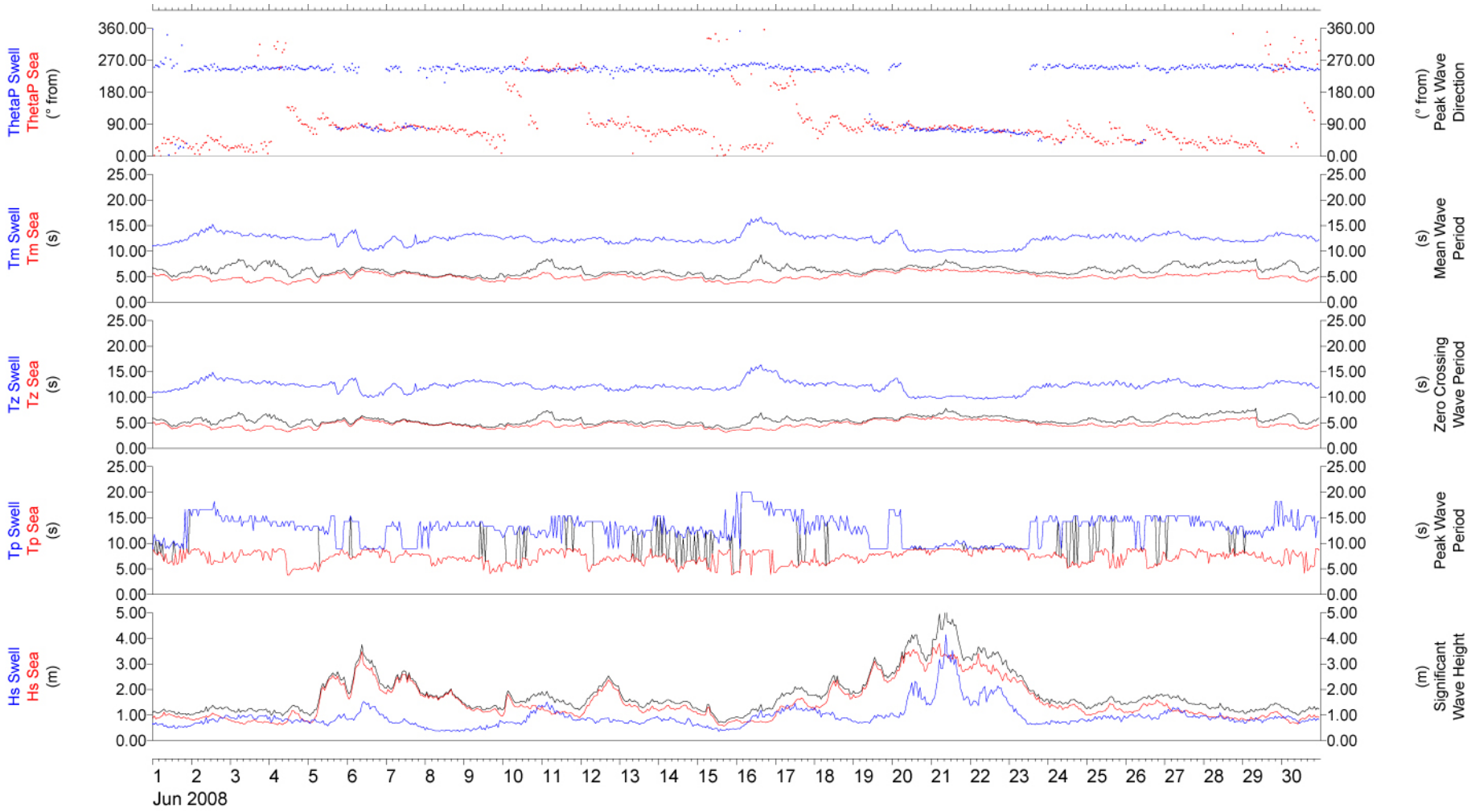


Summer
(Sep Oct Nov Dec Jan Feb Mar)

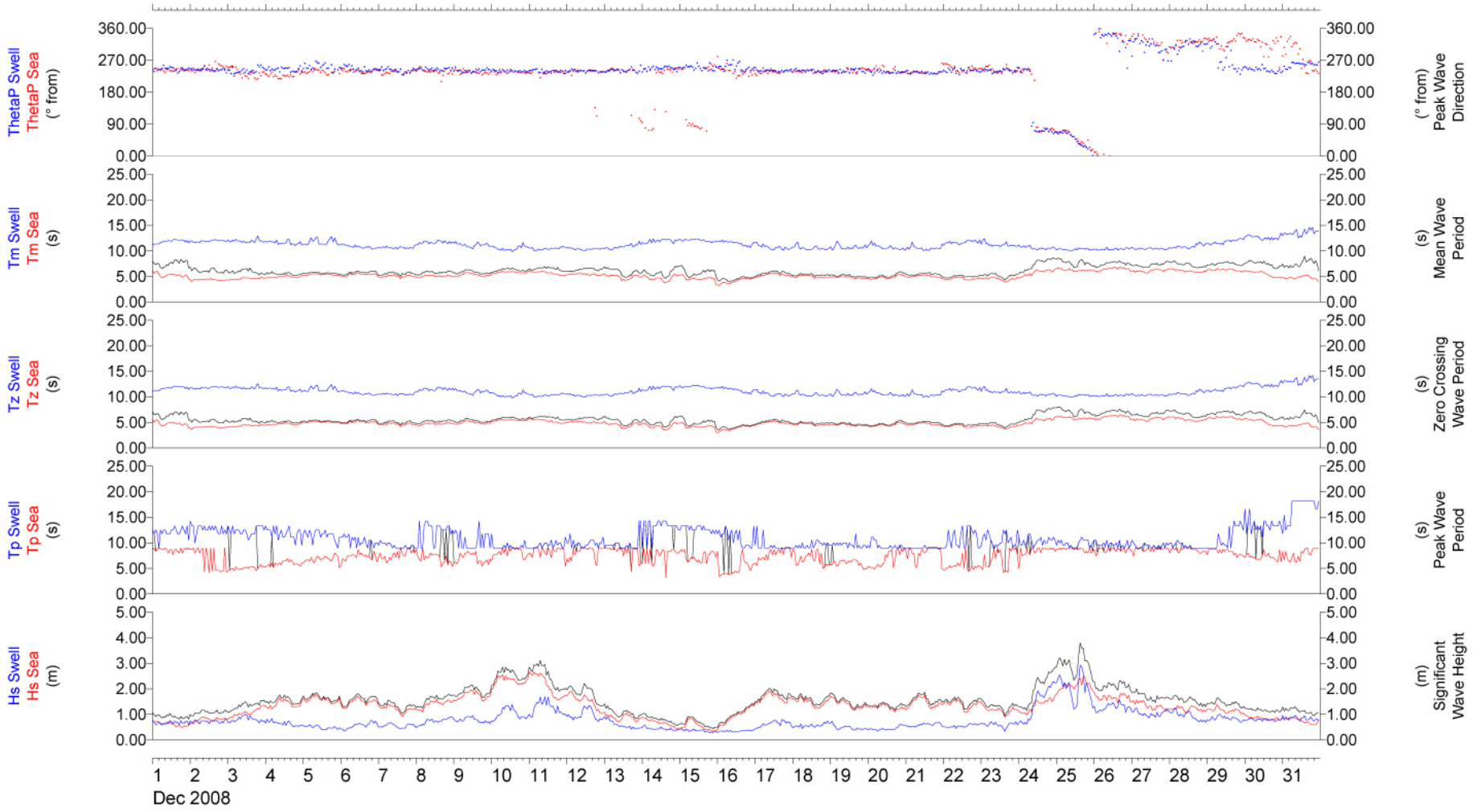


Winter
(Apr May Jun Jul Aug Sep)

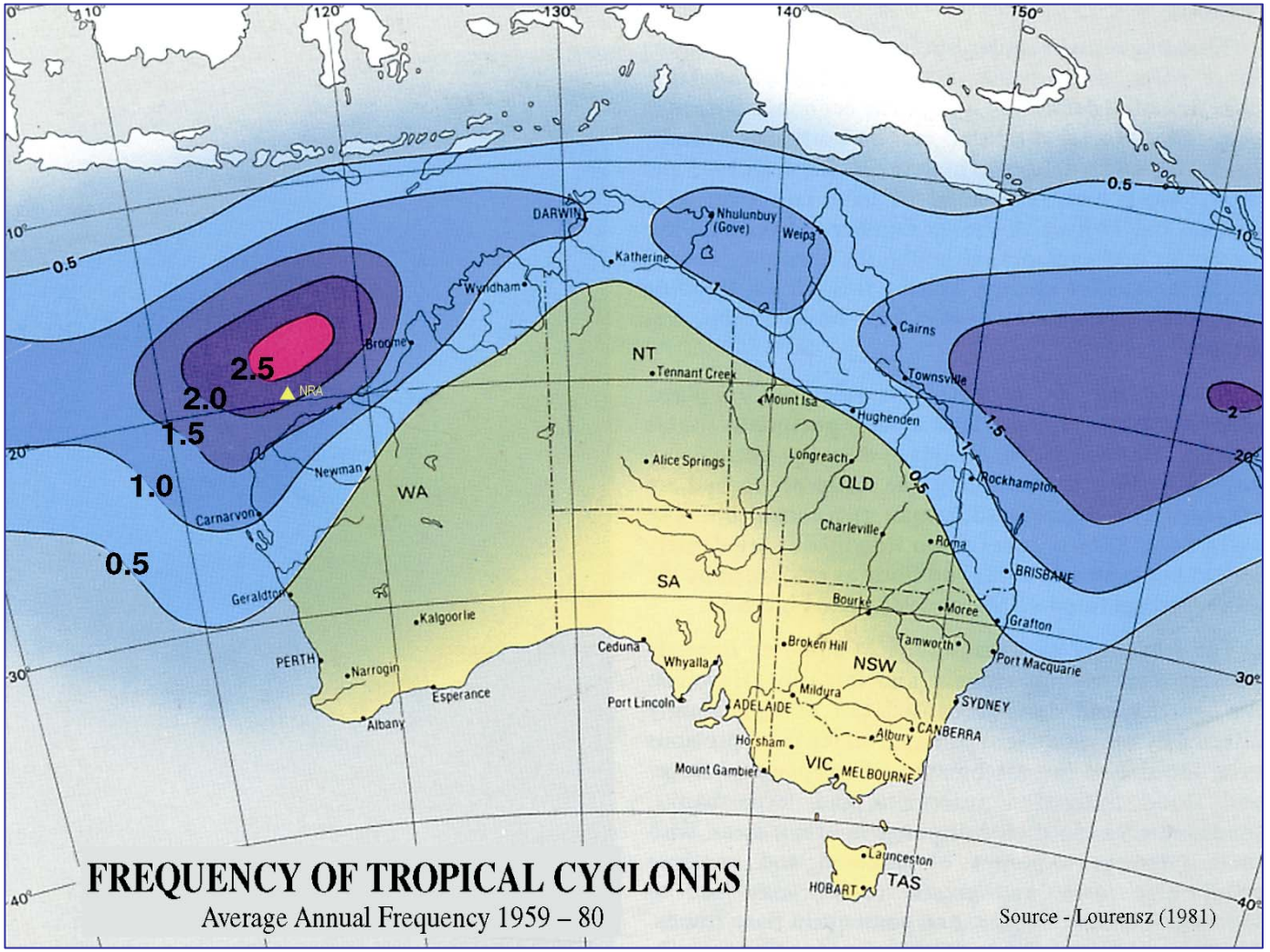
DWR monthly time history plot for June 2008, showing typical winter wave conditions (i.e. easterly seas and a west-southwest background swell)



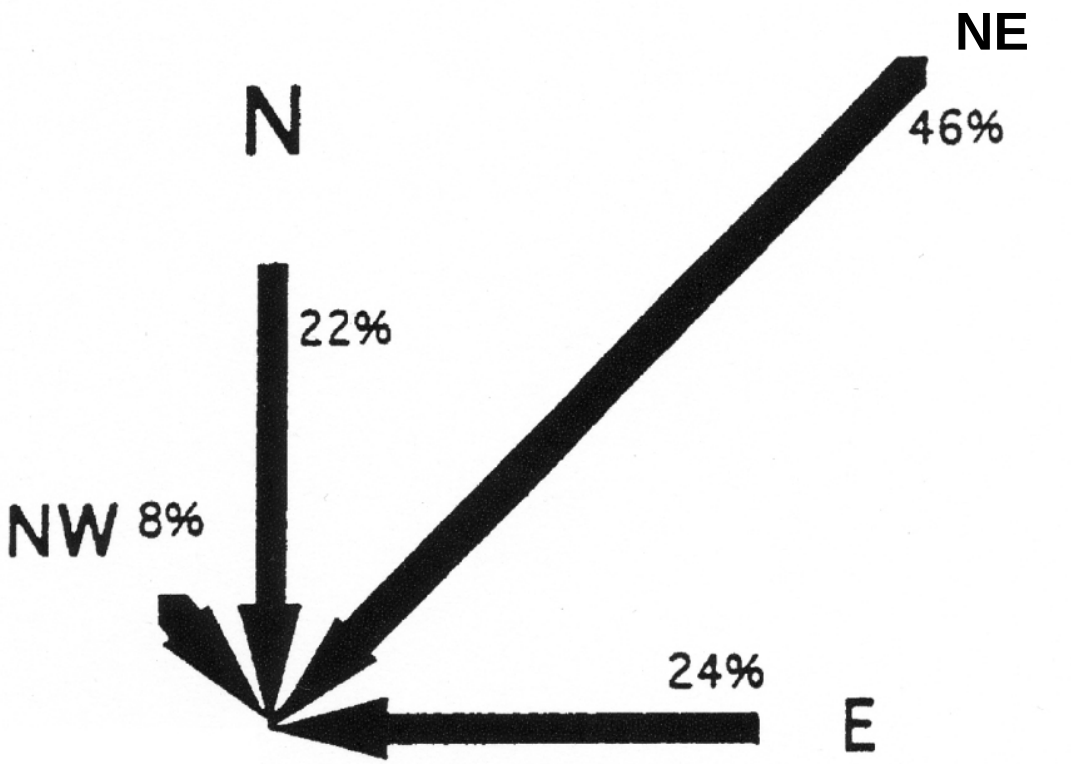
DWR monthly time history plot for December 2008, showing typical summer wave conditions (i.e. seas and swell from the west-southwest and a brief period of easterly waves due to a weak cyclone)



TC SPATIAL DISTRIBUTION



Tropical cyclone approach directions to the North Rankin Platform offshore study area



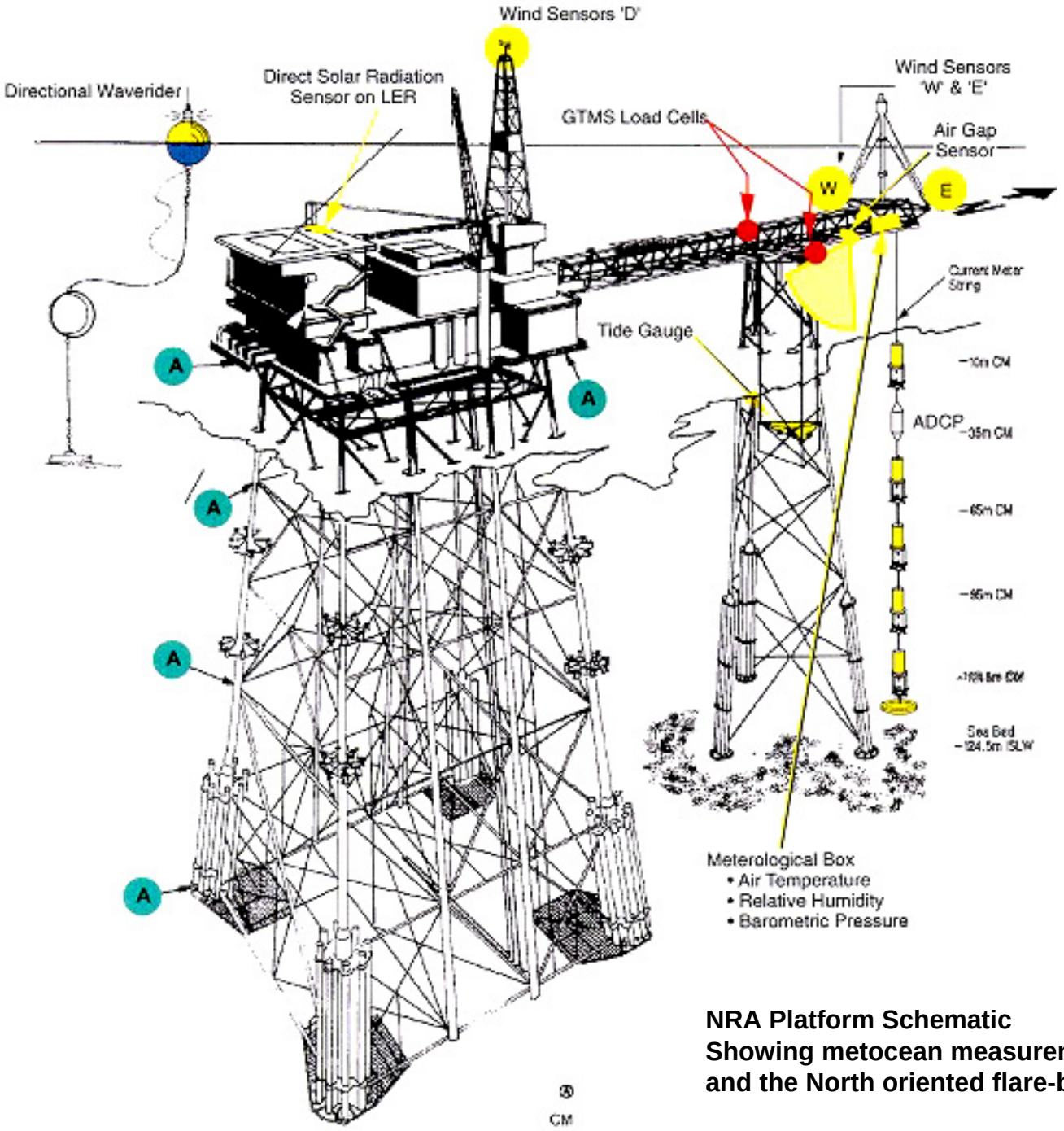
Zero storms approach from SE through to W

Notes: The above plot is based on 52 years of tropical cyclone track data over the tropical cyclone seasons November to April 1938/39 to 1990/91. It is based on 74 storms which passed within 200 km of NRA Platform. Approach direction is the direction from which the storm approached at its closest point to NRA

WAVE INSTRUMENTS

- DWR – a 0.9 m diameter heave, pitch and roll buoy with an internal data logger and Argos top hatch; deployed in 125 m water depth, ~3 km SW of the NRA Platform (and SAAB);
- SAAB – a downward-looking microwave radar, mounted underneath (at +26m AMSL) and several metres from the end of the North oriented ~183 m long flare-bridge on the NRA Platform;
- DWR and SAAB were supplied calibrated by manufacturers;
- DWR was also additionally calibrated prior to deployment in-house (i.e. rotated in a 2 m diameter wheel at periods of 5, 10, 15, 20 and 25 sec);
- DWR and SAAB had similar wave height resolution (0.01 m and 0.012 m, respectively);
- SAAB had a beam width of 10 degrees (at +26 m AMSL), which gave a surface coverage of ~4.6 m (diameter) and 2.4 sec was the shortest wave period resolvable (i.e. very similar to the DWR);

Datawell Directional Waverider Buoy and WaveRadar Rex



NRA Platform Schematic
Showing metocean measurements locations and the North oriented flare-bridge


SAAB is located about 3 m from the end of ~183 m long flare-bridge, about 26 m AMSL
SAAB

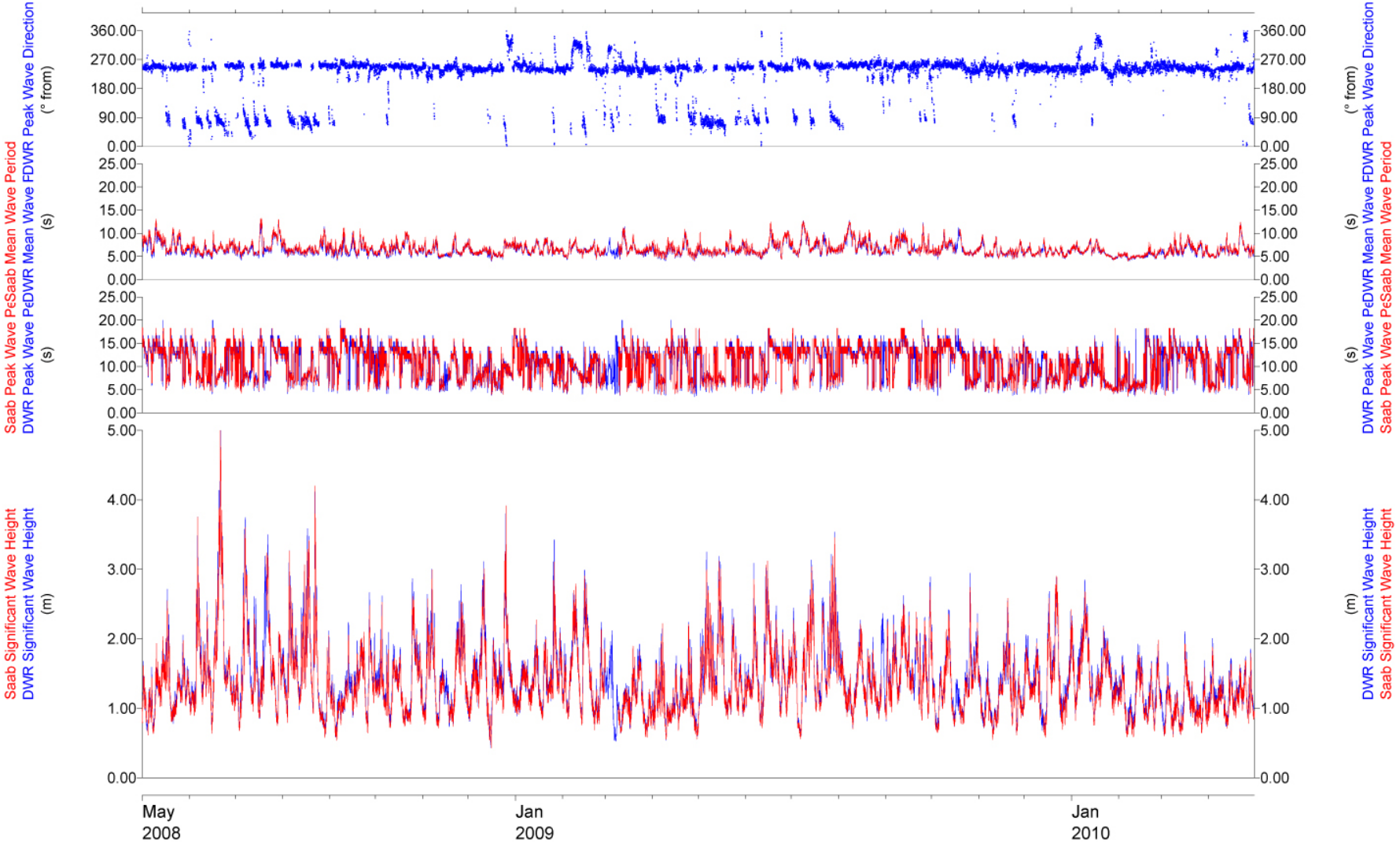
DATA PROCESSING, QC & SAMPLING SCHEMES

- All individual logged raw wave profiles from DWR and SAAB were visually inspected and QC'd using in-house software;
- DWR and SAAB QC'd wave profiles were then processed, to get the most similar data sampling schemes, for subsequent comparison/analysis;
  - » Original frequency bin widths for the DWR and SAAB were 0.005 Hz and ~0.008 Hz and final processed values used in this study were 0.005 Hz and ~0.004 Hz, respectively; and
  - » Original record intervals for the DWR and SAAB were 30 minutes and 20 minutes, respectively, and a 60 minute record interval was used in this study.

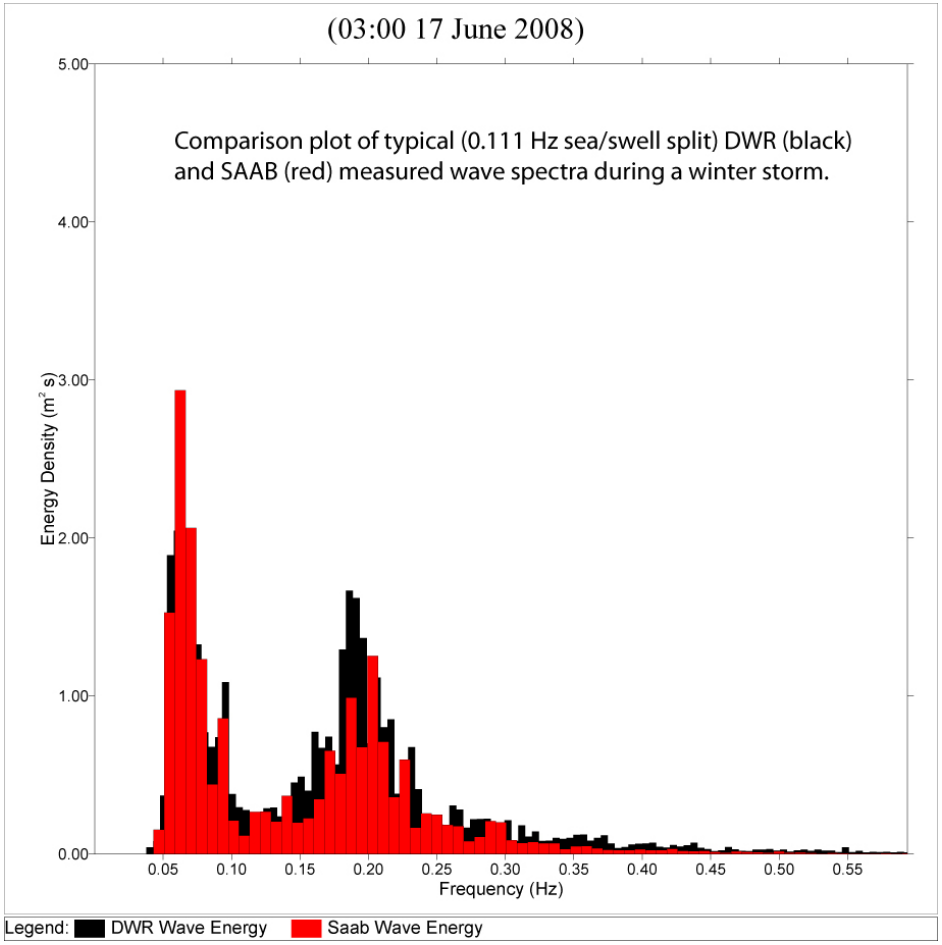
DATA ANALYSES

- DWR and SAAB QC'd wave profiles were spectrally analysed using a Fast Fourier transform technique.
- Resulted in the following parameters for total, sea and swell waves (Hs, T_p, T_m, T_z and $Theta_p$ for DWR only);
- A sea/swell separation frequency of 0.111 Hz (9 seconds) was selected from past review of numerous wave spectra;
- The 2 years of continuous wave data were also separated into easterly (1 to 179°) and westerly
(180 to 359°) data sets for analysis;
- From the 4.8 years of overlapping wave data, 12 tropical cyclone events were selected for some analysis;
  - They had peak wave heights ranging from ~3.5 to 8.0 m; and
  - They consisted of 3 to 6 days of data spanning the storm peaks.
- Correlation and ambient statistical analysis was conducted on the DWR and SAAB wave parameters:
  - Linear regression, with vertical least squares;
  - DWR was placed on the x-axis, because it was considered the benchmark wave instrument for the offshore industry and it was able to be additionally calibrated in-house; and
  - Ambient statistics produced included: min, mean, max, std dev and exceedence percentiles.

Overlay plot of measured DWR (blue) and SAAB (red) total wave data for the 2 year period May 2008 to May 2010



Typical Wave Spectra Plot
(with 0.111Hz or 9 sec Sea/Swell split)



RESULTS

For Ambient or Operational Waves (2008 to 2010)

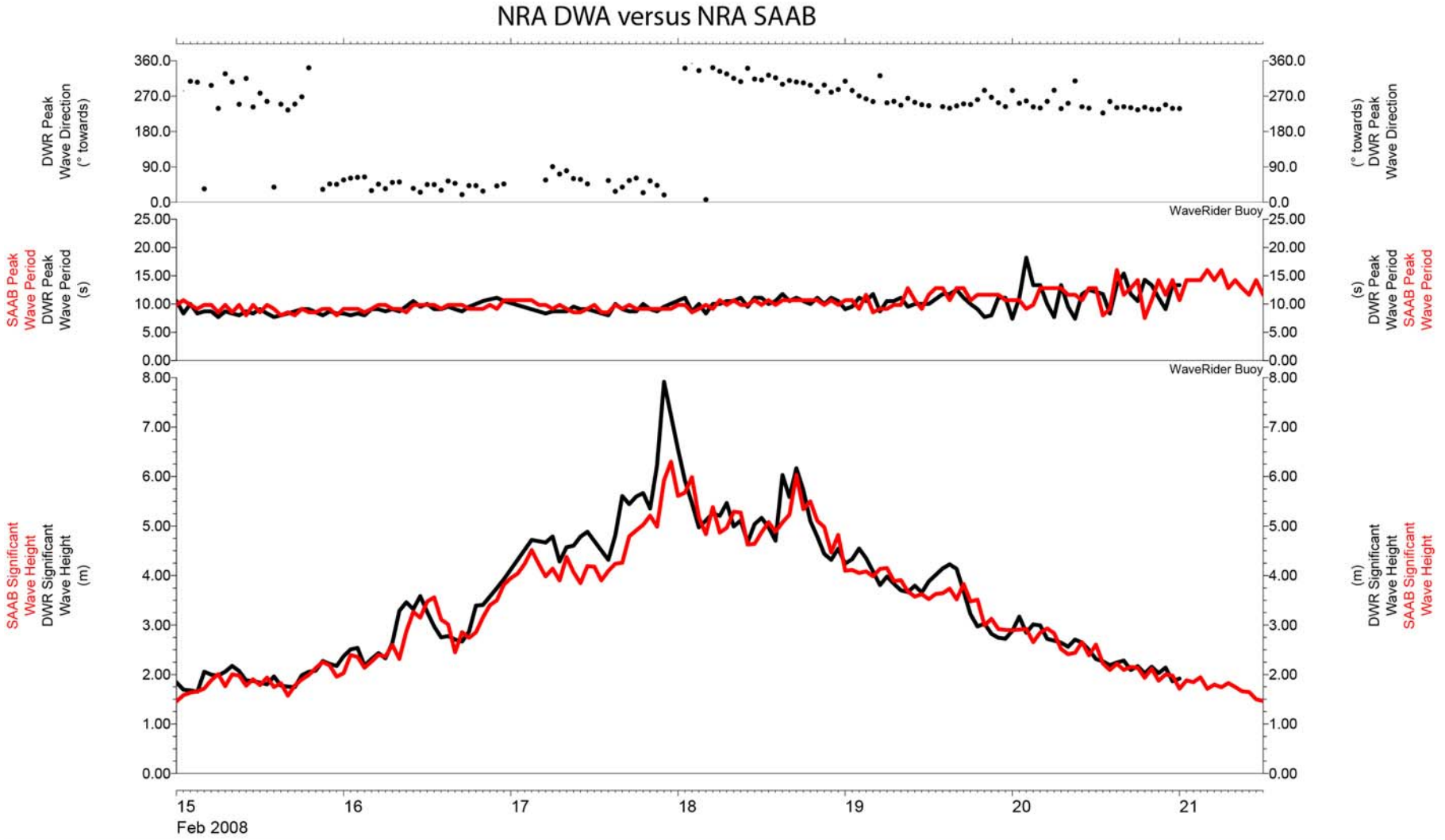
- Produced numerous correlation cross-plots for SAAB versus DWR for total, sea and swell wave heights and periods (mean and peak) for omni-directional, easterly and westerly cases using all ambient data and data when wave heights > 2 m;
- Produced ambient statistics for SAAB and DWR for omni-directional total, sea and swell wave heights and periods (mean, zero-crossing and peak);
- Produced summary tables of the correlation and statistical analysis results:
  - Correlation results included: number of data points used, correlation coefficients, slopes for line of best fit and standard deviations; and
  - Statistical results included: minimums, maximums, means, standard deviations, 20, 5 and 1 exceedence percentiles.

RESULTS (cont'd)

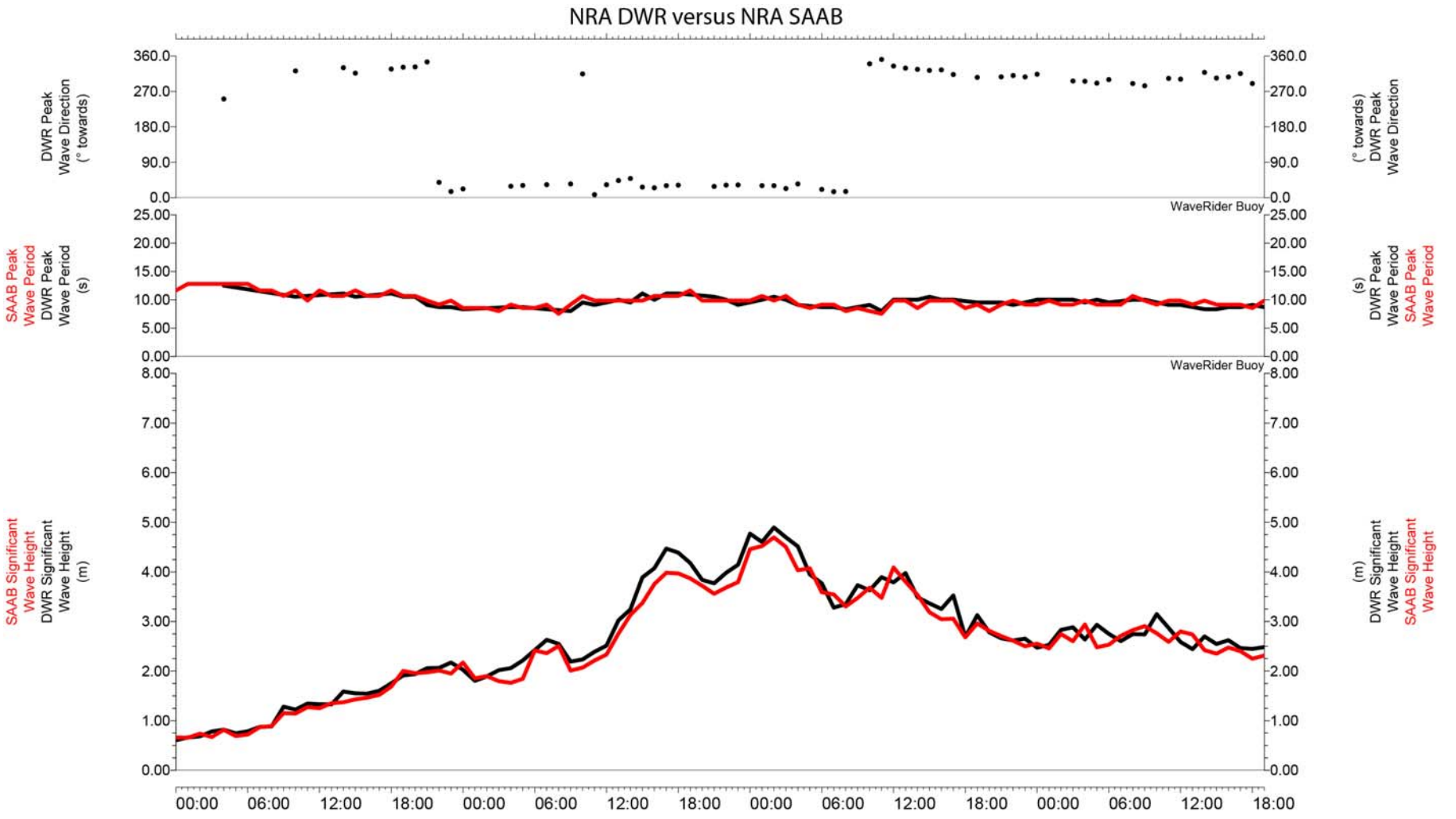
For 12 Tropical Cyclone Storm Wave Events (2006 to 2011)

- Produced numerous correlation cross-plots for SAAB versus DWR for total, sea and swell wave heights and periods (mean and peak) for omni-directional cases using all storm data (3 to 6 days per storm event) and data when wave heights > 4 m;
- Produced summary tables of the correlation analysis results:
  - » Correlation results included: number of data points used, correlation coefficients, slopes for line of best fit and standard deviations;
- Also found the maximum wave heights (total) measured at the peak of each storm by the SAAB and DWR and compared the results (averaged and individual for the 12 storms);

Tropical Cyclone Event expanded overlay plot



Tropical Cyclone Event expanded overlay plot



CONCLUDING REMARKS

- Compared to the DWR, the SAAB under estimates total and sea wave heights during both ambient and tropical cyclone storm conditions (from 4 to 10%);
- SAAB under estimation increases as the wave heights increase;
- Worst at the peak of the 12 storms (average under estimation of ~16%), and for the largest storm under estimation was ~25%;
- SAAB wave data is not considered suitable for extreme analysis purposes, but is usable for operational purposes;
- SAAB and DWR measured essentially the same for swell wave heights (slopes typically within 1%) under both ambient and storm conditions;
- SAAB and DWR compared quite well for wave periods (slopes typically within +/- 4%); and
- Wave direction makes no significant difference to the comparison results, with correlation slopes typically within +/- 1%, for omni-directional, easterly and westerly waves.

ACKNOWLEDGEMENTS

For permission to publish the measured DWR and SAAB wave data used in this presentation/study, Woodside Energy Limited, and their joint venture participants in the North West Shelf Venture, are gratefully acknowledged.