

## **Supporting online information:**

### **Explosives compounds from relic munitions accumulate in marine biota**

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#### **Contains 2 Tables, 2 figures**

Table S1: Blank levels and precision of triplicate extraction replicates.

Table S2. Tissue MC content in individual samples.

Figure S1. MC content in sea stars.

Figure S2. a) ADNT and b) DANT isomer ratios in different organisms.

Table S1. Blank levels and precision of triplicate extraction replicates. Replicate extractions were conducted on samples with sufficient material and included various numbers of a subset of the organism classes (Crustacean, n=1; Asteroidea, n=1; Mollusc, n=7; Fish liver, n=1; Fish muscle, n=16).

	<b>TNT</b>	<b>SumADNT</b>	<b>SumDANT</b>	<b>RDX</b>	<b>DNB</b>
<b>Avg blank (pmol)<sup>1</sup></b>	0	0.07	0.11	0	0.32
<b>1 S.D. blank (pmol)</b>	0	0.08	0.15	0	0.23
<b>3 x S.D. (pmol)</b>	0	0.24	0.46	0	0.70
<b>Extraction replicates<sup>2</sup>:</b>					
<b>Detects (n, of 28 total)</b>	10	13	26	5	17
<b>Conc. median (pmol/g)</b>	6.04	3.70	12.64	0.53	1.20
<b>Conc. Range (pmol/g)</b>	(0.94 - 29200)	(0.69 - 12300)	(5.5 - 199)	(0.19 - 2)	(0.34 - 2)
<b>Avg RSD (%)<sup>3</sup></b>	44	41	51	35	39
<b>Median RSD (%)</b>	27	39	41	30	45
<b>RSD (%) range</b>	(3.2 - 98)	(5.8 - 112)	(4.4 - 140)	(15.3 - 67)	(3.9 - 70)

<sup>1</sup>Due to the very low analytical background, no counts for TNT or RDX were detected in the blanks. Practical experience suggests that the detection limits for these compounds are similar to the others.

<sup>2</sup>Extraction replicates were performed in triplicate

<sup>3</sup>Relative standard deviation of the triplicate extractions, averaged across all samples

Table S2. Tissue MC content in individual samples.					Concentration (pmol/g tissue) <sup>4</sup>					Molar ratio* <sup>5</sup>	
ID	Organism	Info <sup>1</sup>	Location <sup>2</sup>	Dry/Wet <sup>3</sup>	TNT	Sum ADNT	Sum DANT	RDX	DNB	4:2 ADNT	2,4:2,6 DANT
1451	Plankton		KH	dry			97				0.7
1450	Plankton		non-KH	dry			310	3.9			0.8
1452	Plankton		non-KH	dry			59				4.6
1649	Macroalgae		non-KH	wet	13	3.9	0.2	1.0		0.8	
1650	Macroalgae		non-KH	wet	15	4.1	0.4	0.3		1.1	
1654	Macroalgae		non-KH	wet	6.1	8.8	0.5	1.8		1.5	
1655	Macroalgae		non-KH	wet	5.7	9.2	0.4	1.1		1.5	
1709	Macroalgae		non-KH	wet		9.7			0.2	1.8	
1710	Macroalgae		non-KH	wet		11			0.2	1.9	
1711	Macroalgae		non-KH	wet	2.0	11	1.4	2.1	1.0	2.4	
1712	Macroalgae		non-KH	wet		3.7	1.0			2.1	
1717	Macroalgae		non-KH	wet	0.4	1.2			0.2	1.5	
1718	Macroalgae		non-KH	wet	0.6	2.1				1.3	
1468	Macroalgae		KH	dry	37	42			6.4	2.8	
1587	Macroalgae		KH	wet	0.4	17		0.4		2.4	
1588	Macroalgae		KH	wet	0.3	20	0.4	1.0	1.1	2.5	
1616	Macroalgae		KH	wet	2200	1800	0.5	34	16	1.3	
1629	Macroalgae		KH	wet	3700	6500	9	14	290	2.4	
1657	Macroalgae		KH	wet	54	19	0.9	0.2		2.4	
1659	Macroalgae		KH	wet	0.9	12				6.2	
1656	Macroalgae		non-KH	wet	7.9	10	1.2	2.3		1.5	0.3
1467	Macroalgae		KH	dry	180	3200	63	5.7		3.2	0.5
1617	Macroalgae		KH	wet	3300	2500	2.1	57	44	1.4	0.6
1453	Macroalgae		KH	dry		17	39		0.9	2.3	0.7
1627	Macroalgae		KH	wet	160	1500	3.2	0.2	9.9	3.2	0.9
1626	Macroalgae		KH	wet	1600	3000	4.2		39	3.7	1.2
1716	Macroalgae		non-KH	wet	3.8	6.5	1.3	0.1		2.2	1.4
1658	Macroalgae		KH	wet	43	40	4.2	0.6	1.5	2.6	1.6
1628	Macroalgae		KH	wet	110	1400	5.5		7.8	3.5	1.6
1703	Macroalgae		non-KH	wet	0.8	5.1	0.9			1.8	1.6
1465	Macroalgae		KH	dry	410	3000	22		120	3.2	1.7
1471	Macroalgae		KH	dry	2700	4500	15	5.4	16	2.6	1.9
1466	Macroalgae		KH	dry	170	2000	30		36	3.1	2.3
1719	Macroalgae		non-KH	wet		3.2	1.1			2.0	2.4
1619	Macroalgae		KH	wet	3700	21000	21	0.5	160	1.0	3.0
1660	Macroalgae		KH	wet	2.5	5.3	8.1		2.1	1.9	3.4
1457	Macroalgae		KH	dry		6.9	10		2.0	2.3	4.7
1458	Macroalgae		KH	dry	4.4	19	21	0.8		2.0	4.7
1630	Macroalgae		KH	wet	17000	7000	7.0	0.1	22	1.0	5.3
1618	Macroalgae		KH	wet	17000	24000	71	26	110	1.1	16
1454	Tunicate		KH	dry		16.0	7.5		1.5	2.6	
1463	Tunicate		KH	dry	1700	8700	54		54	2.1	1.7
1462	Tunicate		KH	dry	220	17000	30			4.1	1.9

1455	Tunicate		KH	dry		26	43		1.3	4.1	8.3
1707	Sponge		non-KH	wet		5.0	1.1	2.3		2.2	
1720	Sponge		non-KH	wet		5.3		1.1		2.0	
1615	Sponge		KH	wet	19000	22000	1.7	0.6	85	1.2	
1459	Sponge		KH	dry			49				2.6
1694	Crustacean		non-KH	wet	1.1						
1706	Crustacean		non-KH	wet			2.7	0.5			
1592	Crustacean		KH	wet	9.3	1500	12	8.8	2.7	3.4	
1620	Crustacean		KH	wet	7600	9600	15000		1.9	2.3	0.0
1693	Crustacean		non-KH	wet	7.6		3.8		2.7		1.2
1456	Crustacean		KH	dry		52	97		17		1.4
1705	Crustacean		non-KH	wet			1.3				2.3
1643	Crustacean		non-KH	wet	6.4	3.7	5.5		0.7	1.3	3.1
1460	Crustacean		KH	dry		33	19		5.7		3.8
1642	Mollusc		non-KH	wet	11	2.7	34	0.3	0.7	0.4	
1682	Mollusc		non-KH	wet	3.2	1.1		9.6	2.9		
1683	Mollusc		non-KH	wet							
1691	Mollusc		non-KH	wet	5.7	0.4		1.1			
1721	Mollusc		non-KH	wet	0.7	4.4	7.6		1.6	4.1	
1723	Mollusc		non-KH	wet	21	1.3		3.8	6.9		
1732	Mollusc		non-KH	wet	4.5	0.2			0.7		
1614	Mollusc		KH	wet	8200	3700	5.3		10	1.4	
1684	Mollusc		non-KH	wet			17	0.3	1.0		0.0
1632	Mollusc		KH	wet	13	480	22	0.5	0.3	3.6	0.2
1596	Mollusc		KH	wet	24	420	12	0.9	0.9	1.9	0.4
1621	Mollusc		KH	wet	570	3400	14	0.2		1.8	0.6
1689	Mollusc		non-KH	wet	0.8		12				0.7
1731	Mollusc		non-KH	wet	15	2.0	7.5		0.9	1.3	1.6
1733	Mollusc		non-KH	wet	6.7	1.1	2.6			1.5	1.6
1641	Mollusc		non-KH	wet	16	1600	46		1.5	1.3	2.1
1464	Mollusc		KH	dry		2800	280		68	3.1	2.6
1470	Mollusc		KH	dry	220	780	55	2.9		2.1	3.4
1647	Mollusc		non-KH	wet	1.9	2.2				1.1	
1651	Mollusc		non-KH	wet	2.0	3.7		0.5		0.6	
1635	Mollusc		KH	wet	32	760	72	1.7	1.0	2.8	
1638	Mollusc		KH	wet	5.7	14	5.6			1.3	
1690	Echinoderm		non-KH	wet			0.6				
1692	Echinoderm		non-KH	wet				1.2			
1701	Echinoderm		non-KH	wet			6.1		4.3		
1704	Echinoderm		non-KH	wet	2.1		2.3		2.9		
1708	Echinoderm		non-KH	wet				1.3	0.6		
1586	Echinoderm		KH	wet	23	980			2.0	4.2	
1730	Echinoderm		non-KH	wet	6.5	0.9	5.7		1.0		3.5
1631	Echinoderm	<2	KH	wet	45000		440		2.4		1.6
1661	Echinoderm	<2	KH	wet	2.0	0.2	13				1.7
1666	Echinoderm	2-3	KH	wet	8.5	7.0	17		1.1	2.4	1.6

1610	Echinoderm	2-3	KH	wet	26000	17000	62			1.1	0.9
1609	Echinoderm	2-3	KH	wet	15000	21000	83		1.5	1.5	1.2
1608	Echinoderm	2-3	KH	wet	460000	36000	170	0.7	2700	1.3	1.3
1667	Echinoderm	2-3	KH	wet	4.8		17		1.5		1.6
1671	Echinoderm	2-3	KH	wet		0.8	13				2.2
1665	Echinoderm	2-3	KH	wet	8.6	10	22	0.5			5.1
1670	Echinoderm	3-4	KH	wet	2.8	0.5	3.3				
1669	Echinoderm	3-4	KH	wet	4.0		7.4		1.0		0.1
1675	Echinoderm	3-4	KH	wet	1.1		12		0.5		0.2
1673	Echinoderm	3-4	KH	wet			2.0	0.3	0.7		0.2
1672	Echinoderm	3-4	KH	wet			16				0.4
1662	Echinoderm	3-4	KH	wet	4.3		22				1.6
1668	Echinoderm	3-4	KH	wet	3.3		14		0.6		2.3
1674	Echinoderm	3-4	KH	wet	0.8		9.9				4.5
1664	Echinoderm	3-4	KH	wet	11	5.3	21			1.6	7.5
1677	Echinoderm	4-5	KH	wet	0.7		7.4				0.8
1679	Echinoderm	4-5	KH	wet	2.8	13	1.3			2.8	0.8
1611	Echinoderm	4-5	KH	wet	33000	26000	420	2.8	2.1	1.4	1.1
1612	Echinoderm	4-5	KH	wet	39000	27000	280	0.3	1.4	1.8	1.2
1663	Echinoderm	4-5	KH	wet	3.6	12	13			0.8	3.0
1613	Echinoderm	4-5	KH	wet	160000	47000	500	1.6	160	1.3	3.5
1676	Echinoderm	4-5	KH	wet	0.9		13.0				3.6
1678	Echinoderm	5-6	KH	wet	0.2		16.0		0.4		0.6
1593	Echinoderm	5-6	KH	wet	29000	12000	200	0.4	0.5	1.4	0.9
1599	Echinoderm	6-7	KH	wet	18000	14000	620			1.1	0.4
1600	Echinoderm	6-7	KH	wet	2300	6200	56	0.2		1.5	0.7
1601	Echinoderm	6-7	KH	wet	1800	4200	25			1.3	1.6
1602	Echinoderm	6-7	KH	wet	140000	31000	270	0.2	88	1.5	6.6
1603	Echinoderm	>7	KH	wet	53000	36000	640		2.6	1.3	0.5
1604	Echinoderm	>7	KH	wet	55000	27000	590	0.2	2.2	1.3	0.9
1605	Echinoderm	>7	KH	wet	170	2200	56			1.2	1.5
1606	Echinoderm	>7	KH	wet	1400	3800	63		0.7	1.3	1.6
1607	Echinoderm	>7	KH	wet	850	2900	71	0.2	0.4	1.0	2.1
1736	Echinoderm	>7	non-KH	wet	0.8		0.8				
1713	Echinoderm	>7	non-KH	wet			7.0				0.0
1734	Echinoderm	>7	non-KH	wet	1.1	0.9	2.8				0.1
1724	Echinoderm	>7	non-KH	wet		0.3	1.9				0.1
1735	Echinoderm	>7	non-KH	wet			2.2		0.2		0.2
1725	Echinoderm	>7	non-KH	wet	0.5		3.8				0.6
1590	Echinoderm	>7	KH	wet		14	11			3.6	1.1
1589	Echinoderm	>7	KH	wet	2.2	390	21	0.2		1.1	1.5
1461	Echinoderm	>7	KH	dry		2.3	13		0.7		1.7
1686	Echinoderm	>7	non-KH	wet			9.9				1.8
1469	Echinoderm	>7	KH	dry	2400000	520000	2500	16	1100	1.2	2.3
1726	Echinoderm	>7	non-KH	wet	1.4		3.0		0.5		3.2
1680	Polychaete		non-KH	wet	1.6	0.9			1.8		

1681	Polychaete		non-KH	wet							
1695	Polychaete		non-KH	wet				0.6			
1696	Polychaete		non-KH	wet				0.3			
1698	Polychaete		non-KH	wet		0.6	2.0				
1700	Polychaete		non-KH	wet							
1702	Polychaete		non-KH	wet			7.1	1.2			
1714	Polychaete		non-KH	wet	7.0	2.4			0.7	3.2	
1715	Polychaete		non-KH	wet	1.9	0.6					
1727	Polychaete		non-KH	wet	5.4	1.7	0.5		0.4	1.4	
1728	Polychaete		non-KH	wet	4.5	1.4	0.5		0.4	1.2	
1729	Polychaete		non-KH	wet	4.5	5.7	8.4		2.7	0.6	
1685	Polychaete		non-KH	wet	6.5	2.6	1.6			0.5	0.5
1687	Polychaete		non-KH	wet			5.5	1.8			0.6
1688	Polychaete		non-KH	wet	0.5		5.6	0.6			1.5
1697	Polychaete		non-KH	wet	2.0		13				1.8
1699	Polychaete		non-KH	wet		1.1	3.0			1.0	6.1
1722	Anemone		non-KH	wet		4.6		0.7		4.0	
1591	Anemone		KH	wet	10000	66000	6700	30	0.5	1.0	0.2
1552	Fish	Liver	non-KH	dry			9.1	1.9	0.9		
1522	Fish	Liver	KH	dry			95		1.5		
1528	Fish	Liver	KH	dry				1.2			
1487	Fish	Liver	KH	dry			55				0.3
1504	Fish	Liver	KH	dry			92				0.4
1479	Fish	Liver	KH	dry			93		1.5		0.5
1571	Fish	Liver	non-KH	dry			82				0.9
1567	Fish	Liver	non-KH	dry			15				1.6
1493	Fish	Liver	KH	dry			180				1.7
1549	Fish	Liver	non-KH	dry			60				2.3
1517	Fish	Liver	KH	dry			46		1.0		3.2
1537	Fish	Liver	KH	dry			200				4.7
1561	Fish	Liver	non-KH	dry			28				4.8
1533	Fish	Liver	KH	dry		1.1	100				5.0
1576	Fish	Liver	non-KH	dry			290				10
1543	Fish	Liver	non-KH	dry			800				12
1510	Fish	Liver	KH	dry			170		1.3		13
1498	Fish	Liver	KH	dry		1.2	310				41
1473	Fish	Liver	KH	dry	6.8	1.3	490				50
1556	Fish	Liver	non-KH	dry			310		1.2		68
1568	Fish	Stomach	non-KH	dry			8.5		2.3		0.3
1488	Fish	Stomach	KH	dry			8.2				0.4
1562	Fish	Stomach	non-KH	dry			5.7		2.3		0.9
1557	Fish	Stomach	non-KH	dry			11		1.4		1.1
1523	Fish	Stomach	KH	dry			8.0				1.1
1550	Fish	Stomach	non-KH	dry			6.6		3.8		1.2
1544	Fish	Stomach	non-KH	dry			9.6		5.9		1.3
1505	Fish	Stomach	KH	dry		3.3	19	2.4	4.0	1.4	1.4

1474	Fish	Stomach	KH	dry	11	6.8	6.6			1.1	1.5
1577	Fish	Stomach	non-KH	dry			4.7		5.1		1.7
1499	Fish	Stomach	KH	dry		7.1	17		2.0	0.7	1.8
1512	Fish	Stomach	KH	dry			33		4.2		1.8
1480	Fish	Stomach	KH	dry		3.2	6.0		2.3	0.7	1.9
1529	Fish	Stomach	KH	dry			43		1.9		2.2
1553	Fish	Stomach	non-KH	dry			11		3.5		2.4
1518	Fish	Stomach	KH	dry			33		0.9		2.4
1572	Fish	Stomach	non-KH	dry			8.7		2.2		2.7
1538	Fish	Stomach	KH	dry			12				2.8
1534	Fish	Stomach	KH	dry		2.4	33			0.9	3.5
1494	Fish	Stomach	KH	dry		4.5	8.2				4.0
1500	Fish	Kidney	KH	dry		3.6	38		1.4	0.7	0.2
1569	Fish	Kidney	non-KH	dry			15		1.7		0.4
1475	Fish	Kidney	KH	dry		14	46		4.3		0.4
1535	Fish	Kidney	KH	dry			6.1		3.0		0.6
1578	Fish	Kidney	non-KH	dry			10		3.4		0.7
1524	Fish	Kidney	KH	dry			68				0.7
1495	Fish	Kidney	KH	dry		7.7	23			4.5	1.4
1554	Fish	Kidney	non-KH	dry			9.8				1.6
1545	Fish	Kidney	non-KH	dry			11		3.9		1.7
1539	Fish	Kidney	KH	dry			130		3.3		1.7
1573	Fish	Kidney	non-KH	dry			16		1.5		1.7
1481	Fish	Kidney	KH	dry		2.3	17				1.7
1506	Fish	Kidney	KH	dry			29		2.3		2.2
1530	Fish	Kidney	KH	dry			20	1.8	4.3		2.2
1513	Fish	Kidney	KH	dry			19		1.4		2.6
1563	Fish	Kidney	non-KH	dry			11				3.4
1489	Fish	Kidney	KH	dry			24				3.5
1558	Fish	Kidney	non-KH	dry			17				4.7
1519	Fish	Kidney	KH	dry			16		1.4		4.8
1551	Fish	Kidney	non-KH	dry		1.2	19				5.1
1570	Fish	Muscle	non-KH	dry			1.6		4.8		
1574	Fish	Muscle	non-KH	dry				42	12		
1583	Fish	Muscle	non-KH	dry			20		1.6		0.4
1496	Fish	Muscle	KH	dry			13		0.9		0.6
1472	Fish	Muscle	KH	dry	5.2	0.7	19	0.9	1.3		0.7
1546	Fish	Muscle	non-KH	dry			11		1.0		0.8
1559	Fish	Muscle	non-KH	dry			14		0.7		1.1
1564	Fish	Muscle	non-KH	dry			5.7		1.3		1.3
1737	Fish	Muscle	non-KH	wet	0.9	0.9	8.9		0.4	1.8	1.4
1490	Fish	Muscle	KH	dry		0.7	7.2		1.0		1.4
1540	Fish	Muscle	non-KH	dry			9.2		1.4		1.4
1507	Fish	Muscle	KH	dry			11		1.2		1.4
1478	Fish	Muscle	KH	dry	3.2	1.2	5.9	0.5	1.2		1.4
1514	Fish	Muscle	KH	dry			20		1.4		1.6

1582	Fish	Muscle	non-KH	dry			5.7		3.4		1.7
1536	Fish	Muscle	KH	dry			7.1	0.6	2.5		1.8
1531	Fish	Muscle	KH	dry			10		1.2		1.9
1580	Fish	Muscle	non-KH	dry			8.7		2.3		2.1
1575	Fish	Muscle	non-KH	dry			4.8		0.7		3.1
1484	Fish	Muscle	KH	dry		0.7	13		1.5		3.4
1579	Fish	Muscle	non-KH	dry			7.9		6.6		4.0
1501	Fish	Muscle	KH	dry			11		1.7		4.5
1525	Fish	Muscle	KH	dry			18		2.0		5.8
1520	Fish	Muscle	KH	dry			14				6.5
1555	Fish	Muscle	non-KH	dry			3		1.8		2.0

1. Additional information on *A. rubens* size (diameter, cm), or fish viscera type
2. Sample collected from the munitions dumpsite Kolberger Heide (KH) or elsewhere (non-Kolberger Heide; "non-KH").
3. Indicates if sample was freeze-dried before extraction, or processed wet.
4. ADNT and DANT are reported here as the sum of their isomers.
5. No ratio calculated if only one isomer was detected.



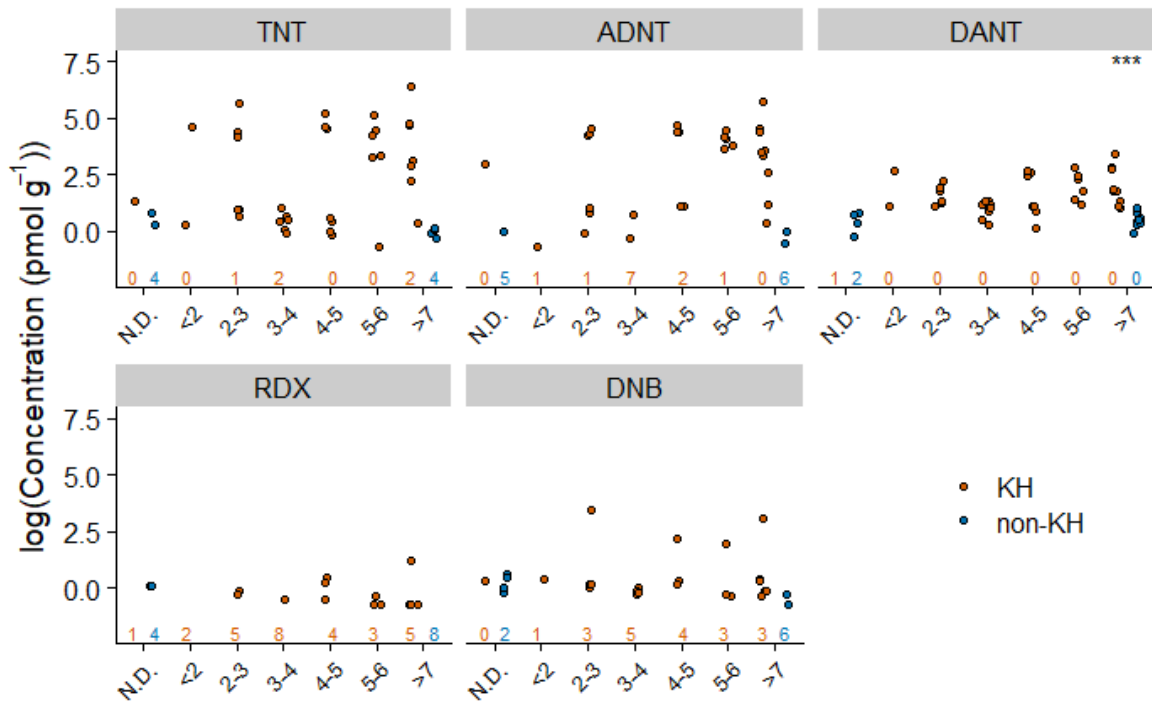


Figure S1. MC content in sea stars (*A. rubens*) of different sizes. “KH” refers to individuals collected within or near the Kolberger Heide munitions dumpsite; “non-KH” refers to those collected in other locations. ADNT and DANT are reported as the sum of their isomers. Values for individual samples are shown as dots. The numbers of samples for each site-organism combination where compounds were not detected is indicated at the base of the graph (also see Table 1 for the detection rate). Results of analysis of statistical differences between sites (Wilcoxon signed rank test performed on KH versus non-KH pairs where n per organism at both sites >4) are indicated above the data: \* - p<0.001, \*\* - p<0.01, \*\*\* - p<0.05, ns - p>0.05. “N.D.” = size not determined.

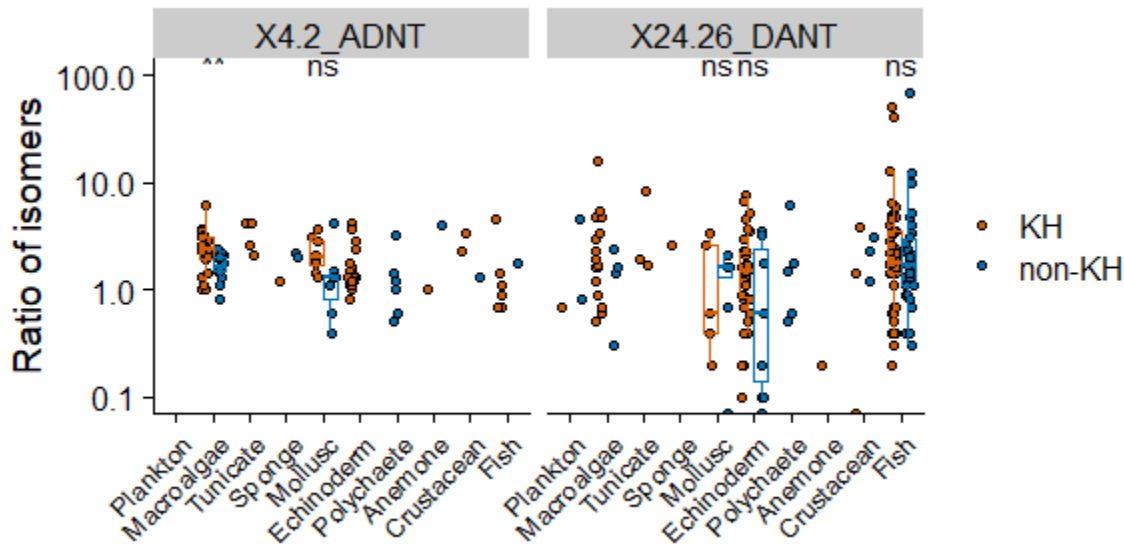


Figure S2. a) ADNT and b) DANT isomer ratios in different organisms. Symbols as in Fig. S1.