Supplementary Information

Table S1: Datasets with selected central place events

Tag	*Species*	*Sex*	*Release Date*	*Length (mm)*	*Disk (mm)*	*Release Latitude*	*Release Longitude*	*Recapture Date*	*Recapture Latitude*	*Recapture Longitude*	*Days At Liberty*	*Displacement (km)*	*No of events*
A01775	Raja brachyura	F	2010-01-05	705	478	50.3679	-4.1734	2010-04-09	50.2734	-3.9342	91	19.99	4
A01840	Raja brachyura	M	2010-04-12	686	516	50.3008	-4.1165	2010-05-17	50.2549	-4.0656	33	6.26	2
A01846	Raja brachyura	M	2010-04-12	624	440	50.3008	-4.1165	2010-06-13	50.0353	-4.0457	60	29.99	5
A01852	Raja brachyura	F	2010-04-15	825	593	50.2601	-3.9339	2010-07-19	50.2558	-3.875	94	4.22	1
A05886	Raja brachyura	F	2010-04-15	600	419	50.2591	-4.0203	2010-07-30	50.3408	-4.2742	105	20.22	6
A05908	Raja brachyura	F	2010-06-09	832	596	50.33	-3.133333	2010-08-05	50.32144	-4.070748	55	66.63	7
A05927	Raja brachyura	F	2010-07-13	681	504	50.3175	-4.1332	2010-09-18	50.2565	-4.9307	65	57.13	2
A05950	Raja brachyura	F	2010-11-23	737	520	50.299	-4.1061	2012-10-10	50.1563	-3.8983	685	21.70	1
A05962	Raja brachyura	M	2010-11-23	760	539	50.299	-4.1061	2011-11-20	50.25	-3.575	360	38.18	28
A06014	Raja brachyura	F	2010-11-23	632	452	50.299	-4.1061	2011-01-25	--	--	61	--	4
B0357a	Raja brachyura	M	2012-01-11	722	520	50.334	-4.1635	2012-04-27	50.2513	-3.9037	101	20.65	2
A01711a	Raja clavata	F	2009-10-02	884	575	50.3318	-4.1672	2010-02-07	50.3281	-4.1912	117	1.75	3
A01735	Raja clavata	F	2009-09-04	840	574	50.3334	-4.1959	2009-12-05	50.328	-4.1843	89	1.02	46
A01736	Raja clavata	M	2009-09-08	520	352	50.3074	-4.2193	2010-09-17	50.2144	-4.2882	372	11.45	13
A01764	Raja clavata	F	2008-06-17	684	471	50.3231	-4.2411	2011-06-02	50.3118	-4.2522	1052	1.48	31
A01767	Raja clavata	F	2008-07-16	543	375	50.39	-4.2006	2010-06-04	50.3413	-4.1571	688	6.24	3
A01770	Raja clavata	F	2008-10-17	883	624	50.3128	-4.1322	2008-12-16	50.2689	-4.0654	41	6.82	12
A01770a	Raja clavata	M	2009-10-01	586	394	50.3365	-4.1563	2010-05-15	50.3296	-4.1923	225	2.68	2
A01773	Raja clavata	F	2009-11-05	834	568	50.3353	-4.1673	2010-05-23	50.3024	-4.1654	163	3.67	1
A05888	Raja clavata	F	2010-04-21	558	413	50.3402	-4.1614	2010-07-22	50.3413	-4.1571	89	0.33	26
A05895	Raja clavata	F	2011-02-08	815	585	50.2946	-4.1289	2011-05-15	50.25	-3.9167	94	15.89	1
A05959	Raja clavata	M	2010-11-01	840	508	50.3623	-4.1874	2011-03-27	50.3628	-4.1349	143	3.73	2
A05961	Raja clavata	F	2010-11-03	865	601	50.3621	-4.1905	2011-01-30	--	--	86	--	1
A05984	Raja clavata	M	2010-04-19	553	384	50.3485	-4.1537	2010-04-22	50.3413	-4.1571	0	0.84	4
A06001	Raja clavata	F	2010-06-09	534	376	50.3307	-4.1336	2010-07-25	--	--	44	--	15

Tag	*Species*	*Sex*	*Release Date*	*Length (mm)*	*Disk (mm)*	*Release Latitude*	*Release Longitude*	*Recapture Date*	*Recapture Latitude*	*Recapture Longitude*	*Days At Liberty*	*Displacement (km)*	*No of events*
A06009	Raja clavata	F	2010-08-12	566	390	50.2475	-3.991	2010-08-18	50.283	-4.1475	5	11.82	23
A06015	Raja clavata	F	2010-11-23	479	362	50.299	-4.1061	2011-02-11	50.225	-4.0583	78	8.91	47
B0324	Raja clavata	F	2012-05-23	818	590	50.2901	-4.2749	2012-07-10	50.3245	-4.2362	46	4.72	1
B0334	Raja clavata	M	2011-05-18	527	356	50.3619	-4.18	2011-12-29	--	--	223	--	15
B0336	Raja clavata	M	2011-05-18	709	472	50.3619	-4.18	2013-01-24	50.2872	-3.9227	615	20.09	1
B0340	Raja clavata	F	2011-05-19	728	512	50.3261	-4.254	2012-06-26	--	--	354	--	4
B0342	Raja clavata	F	2011-07-26	694	482	50.3083	-4.1823	2012-04-03	--	--	249	--	2
B0343	Raja clavata	F	2011-07-26	781	551	50.3083	-4.1823	2011-09-01	50.335	-4.245	34	5.36	10
B0344	Raja clavata	F	2011-07-26	728	508	50.3083	-4.1823	2012-04-28	--	--	274	--	13
B0345	Raja clavata	F	2011-07-26	862	587	50.3083	-4.1823	2012-04-24	--	--	270	--	5
B0347	Raja clavata	F	2011-07-26	835	552	50.3083	-4.1823	2012-03-31	50.3317	-4.2414	246	4.94	7
B0348	Raja clavata	F	2011-07-26	859	578	50.3083	-4.1823	2012-04-16	50.3373	-4.274	262	7.28	3
B0353	Raja clavata	M	2011-10-05	753	489	50.3627	-4.1782	2012-07-28	50.3702	-4.1319	280	3.39	2
B0355	Raja clavata	M	2011-10-05	622	432	50.3627	-4.1782	2012-07-28	50.3455	-4.153	280	2.62	1
B0387	Raja clavata	M	2012-03-21	592	408	50.3176	-4.1811	2012-06-01	50.3445	-4.2725	65	7.16	15
B0391	Raja clavata	M	2012-03-21	705	466	50.3176	-4.1811	2012-04-11	--	--	14	--	17
B0394	Raja clavata	M	2012-03-21	718	459	50.3176	-4.1811	2012-04-11	--	--	14	--	11
A01709	Raja microocellata	F	2009-06-24	851	611	50.2955	-4.1963	2010-05-24	50.2422	-4.0646	333	11.09	2
A01783	Raja microocellata	F	2010-01-14	621	454	50.3095	-4.1908	2010-04-28	50.3204	-4.241	102	3.76	12
A01786	Raja microocellata	F	2010-01-14	581	430	50.3095	-4.1908	2010-07-09	50.2632	-3.8983	174	21.44	18
A01787	Raja microocellata	F	2010-01-14	636	482	50.3095	-4.1908	2010-04-23	--	--	97	--	11
A01789	Raja microocellata	F	2010-01-14	661	498	50.3095	-4.1908	2010-04-29	50.0181	-4.9638	103	63.96	7
A01794	Raja microocellata	M	2010-01-14	650	464	50.3095	-4.1908	2010-08-02	50.3288	-4.2341	198	3.75	4
A01795	Raja microocellata	M	2010-01-14	737	504	50.3095	-4.1908	2010-04-10	50.3406	-4.1617	84	4.03	24
A01810	Raja microocellata	M	2010-02-18	774	518	50.3013	-4.1067	2010-05-26	--	--	90	--	23
A01811	Raja microocellata	F	2010-02-18	648	470	50.3013	-4.1067	2010-05-21	50.3413	-4.1571	85	5.71	7
A01813	Raja microocellata	M	2010-02-10	623	445	50.3013	-4.1067	2010-03-10	50.2742	-4.0652	13	4.22	5
A05967	Raja microocellata	F	2010-12-07	540	411	50.3098	-4.2104	2012-01-08	--	--	395	--	2
A05969	Raja microocellata	M	2011-01-18	800	546	50.3187	-4.133	2011-01-21	50.2931	-4.0417	1	7.09	1
A05970	Raja microocellata	M	2011-01-18	730	516	50.3187	-4.133	2011-09-01	--	--	224	--	15

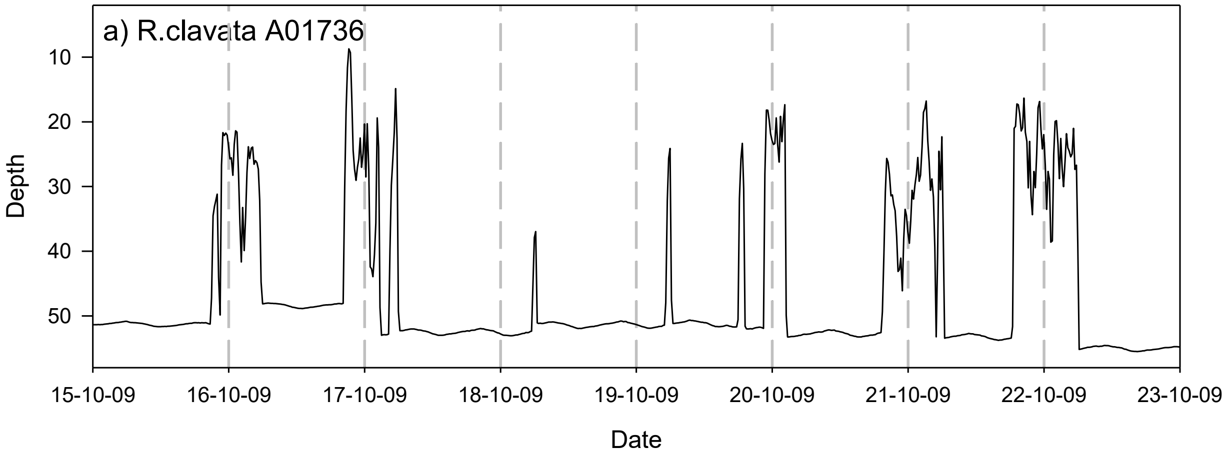
Tag	*Species*	*Sex*	*Release Date*	*Length (mm)*	*Disk (mm)*	*Release Latitude*	*Release Longitude*	*Recapture Date*	*Recapture Latitude*	*Recapture Longitude*	*Days At Liberty*	*Displacement (km)*	*No of events*
A05972	Raja microocellata	M	2011-01-18	697	491	50.3187	-4.133	2011-05-05	50.2627	-3.8832	105	18.83	6
A05982	Raja microocellata	F	2010-04-12	475	346	50.3008	-4.1165	2010-06-18	50.2458	-4.7875	65	48.13	43
A05984a	Raja microocellata	F	2010-05-06	516	384	50.316	-4.1721	2011-03-26	50.3504	-4.3167	322	10.97	15
A05990	Raja microocellata	M	2011-01-18	662	465	50.3187	-4.133	2011-08-02	50.3333	-4.2333	194	7.32	1
A06016	Raja microocellata	F	2010-12-07	536	382	50.3098	-4.2104	2011-07-11	50.3125	-4.5845	214	26.60	1
B0341	Raja microocellata	F	2011-07-14	610	452	50.3137	-4.1789	2011-07-27	50.3054	-4.4901	6	22.14	49
B0360	Raja microocellata	F	2012-01-11	562	417	50.334	-4.1635	2012-05-04	--	--	108	--	1
B0361	Raja microocellata	F	2012-01-11	617	452	50.334	-4.1635	2012-12-10	50.2669	-3.9026	328	20.00	3
B0373	Raja microocellata	M	2012-01-11	584	428	50.334	-4.1635	2013-02-23	50.2044	-3.7599	403	32.14	2
B0374	Raja microocellata	M	2012-01-11	616	442	50.334	-4.1635	2012-04-11	--	--	85	--	2
B0405a	Raja microocellata	M	2013-04-30	760	515	50.3175	-4.1861	2013-06-02	50.3588	-4.3231	17	10.76	2
A01797	Raja montagui	M	2010-01-14	675	437	50.3095	-4.1908	2011-04-26	50.3413	-4.276	465	7.01	1
A01805	Raja montagui	F	2010-01-28	708	479	50.2783	-4.7677	2010-03-08	50.2742	-4.0652	38	49.98	10
A01806	Raja montagui	F	2010-01-28	747	489	50.2783	-4.7677	2010-03-11	50.2753	-4.0322	41	52.33	8
A01837	Raja montagui	M	2010-04-07	666	406	50.302	-4.1567	2010-06-02	50.258	-3.9183	54	17.65	4
A01837a	Raja montagui	M	2010-06-02	667	408	50.2733	-3.935	2011-04-10	50.2617	-3.9167	304	1.84	2
A05883	Raja montagui	F	2010-04-15	690	462	50.2597	-4.0041	2010-07-08	50.2279	-4.066	83	5.65	5
A05887	Raja montagui	M	2010-04-15	654	411	50.2591	-4.0203	2011-04-04	--	--	353	--	1
A05928	Raja montagui	F	2010-07-13	645	431	50.3175	-4.1332	2012-04-29	50.253	-3.9037	654	17.83	6
A05983	Raja montagui	F	2010-04-15	552	360	50.2597	-4.0041	2011-01-20	50.026	-4.0624	279	26.34	7

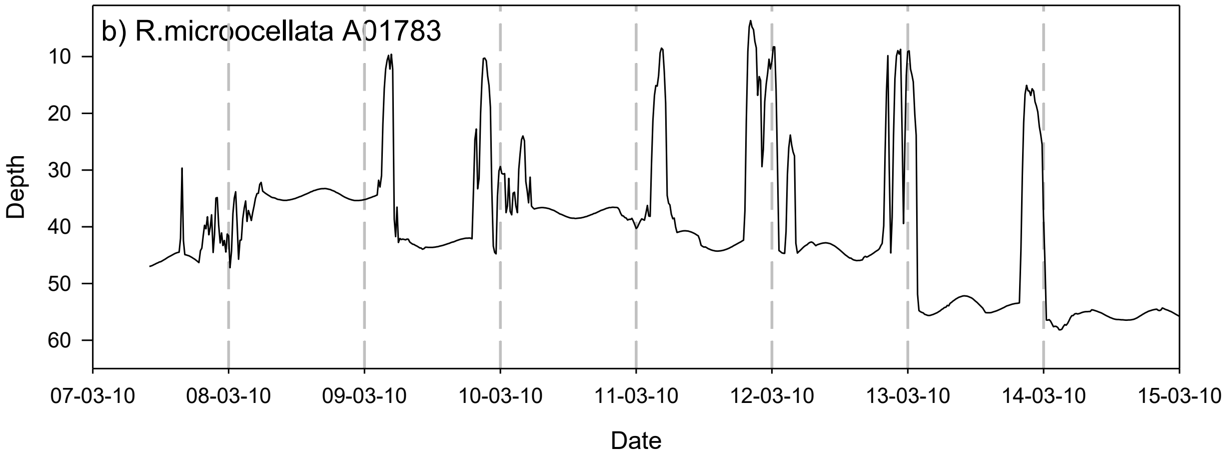
Table S2: Datasets without selected central place events

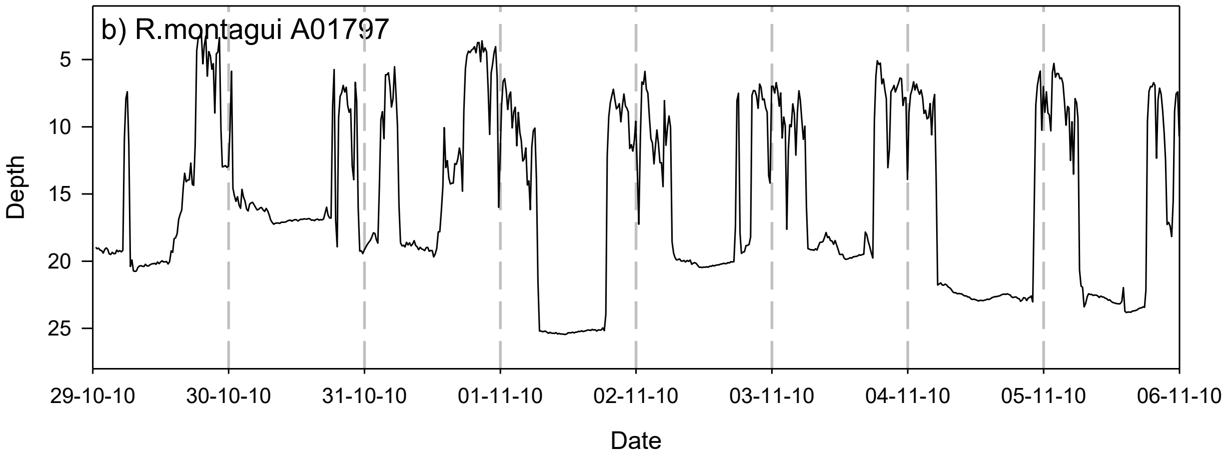
Tag	*Species*	*Sex*	*Release Date*	*Length (mm)*	*Disk (mm)*	*Release Latitude*	*Release Longitude*	*Recapture Date*	*Recapture Latitude*	*Recapture Longitude*	*Days At Liberty*	*Displacement (km)*
A05885	Raja brachyura	F	2010-04-15	621	448	50.2597	-4.0041	2010-04-25	50.2466	-4.0645	9	4.54
A01711	Raja clavata	F	2009-09-04	849	573	50.3334	-4.1959	2009-10-02	50.3338	-4.1897	25	0.00
A01772	Raja clavata	F	2006-10-14	875	584	50.3479	-4.1501	2010-05-07	50.3281	-4.1912	154	3.66

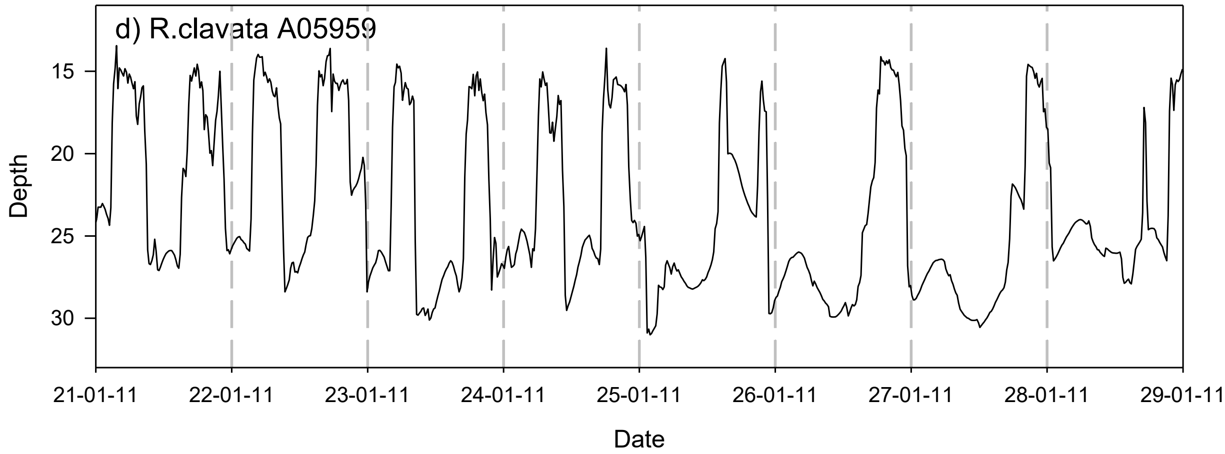
Tag	*Species*	*Sex*	*Release Date*	*Length (mm)*	*Disk (mm)*	*Release Latitude*	*Release Longitude*	*Recapture Date*	*Recapture Latitude*	*Recapture Longitude*	*Days At Liberty*	*Displacement (km)*
A01798	Raja clavata	F	2010-01-15	861	598	50.3292	-4.1655	2010-05-15	50.3296	-4.1923	114	1.91
A01799	Raja clavata	F	2010-01-15	865	604	50.3292	-4.1655	2010-02-11	--	--	21	--
A05952	Raja clavata	F	2010-10-06	830	596	50.3187	-4.1365	2011-01-26	--	--	110	--
A06000	Raja clavata	F	2010-06-09	558	410	50.3307	-4.1336	2010-07-25	--	--	44	--
A06026	Raja clavata	M	2010-11-03	494	345	50.3621	-4.1905	2010-12-16	--	--	41	--
B0357	Raja clavata	F	2011-10-05	736	511	50.3215	-4.1346	2011-12-21	--	--	13	--
B0374a	Raja clavata	F	2012-06-26	805	555	50.2987	-4.1868	2012-10-07	50.3259	-4.2368	96	4.67
B0385	Raja clavata	M	2012-03-21	709	469	50.3176	-4.1811	2012-04-28	--	--	31	--
B0386	Raja clavata	M	2012-03-21	709	478	50.3176	-4.1811	2012-05-08	--	--	41	--
B0389	Raja clavata	M	2012-03-21	810	495	50.3176	-4.1811	2012-04-02	--	--	5	--
A01866	Raja montagui	F	2010-04-15	635	442	50.2601	-3.9339	2010-06-02	50.258	-3.9183	47	1.13

Example DVM plots









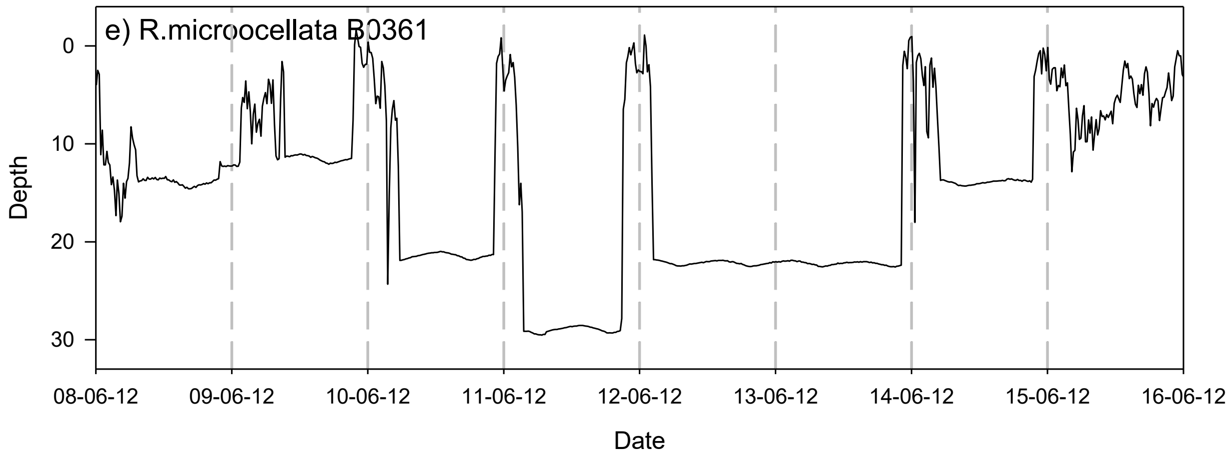


Figure S1: Example DVM plots

Supplementary analysis

Selection of events for analysis

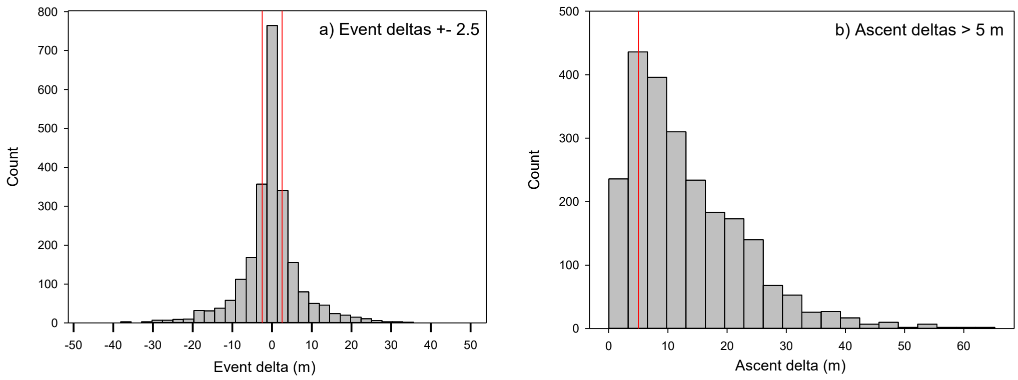


Figure S2: Histograms of event and ascent deltas

The histograms show the range of event (a) and ascent (b) deltas observed in the recorded events. Red lines indicate the cut off values for the events selected for analysis in this paper, where the vertical movement exceeds 5 m, yet the animal returns to within 2.5 m of the starting depth.

Software used to identify event times

To aid in the identification of DVM events, software was developed to display a depth time-series with the option of 1 in 10 under-sampling in order to fit more of the time-series on the display. A sequence of four mouse clicks was used to mark the four defining times of an event (event start, plateau start, plateau end, event end) as shown in the main text (figure 1). Once the final event time had been marked the four times were written to a table in Microsoft Access™ database. When all events for a time-series had been identified in this way the program then processed the non under-sampled time-series data to compute the range of metrics required for the analysis of the events: ascent/descent deltas (overall vertical displacements), speeds and durations; plateau delta, duration and activity (sum of and mean vertical displacements) and pre-event activity (activity in the hour prior to the event start). In addition a straightness index (SI) for each phase was calculated using L_0/L_1 where L_0 is the delta and L_1 is the sum of step lengths. The SI therefore gives a value in the range 0-1, where 1 represents a direct movement and lower values represent reduced straightness, or increased tortuosity.

Event frequency by length

Because of the tagging protocol employed, all individuals were mature and therefore the range of lengths was limited to between 475 and 884 mm. It was not possible therefore to investigate ontogenetic changes in the occurrence of DVM events. Within the range of lengths available no significant relationship was found between length and event frequency (Figure S3; *R. brachyura* r^2=0.04, p=0.53; *R. clavata* r^2=0.03, p=0.78; *R. microocellata* r^2=0.02, p=0.51; *R. montagui* r^2=0.05, p=0.56; SigmaPlot linear regression).

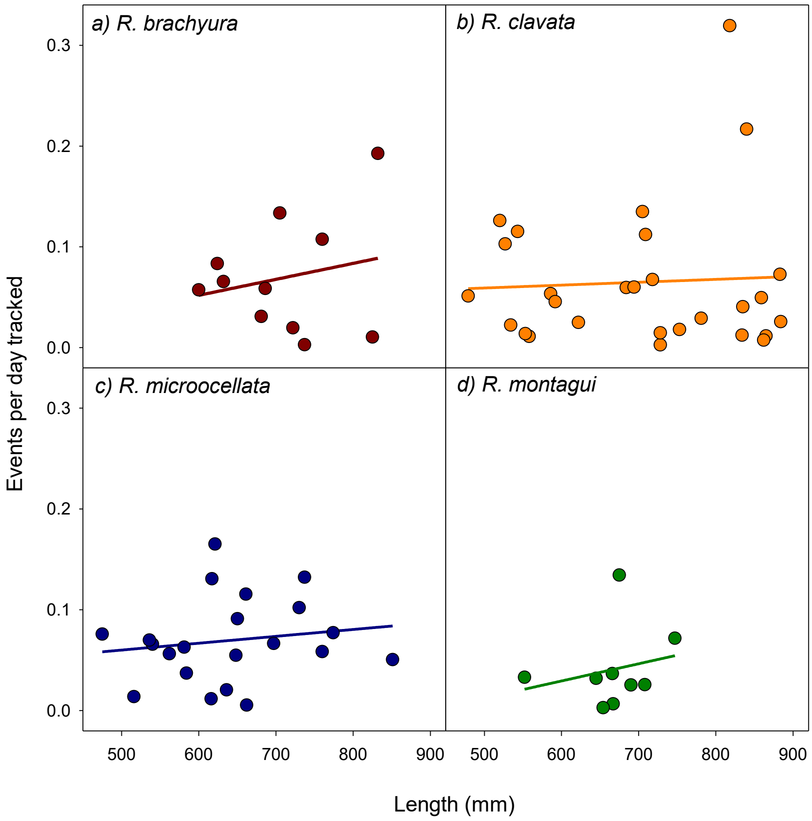


Figure S3: Length v event frequency

The sporadic nature of the observed DVM

The DVM events observed differ from the regular diel vertical migrations seen in many pelagic predators by being relatively infrequent and highly variable in nature. For this reason methods typically associated with the analysis of time-series were not considered appropriate. To support this assertion we performed a spectral analysis of our depth time-series data using FFT and then analysed the results to identify the 1 cycle per day peaks indicative of DVM behaviour. If the observed DVM represented a rhythmic behaviour then there should be a correlation between the amplitude of the 1 cycle/day spectral signal and the number of events observed. This was found not to be the case. The results are given in Table S3 and are shown as a scatter plot in Figure S4. Linear regression gives an r^2 value of only 0.127. Figure S5 shows example spectral plots and illustrates that the amplitude of the 1 cycle/day signal is not a consistent indicator of the number of DVM events found.

Table S3: Amplitude of FFT 1 cycle/day peak v no of events

The table shows, for each individual, the number of recorded events and the relative amplitude of the spectral peak at 1 cycle/day indicative of DVM behaviour. Where this amplitude is greater than 10% of the highest spectral peak in that track it is deemed to be a clear signal of DVM.

Species	*Track*	*No of events*	*Max peak fft*	*Clear DVM peak?*
Raja brachyura	A01775.nc	4	2.98%	
Raja brachyura	A01840.nc	2	5.74%	
Raja brachyura	A01846.nc	5	25.27%	Y
Raja brachyura	A01852.nc	1	4.56%	
Raja brachyura	A05886.nc	6	35.90%	Y
Raja brachyura	A05908.nc	7	32.15%	Y
Raja brachyura	A05927.nc	2	24.43%	Y
Raja brachyura	A05950.nc	1	3.31%	
Raja brachyura	A05962.nc	28	100.00%	Y
Raja brachyura	A06014.nc	4	13.27%	Y
Raja brachyura	B0357a.nc	2	3.54%	
Raja clavata	A01711a.nc	3	19.08%	Y
Raja clavata	A01736.nc	46	13.91%	Y
Raja clavata	A01764.nc	13	43.92%	Y
Raja clavata	A01767.nc	31	19.23%	Y
Raja clavata	A01770.nc	3	16.86%	Y
Raja clavata	A01770a.nc	12	26.27%	Y
Raja clavata	A01773.nc	2	100.00%	Y
Raja clavata	A05888.nc	1	100.00%	Y
Raja clavata	A05959.nc	26	19.41%	Y
Raja clavata	A05961.nc	1	30.57%	Y
Raja clavata	A05984.nc	2	92.28%	Y
Raja clavata	A06001.nc	1	7.61%	
Raja clavata	A06015.nc	4	3.60%	
Raja clavata	B0324.nc	15	100.00%	Y
Raja clavata	B0334.nc	23	100.00%	Y
Raja clavata	B0336.nc	47	100.00%	Y
Raja clavata	B0340.nc	1	4.51%	
Raja clavata	B0342.nc	15	39.74%	Y
Raja clavata	B0343.nc	1	27.36%	Y
Raja clavata	B0344.nc	4	29.69%	Y
Raja clavata	B0345.nc	2	5.26%	
Raja clavata	B0347.nc	10	9.30%	
Raja clavata	B0348.nc	13	100.00%	Y
Raja clavata	B0353.nc	5	100.00%	Y
Raja clavata	B0355.nc	7	23.08%	Y
Raja clavata	B0387.nc	3	100.00%	Y
Raja clavata	B0391.nc	2	27.02%	Y
Raja clavata	B0394.nc	1	1.55%	
Raja microocellata	A01709.nc	15	33.58%	Y
Raja microocellata	A01783.nc	17	75.25%	Y
Raja microocellata	A01786.nc	11	15.75%	Y
Raja microocellata	A01787.nc	2	10.08%	Y
Raja microocellata	A01789.nc	12	43.48%	Y
Raja microocellata	A01794.nc	18	49.93%	Y

Species	*Track*	*No of events*	*Max peak fft*	*Clear DVM peak?*
Raja microocellata	A01795.nc	11	38.97%	Y
Raja microocellata	A01810.nc	7	5.50%	
Raja microocellata	A01811.nc	4	29.33%	Y
Raja microocellata	A05967.nc	24	47.76%	Y
Raja microocellata	A05970.nc	23	30.95%	Y
Raja microocellata	A05972.nc	7	10.43%	Y
Raja microocellata	A05982.nc	5	100.00%	Y
Raja microocellata	A05984a.nc	2	92.00%	Y
Raja microocellata	A05990.nc	1	27.02%	Y
Raja microocellata	A06016.nc	15	74.14%	Y
Raja microocellata	B0360.nc	6	25.12%	Y
Raja microocellata	B0361.nc	43	52.01%	Y
Raja microocellata	B0373.nc	15	100.00%	Y
Raja microocellata	B0374.nc	1	7.72%	
Raja microocellata	B0405a.nc	1	1.56%	
Raja montagui	A01797.nc	49	100.00%	Y
Raja montagui	A01805.nc	1	4.27%	
Raja montagui	A01806.nc	3	4.03%	
Raja montagui	A01837.nc	2	4.45%	
Raja montagui	A01837a.nc	2	2.13%	
Raja montagui	A05883.nc	2	2.23%	
Raja montagui	A05887.nc	1	4.18%	
Raja montagui	A05928.nc	10	3.28%	
Raja montagui	A05983.nc	8	91.35%	Y
Raja montagui	A05983.nc	8	70.52%	Y

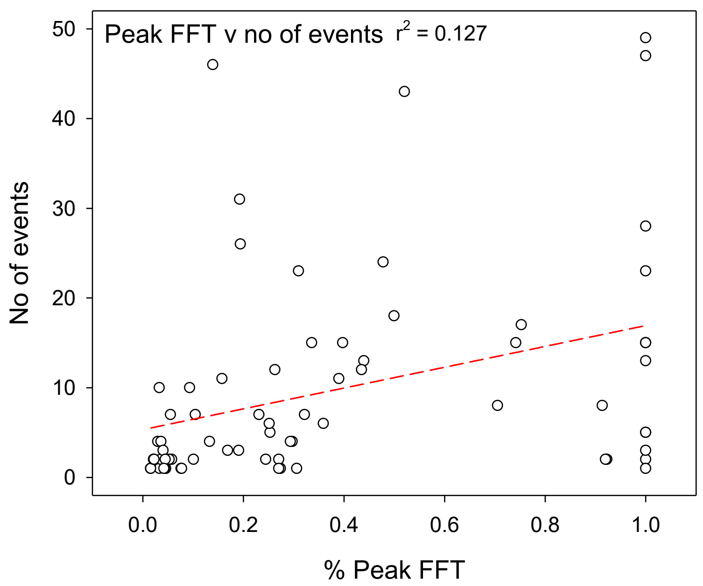


Figure S4: Amplitude of 1 cycle/day spectral signal v no of observed events

The amplitude of the 1 cycle/day spectral signal is not significantly correlated with the number of observed DVM events, as would be expected if DVM evets were consistent.

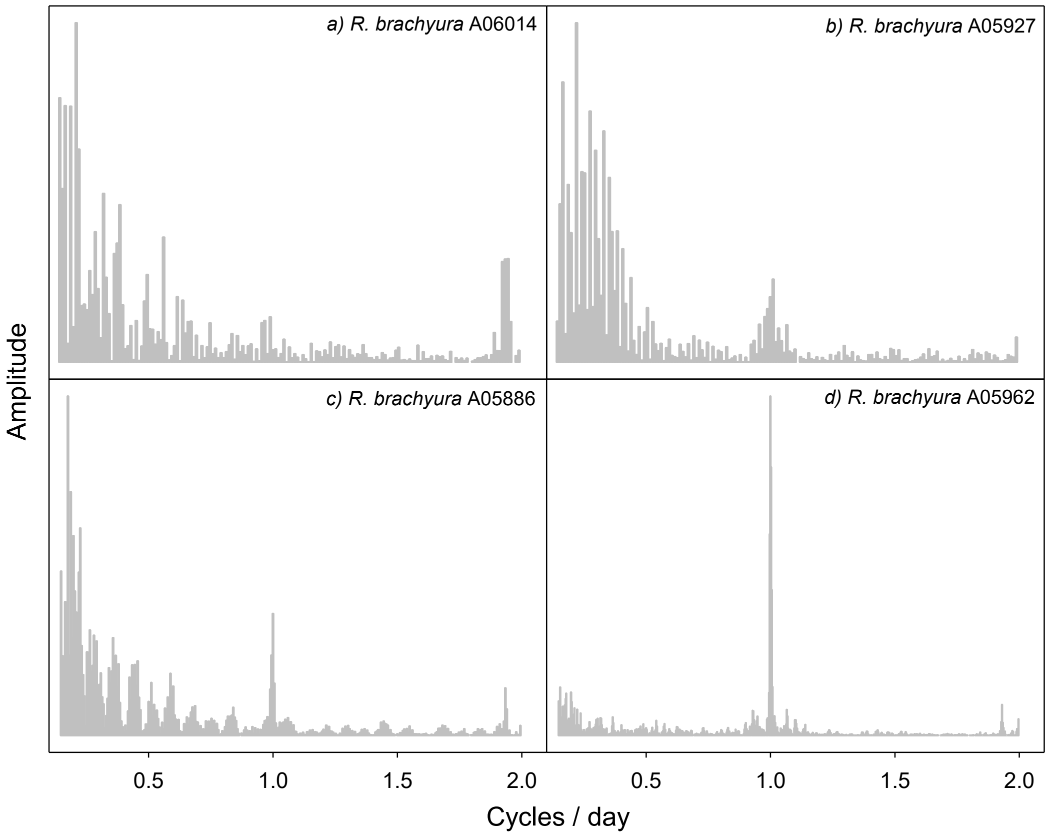


Figure S5 Example spectral plots

These plots show the spectral analysis of four tracks and illustrate an increasing component of a 1 cycle / day signal. The amplitude of this signal is not well correlated with the number of DVM events found. In this case, although d) has the largest number of events (28) a) has more events (4) than b) (2).

Continuous wavelet analysis

A further possibility for the analysis of regular events in time-series data is wavelet analysis (e.g. Giacalone et al. 2015, Zhang et al. 2017). While the Fourier Transform transforms a time-series from the time domain to the frequency domain, to produce a frequency / amplitude (or spectral) plot, a wavelet transform transforms a time-series into a time / frequency plot. Wavelet analysis can therefore be used to investigate how the frequency composition of a time-series changes over time. In particular, wavelet transforms are useful in the study of non-stationary waveforms, where the amplitude of the component frequencies varies over time, as is often the case with complex biological signals. To determine its usefulness here, a sample track (*R. brachyura* A05962) was first interpolated from 20 s and 2 minute intervals to 5 minute intervals. The R package *WaveletComp* (Roesch and Schmidbauer 2014) was used to analyse the interpolated time-series using the command:

```
w = analyze.wavelet(mydata, "mydata.Depth",loess.span=0,dt=1,
       dj=1/32,lowerPeriod=32,upperPeriod=2048,make.pval = T, n.sim = 10)
```

The period parameters set the lower frequency bound to 2.66 h and the upper to 170 h, to ensure that frequencies of 0.5 to 1 cycle per day are adequately captured ((32*5)/60 mins and (2048*5)/60 mins). The results of the analysis are shown in a wavelet power spectrum (Figure S6) and it can be seen that there are a group of peaks of 1 cycle per day activity from approximately mid-April to late July. Earlier in the year there is a series of peaks of activity with a period of approximately 144, equivalent to 2 cycles per day, which indicate the tidal cycle. The average wavelet power, which shows the summarised amplitude of each frequency, shows a clear peak at a period of 288, with a smaller peak at approximately 144; these peaks correspond to 1 cycle/day (DVM) and ~2 cycles/day (tidal) signals respectively Figure S7. The plotted depth time series in Figure S6 matches well with the occurrence of peals in the wavelet power spectrum.

However, while the analysis does confirm that 1 cycle/day activity is occurring and shows the time of year when this is most common, and does identify when DVM is more likely, the output is largely descriptive and is not capable of providing the rich quantative data that the manual approach of marking the events individually yields. Therefore, whilst the manual method employed here to identify DVM events is laborious it does provide detailed information relating to the times and distances involved in every DVM event, which wavelet analysis cannot provide.

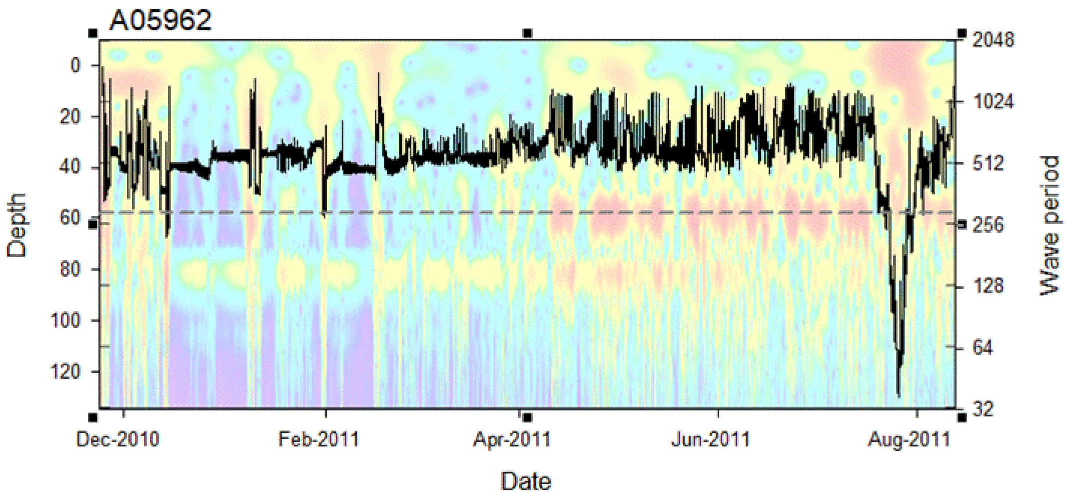


Figure S6: Wavelet analysis of *R. brachyura* A05962

The plot shows the depth time-series for A05962 (interpolated to 5 minutes) overlaid on the wavelet power spectrum. The grey dashed horizontal line is at a period of 288 (1 cycle per day) and represent the frequency of DVM events.

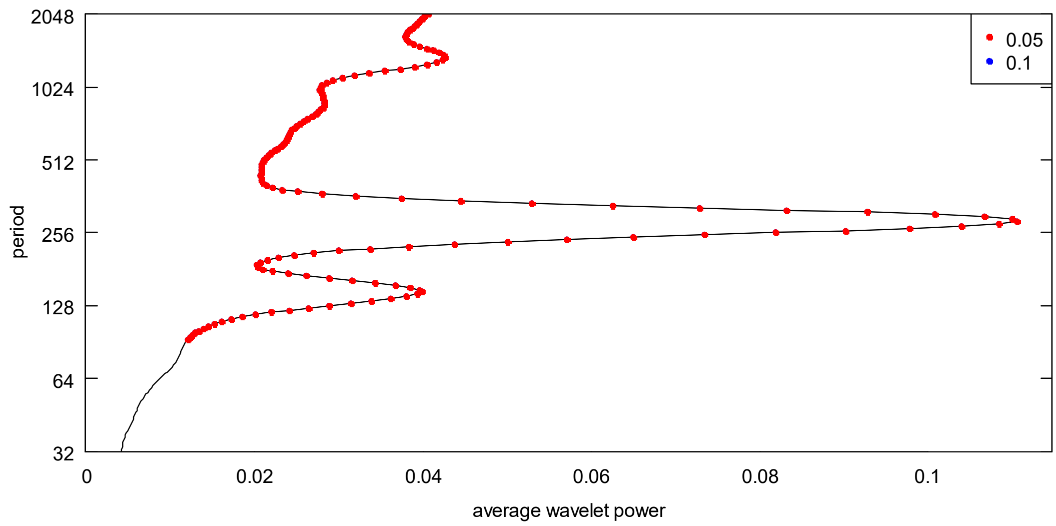


Figure S7: Average power plot

The plot shows a clear peak at a period of approximately 288, the signal of DVM.

Natural habitat heterogeneity

The area where tagged animals were tracked comprises a heterogeneous mosaic of habitats when characterised in terms of water depth, substratum type, water column environmental gradients and temporal scales of fluctuations in those gradients. The study area was located in the coastal waters of the western English Channel, from the city of Plymouth foreshore to approximately 40 km offshore, and spanning from Dodman Point (southeast Cornwall) in the west to Torbay (south Devon) in the east (see Figure S8). Water depth generally increases with distance from the shore, to a maximum depth of 76.5 m approximately 38 km due south of Par Sands (SE Cornwall), although the seabed shelves to 60 m more steeply in the eastern part of the study area (south of Start Point, S. Devon) (Figure S8a). Shallow rocky outcrops are found at the tidally exposed Eddystone Rocks which lie 18 km due south of Whitsand Bay, SE Cornwall and WNW of these rocks at Hand Deeps (min. depth, 7m). A further shallow rocky area known as the East Rutts (min. depth, 8 m) lies approximately 8 km WSW of Bolt Tail.

Seabed substrates within the study site have been mapped by UKSeaMap 2010 (McBreen et al. 2011). This project derived an interactive map of broad scale predicted seabed habitat for the UK continental shelf, combining existing substrate data from a variety of sources to map the seabed substrates over the entire UK continental shelf (Figure S8b). Substrate type varies considerably throughout the study site from bedrock and the rocky outcrops mentioned above, through mixed sediments and sands to fine mud. This degree of variation in substrate type is supported by descriptions of the main collecting grounds in the study area in the Plymouth Marine Fauna (MBA 1957), which also describes other notable habitats including seagrass beds and both natural and artificial reefs, in the form of sea defences and shipwrecks. However, from the descriptions in this document it is also clear that there is also a large amount of variability even within these more general categories. For example, rock may be exposed to high levels of wave action and therefore be barren, it may be covered in encrusting faunal communities such as hydroids, ascidians and anemones, or, in more sheltered locations, it may provide a suitable substrate for the settlement of large kelps. Naturally, the fauna of these habitats also vary. Wave exposed and mobile sediments will likely be relatively barren. Immobile and burrowing species will have specific habitat requirements relating to sediment grain size and prey availability, and even relatively mobile species such as fish, cephalopods and crustaceans will exhibit habitat preferences. Thus, the study area supports heterogeneous habitats as measured by surveys spanning the last century and in terms of substratum type and the species that inhabit those seabed areas.

The water column above the seabed in this area is also variable. The western English Channel is a highly dynamic region with significant physical and biogeographical boundaries (Southward et al. 2005). For example, the area offshore of Plymouth is where the Ushant front, a seasonally persistent thermal tidal front, reaches its northern extent. This front is not only characterised by strong horizontal and vertical gradients in water temperature and other physical characteristics, it is also a hydrographic feature with high productivity, having high in situ primary growth and physical aggregation of phytoplankton and zooplankton assemblages (Le Fèvre 1986). This highly dynamic water column confers heterogeneity to the underlying benthos through stronger physical gradients and nutrient pulses in addition to direct input of particulate carbon which influences community structure and functioning (Southward et al. 2005). These general features are exemplified in example maps. For instance, a map of mean summer (June – Aug 2009) sea-surface temperature values from satellite-derived sea surface temperature data available from the Medspiration project (http://projets.ifremer.fr/cersat/Information/ Projects/MEDSPIRATION2) shows that whilst there is a general pattern of cooler water inshore, temperature values do not typically reflect the underlying bathymetric variation. There exists a stretch of cooler water (16.8 – 17.0$_o$C) running SE from Start Point and water temperatures generally appear to increase with distance east or west of this line, to a maximum temperature of 18.4$_o$C approximately 25 km due S of Fowey, SE Cornwall. Furthermore, figure S1d shows satellite-derived interannual variability in summer (June – August 1998 to 2008) front occurrence within the study site (Miller et al. 2010, Miller and Christodoulou 2014). Whilst it is not possible to detect oceanic fronts reliably from the satellite in the few kilometres immediately adjacent to the coastline, variability in front occurrence fluctuates widely across the rest of the study area, with values ranging from 0 to 48 %. Even between adjacent locations, variability ranges widely, the result being that it is difficult to draw contours around areas with similar variability values. An exception to this is the area running roughly NW to SE and lying 10 – 20 km offshore from Bolt Head. This area corresponds to the site of a frequent summer front (Miller et al. 2010) and thus experiences lower levels of inter-annual variability in summer front occurrence (typically 0 – 16 %) than other regions of the study area (typically 20 – 40 %). This area lies on the SW extremity of the low SST area previously identified. However, areas of high front variability are also associated with this cool area (for example, the area of high variability 5 km south of Bolt Head). Thus, there are no obvious patterns relating variability in frontal occurrence to bathymetry, habitat type or sea surface temperature.

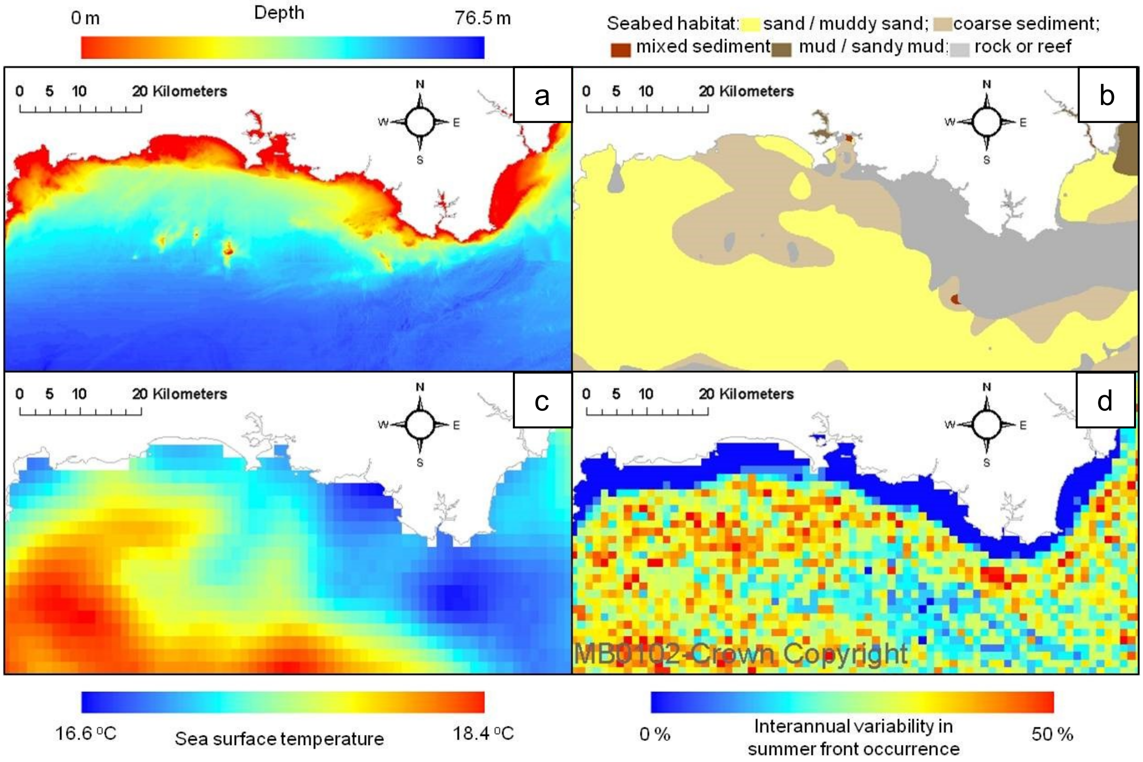


Figure S8: The coastal region of the western English Channel where animals were tracked is highly heterogeneous. (a) Seabed depth ranges from 0 to 76.5 m (© Crown Copyright/SeaZone Solutions. All Rights Reserved. Licence No. 052006.001 31st July 2011) and across this range of depths, seabed sediment type varies from sand, through mud, coarse and mixed sediments, to rock (b) (UKSeaMap 2010). The pelagic marine environment is also variable with the region being characterised by frontal, transitional waters seasonally and mean summer sea surface temperatures ranging from 16.6 – 18.4 ^{o}C (c) together with high levels of interannual variability (0 – 50 %) in the occurrence of fronts during summer months (d) (MB0102-Crown Copyright).

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