

Acoustic behaviours of large crustaceans in NE Atlantic coastal habitats

Laura Coquereau*, Jacques Grall, Jacques Clavier, Aurélie Jolivet, Laurent Chauvaud

*Corresponding author: laura.coquereau@univ-brest.fr

Aquatic Biology 25: 151–163 (2016)

Table S1. Summary of the acoustic features of sounds emitted by crustaceans living in north-east Atlantic coastal habitats and their estimated detection distances. The mean, standard deviation (SD; measured as the square root of the variance) and the minimum and maximum values were determined for the acoustic features of each sound type.

Species	Acoustic behaviour	No. of signals analysed	No. ind. recorded	Acoustics features														
				RL peak to peak (dB re 1 μ Pa (pp))				Peak frequency (kHz)				Bandwidth (kHz)				Estimated <i>in situ</i> detection ranges (m)		
				Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Wenz 1 knot	Wenz 5 knots	ANL maerl
Anomura																		
<i>Galathea squamifera</i>	Moving rock	105	5	103	4	97	119	6	1	3	34	16	5	5	31	0.9	0.4	0.3
	Feeding	92		93	2	90	100	25	19	3	47	25	5	17	35	0.3	0.1	0.1
	Specific behaviour (antenna rubbing)	37		116	9	101	139	36	7	9	65	17	6	4	30	3.9	2.0	1.5
Brachyura																		
<i>Cancer pagurus</i>	Moving rock	118	6	109	5	100	121	5	1	2	35	12	4	3	27	1.7	0.9	0.6
	Moving sand	69		107	2	105	116	18	8	8	53	18	5	12	28	1.4	0.7	0.5
	Feeding	165		117	7	99	130	5	5	2	44	6	3	2	31	4.4	2.2	1.6
	Mandibles rubbing	52		109	6	90	117	28	19	8	64	19	6	7	29	1.7	0.9	0.6
	Specific behaviour (unidentified)	71		142	4	128	146	13	6	5	38	11	4	5	21	77.9	39.0	28.9
	Specific behaviour (antenna rubbing on facial zone)	109		96	3	89	105	33	18	3	65	19	6	9	65	0.4	0.2	0.1
	Type 1	51		110	1	104	121	6	0	2	12	9	0	6	19	2.0	1.0	0.7
Specific behaviour (unidentified)	113	111	4	102	127	45	10	28	64	14	4	8	29	2.2	1.1	0.8		

Species	Acoustic behaviour	No. of signals analysed	No. ind. recorded	Acoustics features														
				RL peak to peak (dB re 1µPa (pp))				Peak frequency (kHz)				Bandwidth (kHz)				Estimated <i>in situ</i> detection ranges (m)		
				Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Wenz 1 knot	Wenz 5 knots	ANL maerl
<i>Carcinus maenas</i>	Moving rock	62	5	97	3	92	106	4	2	2	16	16	5	6	28	0.4	0.2	0.2
	Moving sand	50		112	4	104	127	4	2	3	13	13	4	5	26	2.5	1.2	0.9
	Feeding	163		114	5	100	125	8	3	4	13	6	2	3	17	3.1	1.6	1.2
	Mandibles rubbing	46		97	4	87	106	39	11	16	60	15	4	9	28	0.4	0.2	0.2
	Type 1	108		101	5	93	118	4	4	3	49	14	6	3	30	0.7	0.3	0.3
<i>Necora puber</i>	Moving rock	46	4	104	5	98	124	4	2	2	17	17	4	9	27	1.0	0.5	0.4
	Feeding	185		128	5	116	140	7	4	3	55	6	3	2	21	15.5	7.8	5.8
	Mandibles rubbing	56		109	4	101	119	34	16	13	62	15	6	5	27	1.7	0.9	0.6
	Type 1	19		115	2	112	119	9	3	6	14	8	1	6	11	3.5	1.7	1.3
	Specific behaviour (mandible rubbing with cheliped)	78		108	3	100	115	30	17	9	64	15	5	6	28	1.6	0.8	0.6
Specific behaviour (chelipeds rubbing)	145	101	4	93	115	33	17	8	63	15	5	6	29	0.7	0.3	0.3		
<i>Pachygrapsus marmoratus</i>	Moving rock	65	3	112	9	99	135	7	6	2	24	12	1	6	26	2.5	1.2	0.9
	Feeding	146		115	3	103	120	4	1	2	6	5	1	3	7	3.5	1.7	1.3
	Type 1	228		103	7	103	126	3	3	3	29	12	6	2	28	0.9	0.4	0.3
<i>Lophozozymus incisus</i>	Moving rock	107	6	102	4	94	117	6	2	2	16	11	5	4	29	0.8	0.4	0.3
	Moving sand	52		120	1	103	144	13	10	2	40	22	5	14	31	6.2	3.1	2.3
	Feeding	23		97	5	90	107	7	6	3	26	13	7	4	28	0.4	0.2	0.2
	Mandibles rubbing	10		93	1	91	94	41	11	19	55	20	4	15	27	0.3	0.1	0.1
	Type 1	52		114	6	105	125	12	6	2	30	8	3	4	16	3.1	1.6	1.2
Caridea																		
<i>Crangon crangon</i>	Swimming	72	35	98	4	91	108	37	16	5	61	16	6	7	30	0.5	0.2	0.2
<i>Palaemon serratus</i>	Swimming	202	15	96	4	86	108	26	13	3	59	14	5	5	38	0.4	0.2	0.1
	Feeding	50		102	5	91	116	35	13	12	58	13	4	8	24	0.8	0.4	0.3
Cirripedia																		
<i>Pollicipes pollicipes</i>	Specific behaviour (contacts between individuals)	111	53	103	7	86	118	40	14	4	64	15	6	5	30	0.9	0.4	0.3

RL = received level measured in the tank. Estimated *in situ* detection ranges calculated from the formula described by Di Iorio et al. (2012): $R_{max} = R_0 \cdot 10^{(RL - (NL + 8))/20}$ where R_0 distance between the hydrophone and organism in meters, NL = Wenz noise level with wind speed of 1 kn (NL= 77) or 5 kn (NL= 83) (dB re 1 µPa), ANL = background ambient noise level from *in situ* coastal habitat recordings. 8 dB corresponds to the minimum signal to noise ratio needed to detect the signal among noise.

Table S2. Summary of the acoustic features of sounds emitted by crustacean behaviours and their estimated detection distances. The mean, standard deviation (SD; measured as the square root of the variance) and the minimum and maximum values were determined for the acoustic features of each sound type.

Acoustic behaviour	Species	No. of signals analysed	No. ind. recorded	Acoustics features														
				RL peak to peak (dB re 1 μ Pa (pp))				Peak frequency (kHz)				Bandwidth (kHz)				Estimated <i>in situ</i> detection ranges (m)		
				Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Wenz 1 knot	Wenz 5 knots	ANL maerl
Moving rock	<i>Cancer pagurus</i>	118	6	109	5	100	121	5	1	2	35	12	4	3	27	1.7	0.9	0.6
	<i>Carcinus maenas</i>	62	5	97	3	92	106	4	2	2	16	16	5	6	28	0.4	0.2	0.2
	<i>Necora puber</i>	46	4	104	5	98	124	4	2	2	17	17	4	9	27	1.0	0.5	0.4
	<i>Pachygrapsus marmoratus</i>	65	3	112	9	99	135	7	6	2	24	12	6	4	26	2.5	1.2	0.9
	<i>Lophozozymus incisus</i>	107	6	102	4	94	117	6	2	2	16	11	5	4	29	0.8	0.4	0.3
	<i>Galathea squamifera</i>	105	5	103	4	97	119	6	1	3	34	16	5	5	31	0.9	0.4	0.3
Moving sand	<i>Cancer pagurus</i>	69	6	107	2	105	116	18	8	8	53	18	3	12	28	1.4	0.7	0.5
	<i>Carcinus maenas</i>	50	5	112	4	104	127	4	2	3	13	13	4	5	26	2.5	1.2	0.9
	<i>Lophozozymus incisus</i>	52	6	120	1	103	144	13	10	2	40	22	5	14	31	6.2	3.1	2.3
Swimming	<i>Crangon crangon</i>	72	35	98	4	91	108	37	16	5	61	16	6	7	30	0.5	0.2	0.2
	<i>Palaemon serratus</i>	202	15	96	4	86	108	26	13	3	59	14	5	5	38	0.4	0.2	0.1
Feeding	<i>Cancer pagurus</i>	165	6	117	7	99	130	5	5	2	44	6	3	2	31	4.4	2.2	1.6
	<i>Carcinus maenas</i>	163	5	114	5	100	125	8	3	4	13	6	2	3	17	3.1	1.6	1.2
	<i>Necora puber</i>	185	4	128	5	116	140	7	4	3	55	6	3	2	21	15.5	7.8	5.8
	<i>Pachygrapsus marmoratus</i>	146	3	125	3	103	120	4	1	2	6	5	1	3	7	11.0	5.5	4.1
	<i>Lophozozymus incisus</i>	23	6	97	5	90	206	7	6	3	26	13	7	4	28	0.4	0.2	0.2
	<i>Galathea squamifera</i>	92	5	93	2	90	100	25	19	3	47	25	5	17	35	0.3	0.1	0.1
	<i>Palaemon serratus</i>	50	15	102	5	91	116	35	13	12	58	13	4	8	24	0.8	0.4	0.3
Mandibles rubbing	<i>Cancer pagurus</i>	52	6	109	6	90	117	28	19	8	64	19	6	7	29	1.7	0.9	0.6
	<i>Carcinus maenas</i>	46	5	97	4	87	106	39	11	16	60	15	4	9	28	0.4	0.2	0.2
	<i>Necora puber</i>	56	4	109	4	101	119	34	16	13	62	15	6	5	27	1.7	0.9	0.6
	<i>Lophozozymus incisus</i>	10	6	93	1	91	94	41	11	19	55	20	4	15	27	0.3	0.1	0.1
Type 1 behaviour	<i>Cancer pagurus</i>	51	6	110	4	104	121	6	2	2	12	9	3	6	19	2.0	1.0	0.7
	<i>Carcinus maenas</i>	108	5	101	5	93	118	4	4	3	49	14	6	3	30	0.7	0.3	0.3
	<i>Necora puber</i>	19	4	115	2	112	119	9	3	6	14	8	1	6	11	3.5	1.7	1.3
	<i>Pachygrapsus marmoratus</i>	228	3	103	7	93	126	3	2	3	29	12	6	2	28	0.9	0.4	0.3
	<i>Lophozozymus incisus</i>	52	6	114	6	105	125	12	6	2	30	8	3	4	16	3.1	1.6	1.2

Acoustic behaviour	Species	No. of signals analysed	No. ind. recorded	Acoustics features														
				RL peak to peak (dB re 1 μ Pa (pp))				Peak frequency (kHz)				Bandwidth (kHz)				Estimated <i>in situ</i> detection ranges (m)		
				Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Wenz 1 knot	Wenz 5 knots	ANL maerl
Species-specific behaviours	<i>Cancer pagurus</i> (unidentified behaviour)	71	6	142	4	128	146	13	6	5	38	11	4	5	21	77.9	39.0	28.9
	<i>Cancer pagurus</i> (antenna rubbing on facial zone)	109	6	96	3	89	105	33	18	3	65	19	6	9	65	0.4	0.2	0.1
	<i>Cancer pagurus</i> (unidentified behaviour)	113	6	111	4	102	127	45	10	28	64	14	4	8	29	2.2	1.1	0.8
	<i>Necora puber</i> (mandible rubbing with cheliped)	78	4	108	3	100	115	30	17	9	64	15	5	6	28	1.6	0.8	0.6
	<i>Necora puber</i> (chelipeds rubbing)	145	4	101	4	93	115	33	17	8	63	15	5	6	29	0.7	0.3	0.3
	<i>Pollicipes pollicipes</i> (contacts between individuals)	111	53	103	7	86	118	40	14	4	64	15	6	5	30	0.9	0.4	0.3
	<i>Galathea squamifera</i> (antenna rubbing)	37	5	116	9	101	139	36	16	9	65	17	6	4	30	3.9	2.0	1.5

RL = received level measured in the tank. Estimated *in situ* detection ranges calculated from the formula described by Di Iorio et al. (2012): $R_{max} = R_0 \cdot 10^{(RL - (NL + 8))/20}$ where R_0 distance between the hydrophone and organism in meters, NL = Wenz noise level with wind speed of 1 kn (NL= 77) or 5 kn (NL= 83) (dB re 1 μ Pa), ANL = background ambient noise level from *in situ* coastal habitat recordings. 8 dB corresponds to the minimum signal to noise ratio needed to detect the signal among noise.