nature ecology & evolution

SUPPLEMENTARY INFORMATION

VOLUME: 1 | ARTICLE NUMBER: 0195

In the format provided by the authors and unedited.

Widely used marine seismic survey air gun operations negatively impact zooplankton

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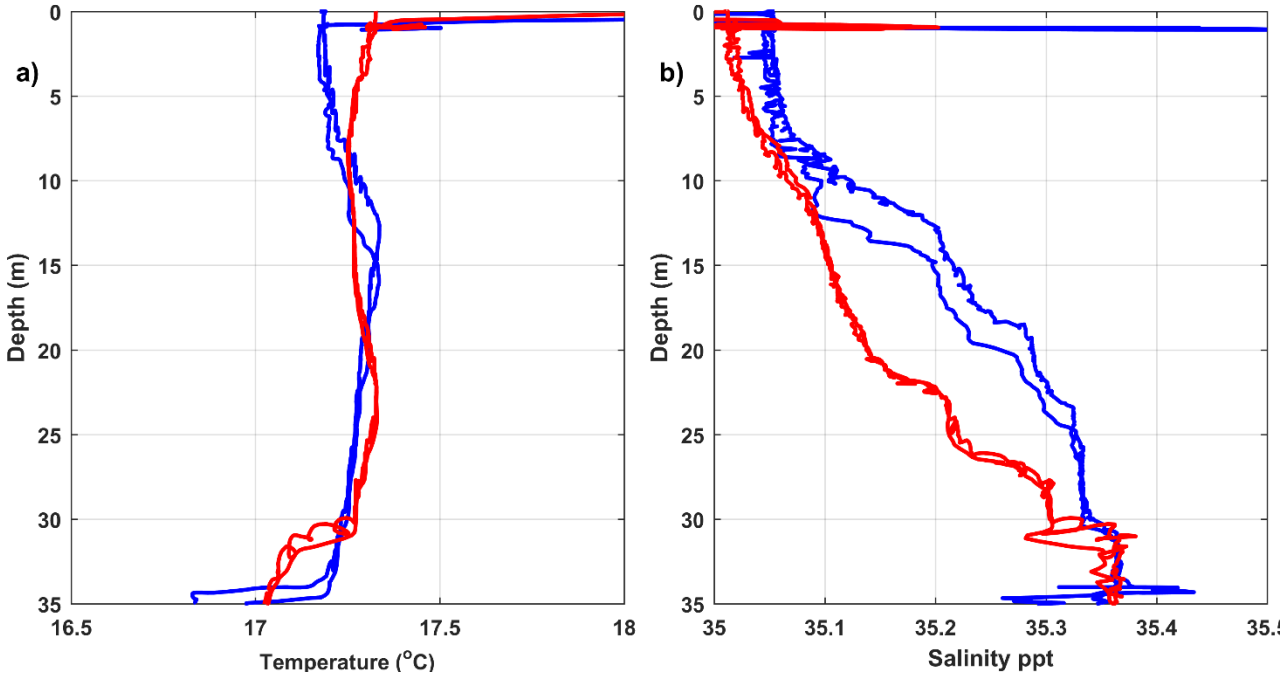
Supplementary Figures



Supplementary Figure 1 | **Pre- and post- air gun run temperature and salinity profiles for Day-2** with: a) temperature at 07:30 on 03-Mar-2015 (blue) and 11:30, 03-Mar-2015 (red); and b) salinity, same times / colours.

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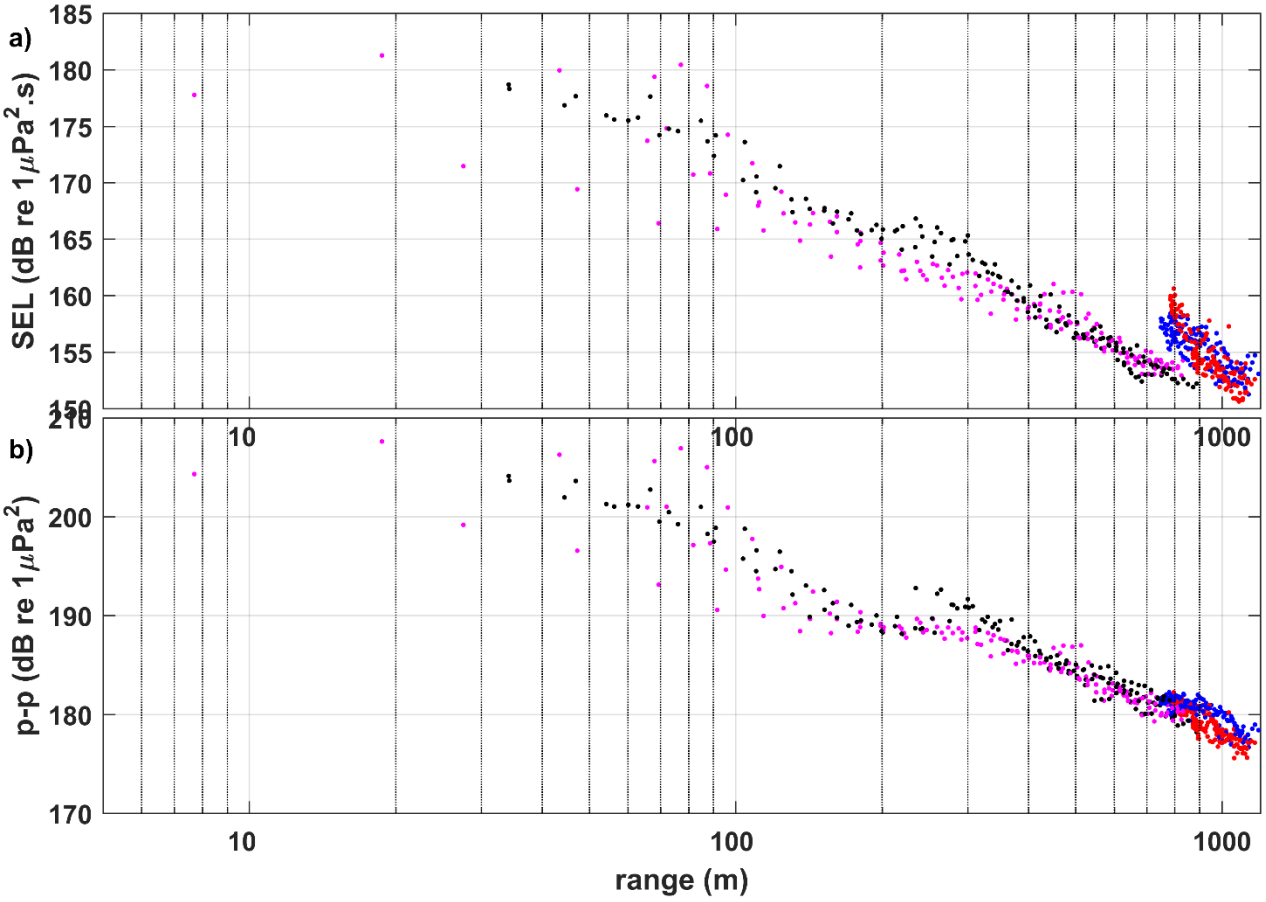

Supplementary Figure 2 | **Measured air gun signal levels**, showing: a) sound exposure level (SEL) with logarithmic range; and b) peak-peak. The colours represent different receivers, with: blue and red for receivers on seabed at sonar transect ends; and magenta and black at intersection of sonar and air gun transects (Z_e), with magenta points a mid-water receiver and black points on seabed.

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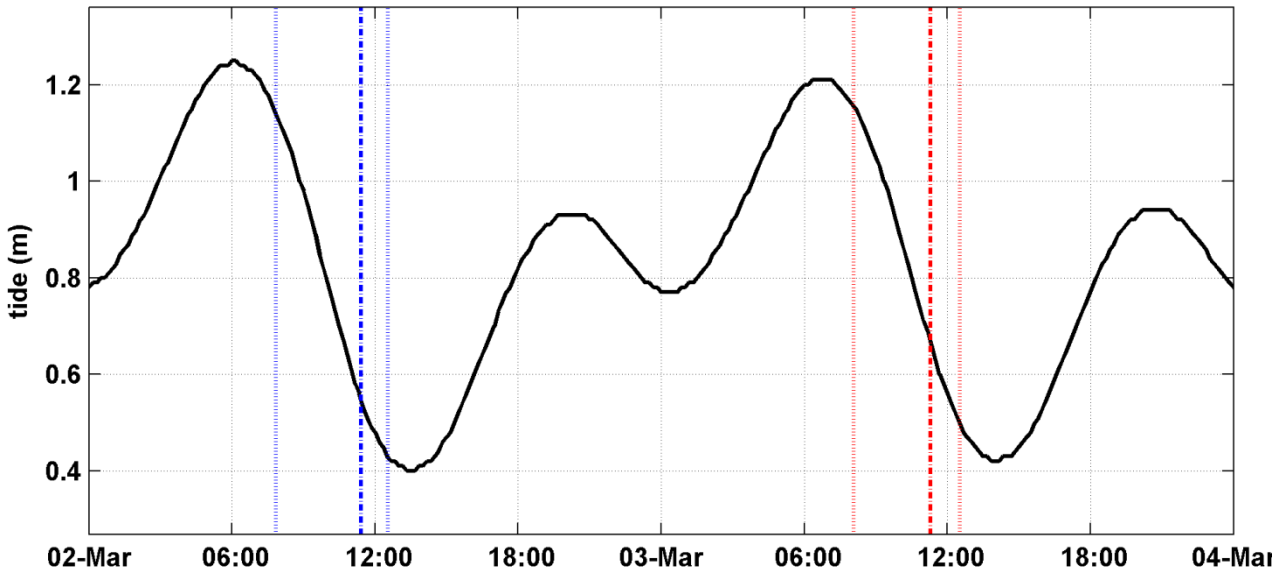

Supplementary Figure 3 | **Tidal height above chart datum for experimental period** (solid black line). The start and end of Day-1 sonar transects are shown by blue dotted lines while the time of last air gun shot is shown by the blue dot-dashed line. The start and end of Day-2 sonar transects are shown by red dotted lines while the time of last air gun shot is shown by the red dot-dashed line. Tidal data based on software wxtide32.exe, *http://www.wxtide32.com/*.

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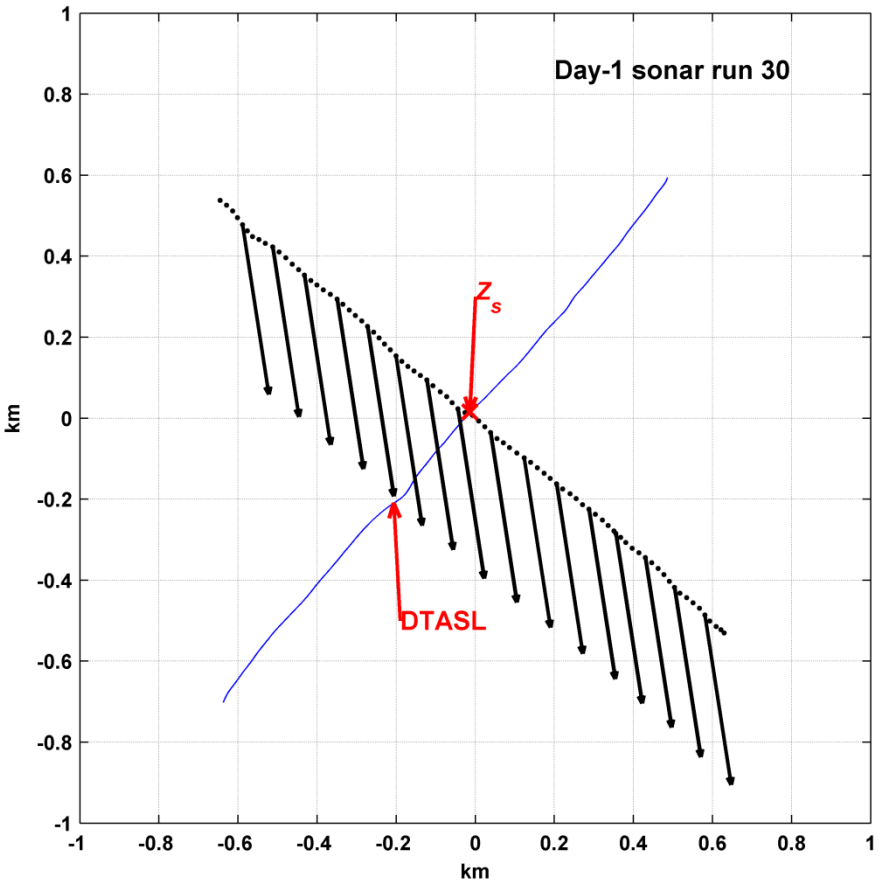

Supplementary Figure 4 | **Movement of air gun impacted signal locations for one sonar ping**. The fired air gun locations are the black dots, the drift translated air gun signal locations are shown for every 5th air gun signal and only for the ping in the entire transect which had the nearest air gun signal to any ping. The drift translated air gun signal location is shown, as is the sonar and air gun transect crossing point (Z_s). The scale has been zeroed on the central point of the air gun line, at the nominated Z_e location.

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Supplementary Tables

Supplementary Table 1 | **Raw plankton abundance counts**, with animals·m^{-3} given for control / exposed tows, at the three nominal ranges, for Day-1 and Day-2, for each taxa counted.

#	Taxa	Day-1 0 m	Day-1 250 m	Day-1 800 m	Day-2 0 m	Day-2 250 m	Day-2 800 m
1	*Calanoides* spp.	20/ 3	18/ 2	4/ 1	3/ 0	4/ 0	0/ 2
2	*Calanus australis*	41/ 16	27/ 21	98/ 25	0/ 2	4/ 3	1/ 7
3	*Clausocalanus/Paracalanus* spp.	1047/336	812/499	958/525	96/ 45	73/ 68	23/185
4	*Temora turbinata*	55/ 35	88/ 54	106/ 49	4/ 2	2/ 3	2/ 8
5	*Candacia* spp.	70/ 27	43/ 18	232/ 11	37/ 1	5/ 2	2/ 0
6	*Oithona* spp.	223/ 44	212/ 41	247/ 76	45/ 10	28/ 15	10/ 24
7	F. Corycaeidae	16/ 11	25/ 7	16/ 12	0/ 1	3/ 0	0/ 0
8	Unidentified copepods	12/ 4	15/ 1	165/ 16	0/ 6	1/ 1	6/ 9
9	*Podon* spp.	194/160	263/145	346/ 98	31/ 8	15/ 7	8/ 29
10	*Penilia* spp.	0/ 0	0/ 0	4/ 0	0/ 0	0/ 0	0/ 0
11	*Pseudoevadne* spp.	0/ 0	13/ 1	8/ 1	0/ 0	0/ 0	0/ 0
12	*Evadne* spp.	51/ 26	52/ 18	27/ 27	11/ 4	5/ 4	3/ 12
13	*Nyctiphanes australis* Nauplius I	8/ 0	10/ 0	0/ 0	1/ 0	0/ 0	0/ 0
14	*Nyctiphanes australis* Calyptopis I	23/ 1	40/ 0	51/ 2	8/ 1	11/ 2	2/ 5
15	*Nyctiphanes australis* Calyptopis II	25/ 2	21/ 1	8/ 14	4/ 4	3/ 7	0/ 14
16	*Nyctiphanes australis* Calyptopis III	12/ 18	34/ 16	24/ 12	2/ 0	0/ 1	1/ 3

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17	Mysid	22/ 0	4/ 2	4/ 0	0/ 0	0/ 0	0/ 0
18	Amphipod	0/ 0	0/ 0	1/ 0	0/ 0	0/ 0	0/ 0
19	Ostracod	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
20	Decopod larvae (crab)	8/ 7	9/ 14	0/ 5	0/ 0	2/ 1	1/ 1
21	Decopod larvae (shrimp)	0/ 10	33/ 9	20/ 11	1/ 0	0/ 0	0/ 1
22	*Sagitta minima*	6/ 2	6/ 1	16/ 4	0/ 0	0/ 0	0/ 1
23	*Sagitta lyra*	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
24	Appendicularia	72/ 43	99/ 24	177/ 53	19/ 7	16/ 6	5/ 27
25	Pteropod	2/ 0	4/ 2	35/ 1	0/ 0	0/ 1	1/ 3
26	Gastropod	2/ 0	3/ 1	0/ 2	0/ 0	0/ 0	0/ 1
27	Polychaete larvae	0/ 3	1/ 1	8/ 2	0/ 0	0/ 0	0/ 0
28	Thaliacea	2/ 1	4/ 1	4/ 1	1/ 0	0/ 1	0/ 1
29	*Echinopluteus larvae*	0/ 0	0/ 0	0/ 2	0/ 0	0/ 0	0/ 1
30	*Noctiluca scintillans*	0/ 1	0/ 5	0/ 0	1/ 0	0/ 0	0/ 0
31	Siphonophore	4/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
32	Medusae	4/ 1	16/ 1	20/ 1	1/ 1	2/ 0	0/ 3
33	Juvenile fish	2/ 0	10/ 3	0/ 9	0/ 0	0/ 0	0/ 0
34	Eggs and egg masses	6/ 3	33/ 10	24/ 15	9/ 4	8/ 3	8/ 17

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Supplementary Table 2 | **Nominal and actual range of plankton tow location from fired air gun signal location** when accounting for water drift and elapsed time. Drift on Day-2 was faster and more perpendicular to the air gun transect, than on Day 1, thus offset the nominal ranges more than on Day-1.

Day	Nominal 0 m range Actual range (m)	Nominal 250 m range Actual range (m)	Nominal 800 m range Actual range (m)
1	79	71	451
2	149	547	1248 - 1300

Supplementary Table 3 | **Zooplankton vital stain results**, showing counts of dead / total (total = live + dead) animals and the ratio of dead to total animals counted for the three nominal sample ranges, three taxonomic groups, and Day-1 and Day-2.

	0 m	250 m	800 m
Day-1 copepods control	115/1170, 0.098	270/1474, 0.183	461/2048, 0.225
Day-1 copepods exposed	611/1145, 0.534	476/1060, 0.449	694/1552, 0.447
Day-2 copepods control	178/1033, 0.172	265/1063, 0.249	177/1242, 0.143
Day-2 copepods exposed	537/1289, 0.417	596/1209, 0.493	389/1133, 0.343
Day-1 nauplii control	13/ 221, 0.059	75/ 262, 0.286	69/ 239, 0.289
Day-1 nauplii exposed	134/ 236, 0.568	52/ 185, 0.281	64/ 285, 0.225
Day-2 nauplii control	27/ 116, 0.233	28/ 159, 0.176	41/ 221, 0.186
Day-2 nauplii exposed	37/ 83, 0.446	133/ 192, 0.693	54/ 139, 0.388
Day-1 'other' control	8/ 143, 0.056	68/ 258, 0.264	23/ 104, 0.221
Day-1 'other' exposed	93/ 201, 0.463	124/ 336, 0.369	65/ 275, 0.236
Day-2 'other' control	40/ 237, 0.169	58/ 278, 0.209	31/ 203, 0.153
Day-2 'other' exposed	148/ 292, 0.507	143/ 284, 0.504	115/ 173, 0.665

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Supplementary Table 4 | **Significance values for plankton-tow dead/total ratios, exposed compared with control,** (*p* using two tailed t-test) for each taxon and range grouping (see Extended data Table 3 for actual range of each plankton tow). All significance values implied more dead animals in exposed animals.

taxa	*p* value a) (79, 71 & 149 m)	*p* value b) (451 & 547 m)	*p* value c) (1248-1300 m)
copepods	< 0.001	< 0.001	< 0.05
nauplii	< 0.001	< 0.05	< 0.05
other	< 0.001	< 0.05	< 0.001

Supplementary Table 5 | **Details of control, air gun and sonar transects for each day**. Given are: # - day; *C start C end* - control start and end time; *C e* - control elapsed time (minutes); *C s C d* control speed (ms^{-1}) and distance (km); *C h* - mean control heading (compass true); *A* - number air gun signals; *A start A end* - time air gun start / end; *A e* - air gun elapsed time (minutes); *A s A d* - air gun speed (ms^{-1}) and distance (km); *A h* - mean air gun heading (compass true); *SR* - number sonar transects; *S start / end* - sonar start and end; *S s* mean sonar speed (ms^{-1}); *S h* - mean sonar heading to NE and SW (compass true).

#	C start C end	C e	C s C d	C h	A	A start A end	A e	A s A d	A h	SR	S start S end	S s	S h
1	07:15:23 07:27:01	11.6	2.1 1.5	314	84	11:09:25 11:24:59	15.6	1.8 1.7	310	34	07:50:43 12:31:57	3.4	40 221
2	08:10:26 08:24:09	13.7	1.9 1.6	308	72	11:04:40 11:18:17	13.6	1.9 1.6	310	28	08:04:37 12:32:34	3.2	41 220

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Supplementary Table 6 | **Mean values for ascents of plankton tows**, with: set; ascent time; ascent rate; horizontal distance moved during ascent (according to GPS); and volume sampled by each cod-end (using GPS). Errors are 95% confidence limits.

set	Ascent time (s ± 95%)	Ascent rate (ms^{-1} ± 95%)	Horizontal distance (m ± 95%)	Volume sampled (m^3)
Day 1 control	171 ± 50.1	0.22 ± 0.056	41 ± 11.5	24.4 ± 4.6
Day 1 active	136 ± 21.7	0.27 ± 0.057	37 ± 18.1	23.3 ± 5.1
Day 2 control	163 ± 6.0	0.23 ± 0.052	39 ± 21.3	24.0 ± 7.5
Day 2 active	137 ± 19.1	0.27 ± 0.044	24 ± 8.7	19.3 ± 2.1

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