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1 Waders such as red knots *Calidris canutus* gather in large flocks in the Wadden Sea, where they forage on the intertidal mudflats;
 2 Knots use social information in the lab to find food¹, and learn the location of foraging patches by observing flock-mates²;
 3 Knots benefit from associations, but do they have 'friends' – persistent, non-random associations – within & between tidal intervals^{3,4}?

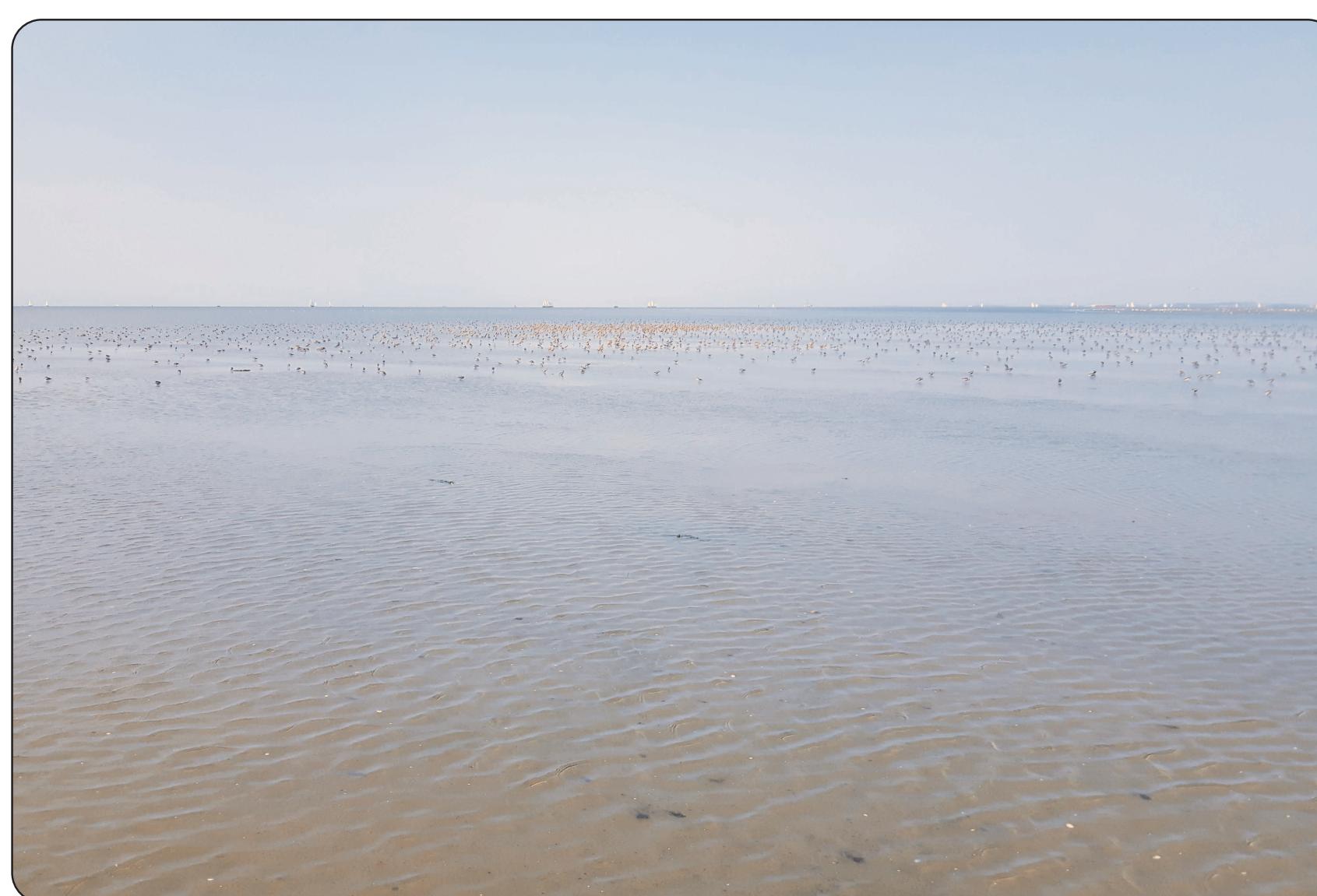


Fig. 1 Wadden Sea mudflats at low tide, with foraging waders

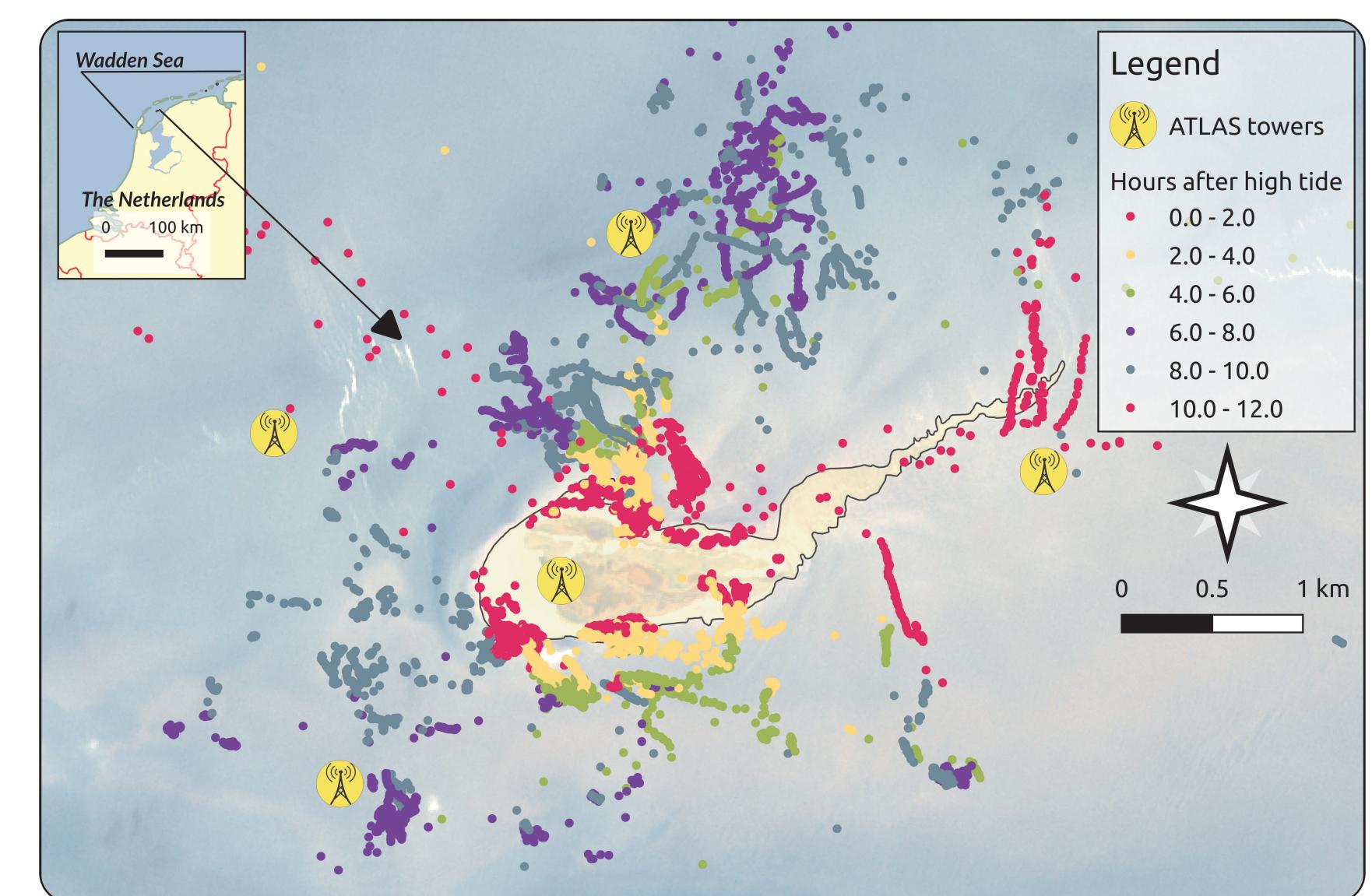


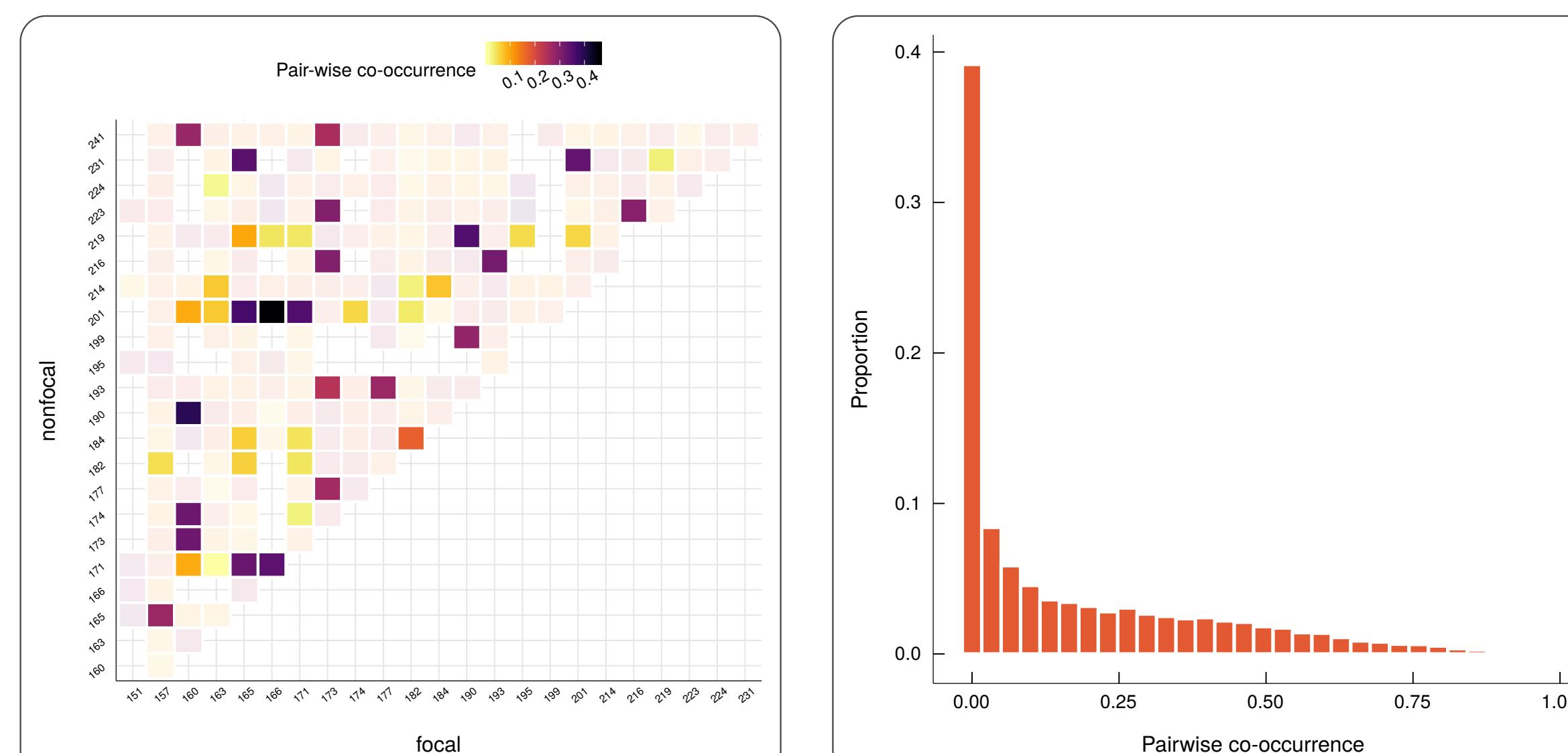
Fig. 2 Study area; ATLAS tower locations; knot positions coloured by hours after high tide.

We ask: Do knots have 'friends'?

METHODS

ATLAS tracking

Over a 19-day tracking period (23 Aug – 11 Sep 2017), we collected position data from 35 tagged knots. Tags (4.2 g, 1 Hz, aggregated over 1 minute) emit radio signals allowing the triangulation of position by an array of five ATLAS towers.



Tidal intervals

We determined tidal intervals (high tide to high tide) – 44 tidal intervals over 19 calendar days, and analysed each knot's positions and association with other knots between and within tidal intervals.



Courtesy Benjamin Gnepp COS-NIOZ

Knot association c_{ij}

We calculated the number of times that the positions of two individuals i and j were both known as n_{ij} and association between them as c_{ij} , the proportion of n_{ij} when the distance between i and j was ≤ 250 m;

c_{ij} varies from 0 (= the distance between the birds was always > 250 m) to 1 (= the distance was always ≤ 250 m);

We obtained one c_{ij} value per pair per tidal interval, for a maximum of 44 values per pair.

RESULTS

Association is skewed, 10% pairs are 'friends'

- 1 c_{ij} was strongly skewed (mean \pm SD = 0.14 ± 0.3);
- 2 ~80% pairwise c_{ij} distributions were not different from the overall c_{ij} distribution (Kolmogorov-Smirnov test);
- 3 10.5% of pairwise c_{ij} were higher than expected by chance; 10% were lower than expected by chance.

Knot associations are tidally forced

c_{ij} was highest during the receding tide (0 – 3 hours post high tide, 95% CI = 0.22 ± 0.008) and substantially lower in the advancing tide (10 – 12 hours post high tide, 95% CI = 0.12 ± 0.007) and around low tide (4 – 9 hours post high tide, 95% CI = 0.11 ± 0.005).

CONCLUSIONS

- 1 Most knots, like other waders^{3,4}, have no 'friends';
- 2 However, 20% of pairwise associations are different from random expectation – consistent behavioural differences may play a role;
- 3 Association tracks tidal water level, suggesting that wader density and association is largely a result of environmental, and not social, drivers.

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