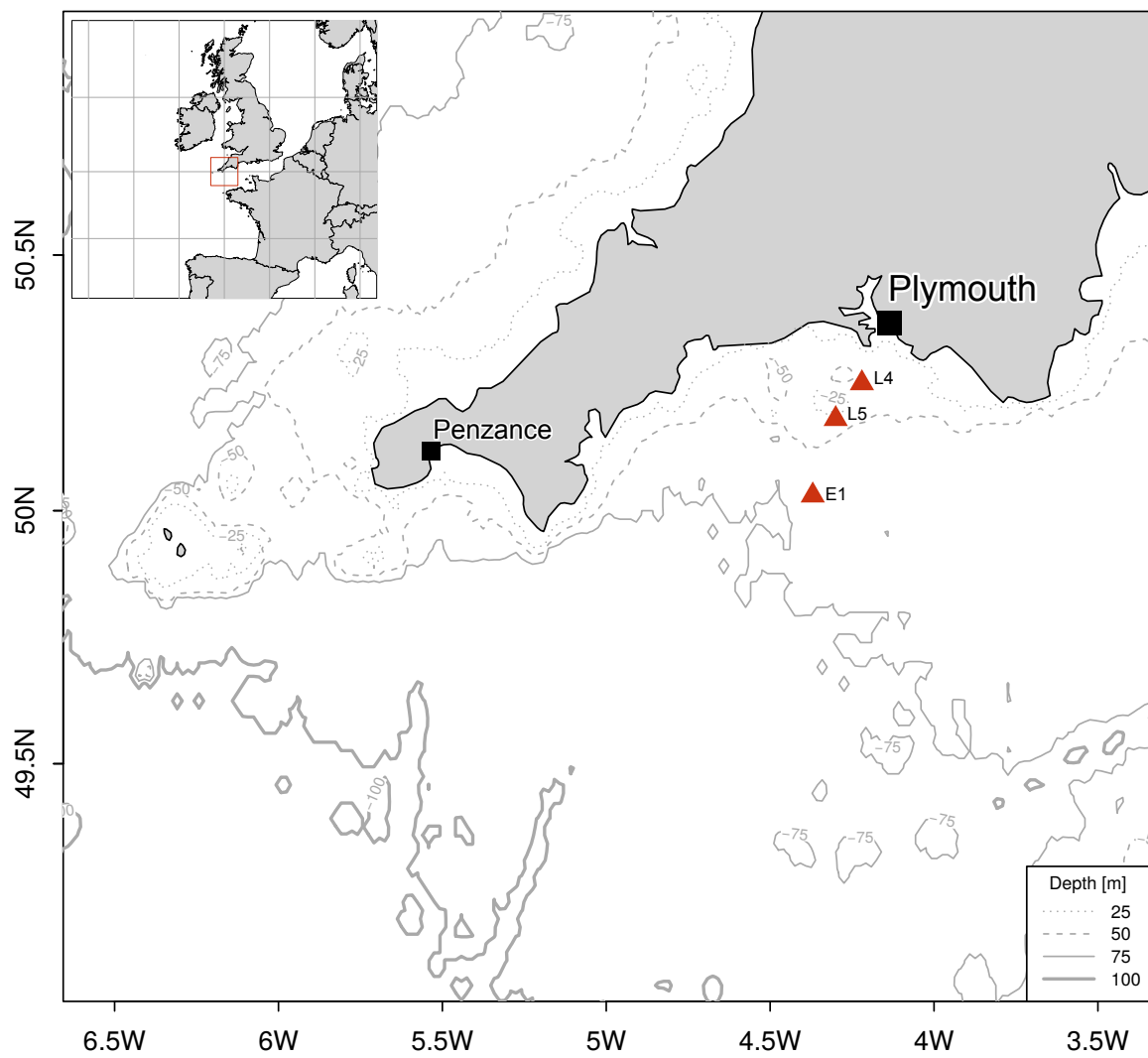


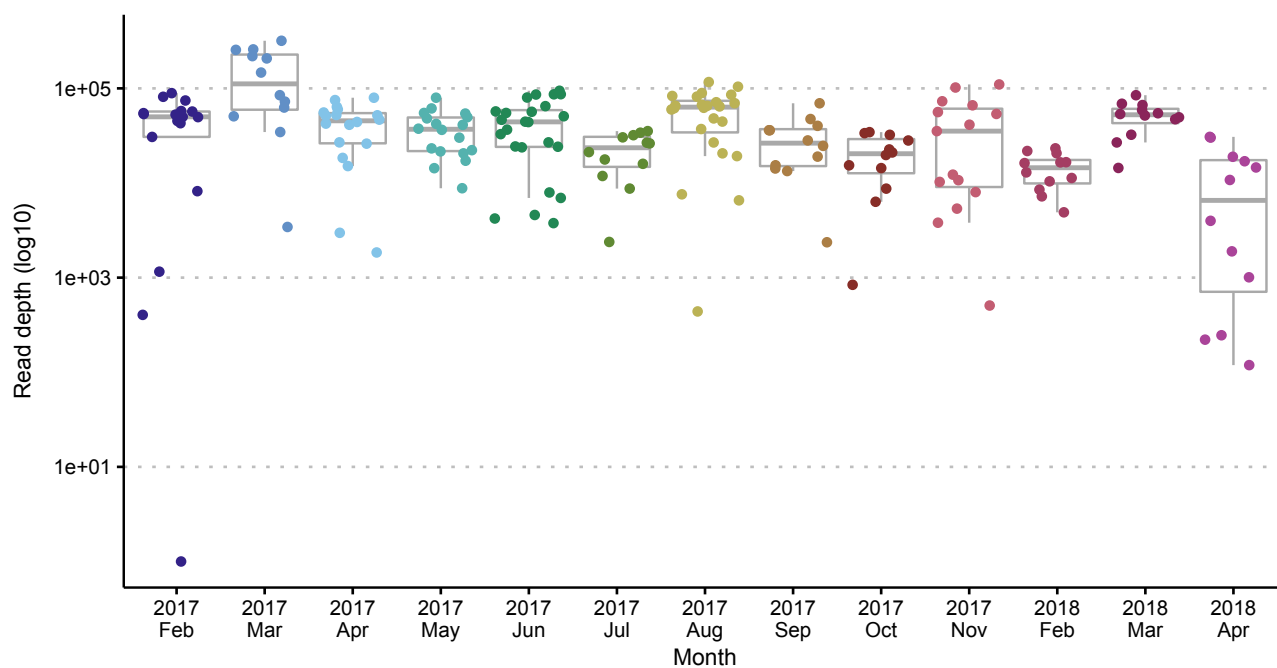
Data description for:
Reproduction explains marine eDNA variation

Rupert A. Collins, Charles Baillie, Nicholas C. Halliday, Sophie Rainbird,
David W. Sims, Stefano Mariani and Martin J. Genner

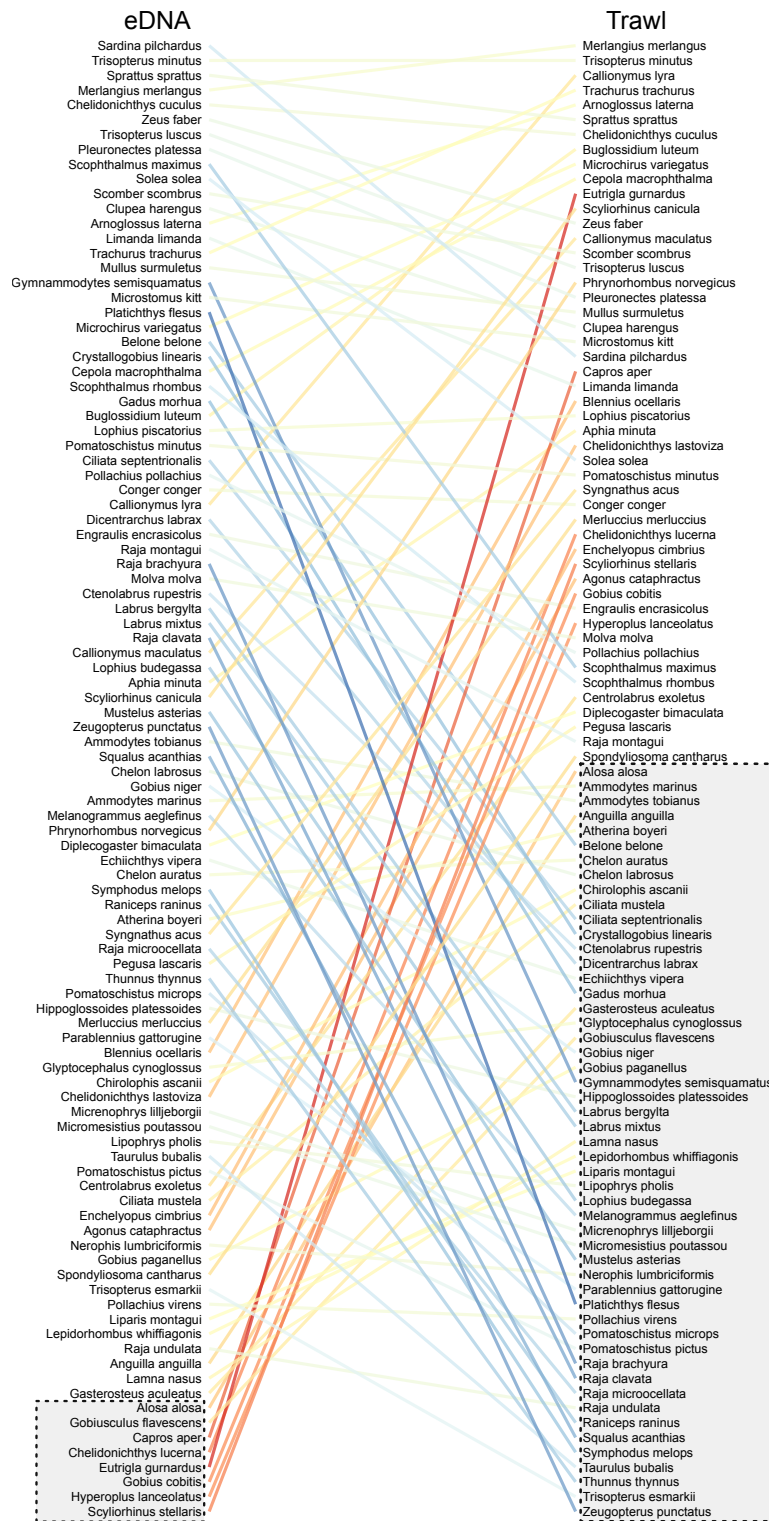
May 12, 2021



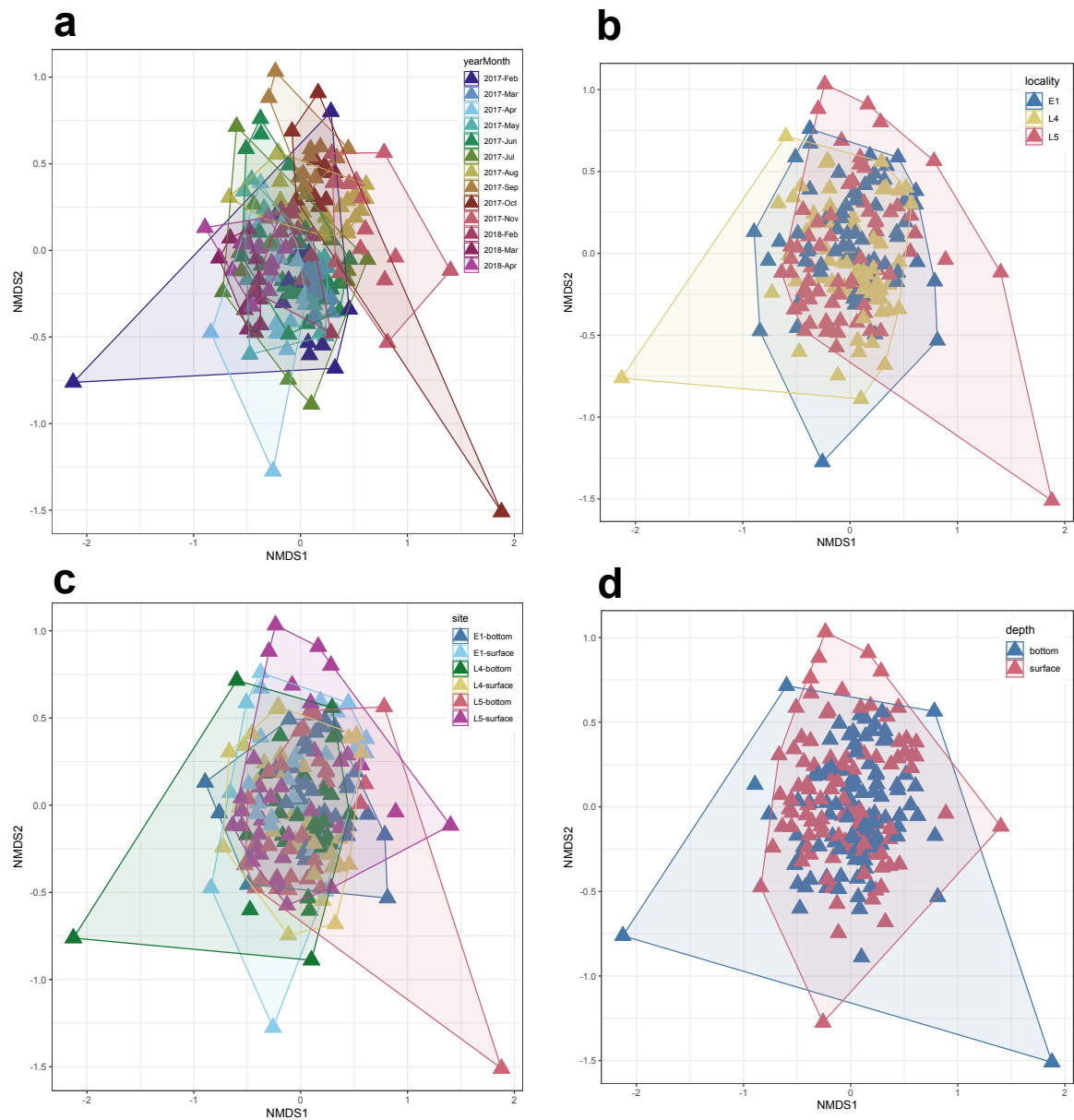
Supplementary Figure S1: Map of sampling locations in relation to the Western English Channel. Inset panel shows position of study area in reference to the UK and western Europe. Sampling locations L4, L5 and E1 are marked with red triangles.



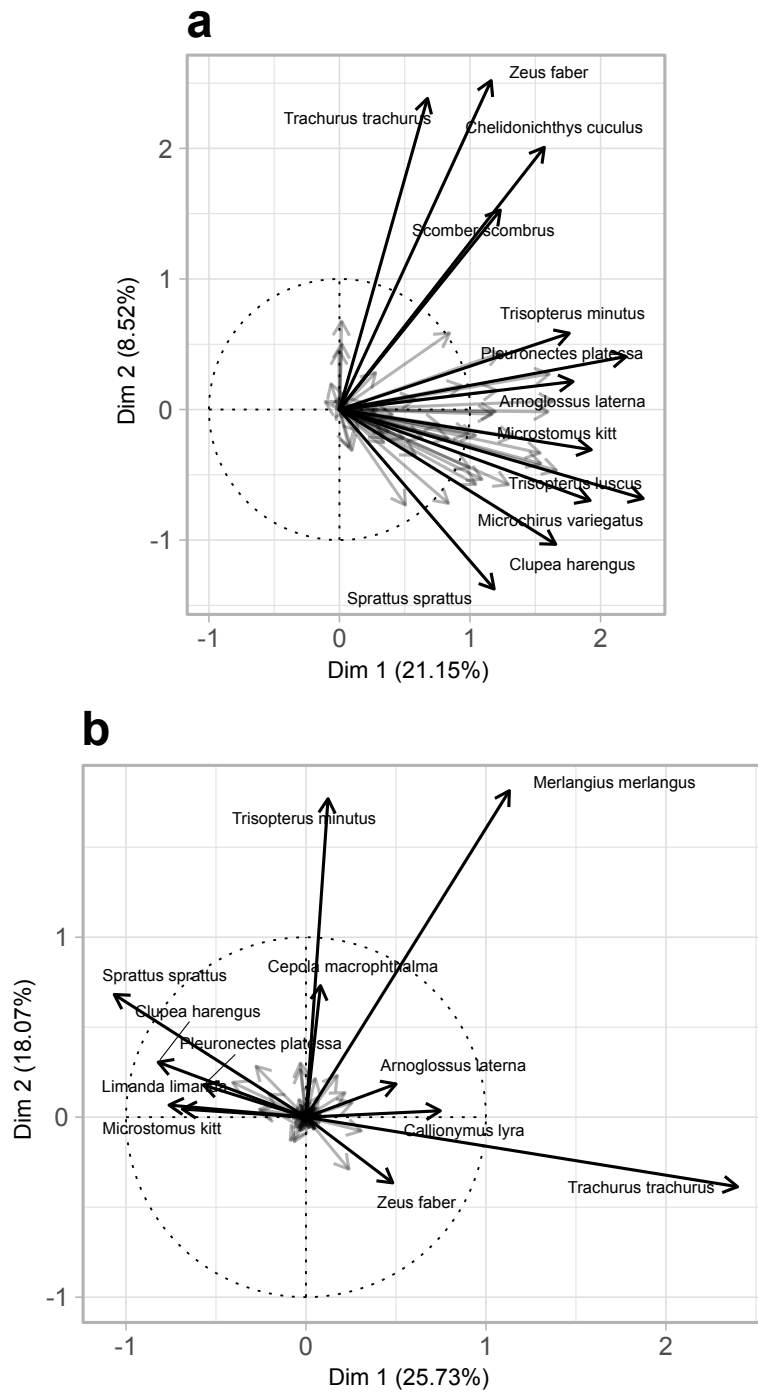
Supplementary Figure S2: Sequencing read depth per sample by month after bioinformatic processing and taxonomic assignment. All locations; samples $n = 200$; reads $n = 8,633,309$.



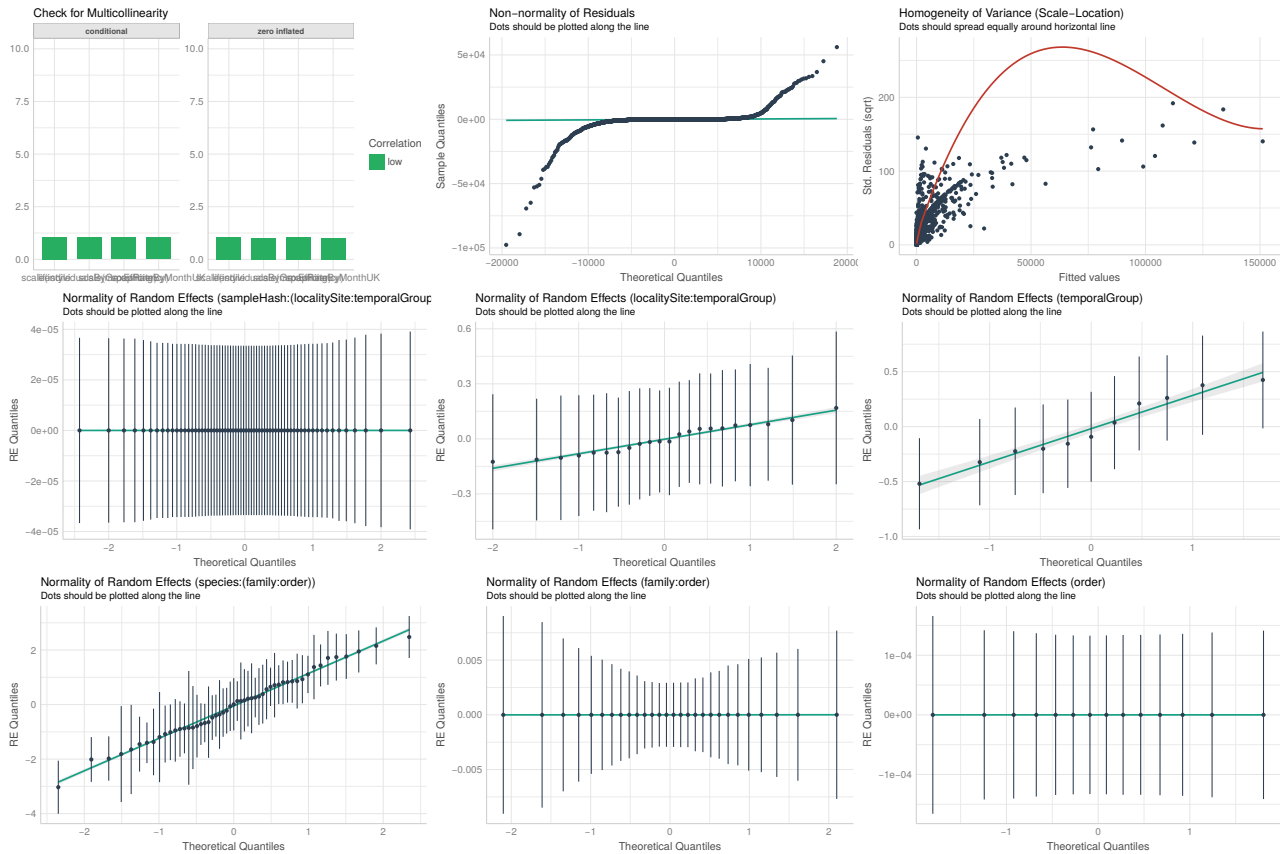
Supplementary Figure S3: Ranked species abundances for eDNA (all locations; species $n = 94$; reads $n = 8,633,309$) and demersal trawl (site L4; species $n = 49$; individuals $n = 99,026$) over survey period February 2017 to April 2018. Blue indicates eDNA rank higher than demersal trawl rank; red indicates demersal trawl rank higher than eDNA rank. Colour intensity reflects degree of difference in rank. Species in grey boxes are those with zero abundance.



Supplementary Figure S4: Patterns in eDNA variation. Non-metric multidimensional scaling (NMDS) ordinations of fish community eDNA by (a) month; (b) location; (c) location and water depth; and (d) water depth. Period Feb 2017 to Apr 2018; samples $n = 200$; reads $n = 8,633,309$. Stress = 0.278.



Supplementary Figure S5: Species contributions to principal components dimensions for (a) eDNA at all sites (period Feb 2017 to Apr 2018; samples $n = 200$; species $n = 94$; reads $n = 8,633,309$); and (b) demersal trawl at location L4 (period Jan 2016 to Nov 2017; samples $n = 62$; species $n = 70$; individuals $n = 180,738$). Only the top twelve species with the greatest contributions are labelled. These plots show a seasonal signal in different axes; in the demersal trawl data (b), this information is contained in the PC-1 axis (Dim 1), while in the eDNA data (a), this signal is contained in the PC-2 axis (Dim 2), with many of the same seasonal species represented. This is the same for the seasonal by-month plots in main Figure 1a,b. The PC-1 (eDNA) and PC-2 (trawl) axes represent overall species abundance.



Supplementary Figure S6: Model performance and diagnostics for the zero-inflated negative-binomial generalised-linear mixed-model fitted in the *glmmTMB* v1.0.2.1 package. Simplified model formula: $\text{reads} \sim \text{offset}(\text{sampleTotalReads}) + \text{trawlCPUE} + \text{PCRefficiency} + \text{reproductionMonth} + \text{lifestyle} + (1|\text{event/location/sample}) + (1|\text{order/family/species})$. Diagnostics were estimated with the *performance* v0.7.0 package.

Supplementary Table S1: Bioinformatic steps. Number reads remaining at each bioinformatic step for each library. Taxonomy assigned reads are reads assigned to species level using the curated British Isles fishes reference library (<https://doi.org/10.5281/zenodo.4646255>), and after exclusion of contaminant reads. Libraries 1 and 2 additionally include reads from other projects. Total study reads $n = 8,633,309$.

| Filtering step | Library1 | Library2 | Library3 | Library4 |
|----------------------|------------|-----------|-----------|-----------|
| Total passing filter | 11,870,442 | 8,452,438 | 5,121,196 | 5,521,444 |
| Detect primers | 9,117,734 | 6,267,911 | 4,164,044 | 4,379,211 |
| Demultiplex | 6,208,992 | 4,191,401 | 3,162,978 | 3,540,113 |
| Trim primers | 6,184,571 | 4,183,246 | 3,048,388 | 3,501,781 |
| Quality filter | 6,148,805 | 4,157,127 | 3,046,157 | 3,492,757 |
| Merge | 5,172,752 | 3,920,679 | 2,980,232 | 3,064,478 |
| Remove chimerae | 5,039,156 | 3,808,734 | 2,928,307 | 3,038,131 |
| Homology search | 4,962,399 | 3,776,147 | 2,881,204 | 2,983,483 |
| Taxonomy assigned | 3,138,146 | 2,743,460 | 2,076,113 | 2,481,562 |

Supplementary Table S2: Abundances by combined species ($n = 100$) for eDNA (all locations; species $n = 94$; reads $n = 8,633,309$) and demersal trawl (site L4; species $n = 49$; individuals $n = 99,026$) over the survey period (Feb 2017 to Apr 2018). Species merged reflect those that are not resolved in eDNA (*) or trawl survey ([†]) to species level.

| Family | Species | Merged taxa as | Total eDNA reads | Total trawl abundance |
|----------------|-------------------------------------|--|------------------|-----------------------|
| Anguillidae | <i>Anguilla anguilla</i> | | 41 | 0 |
| Congridae | <i>Conger conger</i> | | 21,425 | 6 |
| Atherinidae | <i>Atherina boyeri</i> | | 969 | 0 |
| Belonidae | <i>Belone belone</i> | | 88,575 | 0 |
| Clupeidae | <i>Alosa alosa</i> | | 1 | 0 |
| Clupeidae | <i>Clupea harengus</i> | | 162,400 | 90 |
| Clupeidae | <i>Sardina pilchardus</i> | | 1,735,703 | 60 |
| Clupeidae | <i>Sprattus sprattus</i> | | 921,236 | 1,739 |
| Engraulidae | <i>Engraulis encrasicolus</i> | | 14,978 | 2 |
| Gadidae | <i>Gadus morhua</i> | | 43,992 | 0 |
| Gadidae | <i>Melanogrammus aeglefinus</i> | <i>Merlangius/Melanogrammus*</i> | 2,124 | 0 |
| Gadidae | <i>Merlangius merlangus</i> | <i>Merlangius/Melanogrammus*</i> | 631,654 | 43,112 |
| Gadidae | <i>Micromesistius poutassou</i> | | 518 | 0 |
| Gadidae | <i>Pollachius pollachius</i> | | 22,327 | 2 |
| Gadidae | <i>Pollachius virens</i> | | 72 | 0 |
| Gadidae | <i>Raniceps raninus</i> | | 979 | 0 |
| Gadidae | <i>Trisopterus esmarkii</i> | | 83 | 0 |
| Gadidae | <i>Trisopterus luscus</i> | | 382,281 | 152 |
| Gadidae | <i>Trisopterus minutus</i> | | 1,409,597 | 39,411 |
| Lotidae | <i>Ciliata mustela</i> | | 376 | 0 |
| Lotidae | <i>Ciliata septentrionalis</i> | | 23,853 | 0 |
| Lotidae | <i>Enchelyopus cimbrius</i> | | 268 | 4 |
| Lotidae | <i>Molva molva</i> | | 10,462 | 2 |
| Merlucciidae | <i>Merluccius merluccius</i> | | 770 | 6 |
| Gasterosteidae | <i>Gasterosteus aculeatus</i> | | 2 | 0 |
| Gobiesocidae | <i>Diplecogaster bimaculata</i> | | 2,014 | 1 |
| Lophiidae | <i>Lophius budegassa</i> | | 4,450 | 0 |
| Lophiidae | <i>Lophius piscatorius</i> | | 39,061 | 31 |
| Mugilidae | <i>Chelon auratus</i> | | 1,602 | 0 |
| Mugilidae | <i>Chelon labrosus</i> | <i>Chelon labrosus/ramada*</i> | 2,727 | 0 |
| Ammodytidae | <i>Ammodytes marinus</i> | <i>Ammodytidae*</i> | 2,313 | 0 |
| Ammodytidae | <i>Ammodytes tobianus</i> | <i>Ammodytidae*</i> | 3,057 | 0 |
| Ammodytidae | <i>Gymnammodytes semisquamatus</i> | <i>Ammodytidae*</i> | 135,574 | 0 |
| Ammodytidae | <i>Hyperoplus lanceolatus</i> | <i>Ammodytidae*</i> | 0 | 2 |
| Blenniidae | <i>Blennius ocellaris</i> | | 704 | 33 |
| Blenniidae | <i>Lipophrys pholis</i> | | 503 | 0 |
| Blenniidae | <i>Parablennius gattorugine</i> | | 731 | 0 |
| Callionymidae | <i>Callionymus lyra</i> | | 20,676 | 3,821 |
| Callionymidae | <i>Callionymus maculatus</i> | | 5,641 | 231 |
| Caproidae | <i>Capros aper</i> | | 0 | 44 |
| Carangidae | <i>Trachurus trachurus</i> | | 140,328 | 3,534 |
| Cepolidae | <i>Cepola macrophthalmia</i> | | 73,381 | 531 |
| Gobiidae | <i>Aphia minuta</i> | <i>Aphia/Crystallogobius[†]</i> | 4,353 | 24 |
| Gobiidae | <i>Crystallogobius linearis</i> | <i>Aphia/Crystallogobius[†]</i> | 76,700 | 0 |
| Gobiidae | <i>Gobiusculus flavescens</i> | | 1 | 0 |
| Gobiidae | <i>Gobius cobitis</i> | <i>Gobius[†]</i> | 0 | 3 |
| Gobiidae | <i>Gobius niger</i> | <i>Gobius[†]</i> | 2,583 | 0 |
| Gobiidae | <i>Gobius paganellus</i> | <i>Gobius[†]</i> | 126 | 0 |
| Gobiidae | <i>Pomatoschistus microps</i> | <i>Pomatoschistus[†]</i> | 837 | 0 |
| Gobiidae | <i>Pomatoschistus minutus</i> | <i>Pomatoschistus[†]</i> | 24,275 | 11 |
| Gobiidae | <i>Pomatoschistus pictus</i> | <i>Pomatoschistus[†]</i> | 423 | 0 |
| Labridae | <i>Centrolabrus exoletus</i> | | 382 | 1 |
| Labridae | <i>Ctenolabrus rupestris</i> | | 9,961 | 0 |
| Labridae | <i>Labrus bergylta</i> | | 8,426 | 0 |
| Labridae | <i>Labrus mixtus</i> | | 8,101 | 0 |
| Labridae | <i>Symphodus melops</i> | | 1,412 | 0 |
| Moronidae | <i>Dicentrarchus labrax</i> | | 17,359 | 0 |
| Mullidae | <i>Mullus surmuletus</i> | | 139,673 | 95 |
| Scombridae | <i>Scomber scombrus</i> | | 188,730 | 182 |
| Scombridae | <i>Thunnus thynnus</i> | | 852 | 0 |
| Sparidae | <i>Spondyliosoma cantharus</i> | | 85 | 1 |
| Stichaeidae | <i>Chirolophis ascanii</i> | | 637 | 0 |
| Trachinidae | <i>Echiichthys vipera</i> | | 1,714 | 0 |
| Bothidae | <i>Arnoglossus laterna</i> | | 155,723 | 1,773 |
| Pleuronectidae | <i>Glyptocephalus cynoglossus</i> | | 658 | 0 |
| Pleuronectidae | <i>Hippoglossoides platessoides</i> | | 836 | 0 |
| Pleuronectidae | <i>Limanda limanda</i> | | 152,373 | 41 |
| Pleuronectidae | <i>Microstomus kitt</i> | | 95,414 | 77 |
| Pleuronectidae | <i>Platichthys flesus</i> | | 93,679 | 0 |
| Pleuronectidae | <i>Pleuronectes platessa</i> | | 299,650 | 97 |
| Scophthalmidae | <i>Lepidorhombus whiffiagonis</i> | | 49 | 0 |
| Scophthalmidae | <i>Phrynorhombus norvegicus</i> | | 2,119 | 116 |
| Scophthalmidae | <i>Scophthalmus maximus</i> | | 201,003 | 2 |
| Scophthalmidae | <i>Scophthalmus rhombus</i> | | 62,668 | 2 |
| Scophthalmidae | <i>Zeugopterus punctatus</i> | | 3,761 | 0 |
| Soleidae | <i>Buglossidium luteum</i> | | 41,142 | 891 |
| Soleidae | <i>Microchirus variegatus</i> | | 92,396 | 864 |
| Soleidae | <i>Pegusa lascaris</i> | | 890 | 1 |
| Soleidae | <i>Solea solea</i> | | 189,255 | 14 |
| Agonidae | <i>Agonus cataphractus</i> | | 192 | 3 |
| Cottidae | <i>Micrenophrys lilljeborgii</i> | | 557 | 0 |
| Cottidae | <i>Taurulus bubalis</i> | | 426 | 0 |
| Liparidae | <i>Liparis montagui</i> | | 59 | 0 |
| Triglidae | <i>Chelidonichthys cuculus</i> | <i>Triglidae*</i> | 409,796 | 942 |
| Triglidae | <i>Chelidonichthys lastoviza</i> | <i>Triglidae*</i> | 586 | 15 |
| Triglidae | <i>Chelidonichthys lucerna</i> | <i>Triglidae*</i> | 0 | 4 |
| Triglidae | <i>Eutrigla gurnardus</i> | <i>Triglidae*</i> | 0 | 494 |
| Syngnathidae | <i>Nerophis lumbriciformis</i> | | 186 | 0 |
| Syngnathidae | <i>Syngnathus acus</i> | | 920 | 9 |
| Zeidae | <i>Zeus faber</i> | | 394,102 | 249 |
| Scyliorhinidae | <i>Scyliorhinus canicula</i> | | 4,106 | 296 |
| Scyliorhinidae | <i>Scyliorhinus stellaris</i> | | 0 | 4 |
| Triakidae | <i>Mustelus asterias</i> | | 4,074 | 0 |
| Lamnidae | <i>Lamna nasus</i> | | 4 | 0 |
| Rajidae | <i>Raja brachyura</i> | | 11,037 | 0 |
| Rajidae | <i>Raja clavata</i> | | 5,658 | 0 |
| Rajidae | <i>Raja microcellata</i> | | 910 | 0 |
| Rajidae | <i>Raja montagui</i> | | 12,135 | 1 |
| Rajidae | <i>Raja undulata</i> | | 48 | 0 |
| Squalidae | <i>Squalus acanthias</i> | | 2,819 | 0 |

Supplementary Table S3: Model output for the zero-inflated negative-binomial generalised-linear mixed-model fitted in the *glmmTMB* v1.0.2.1 package for R. Simplified model formula: reads ~ offset(sampleTotalReads) + trawlCPUE + PCRefficiency + reproductionMonth + lifestyle + (1|event/location/sample) + (1|order/family/species).

| Effect | Component | Grouping | Term | Estimate | Std. error | Statistic | p value |
|---------|-----------|---|-------------------------------|----------|------------|-----------|----------|
| fixed | cond | | (Intercept) | -5.41 | 0.28 | -19.48 | 1.66e-84 |
| fixed | cond | | scale(individualsByGroupRate) | 0.16 | 0.04 | 4.46 | 8.02e-06 |
| fixed | cond | | scale(maxEfficiency) | 0.81 | 0.19 | 4.35 | 1.36e-05 |
| fixed | cond | | spawningByMonthUKTRUE | 0.83 | 0.13 | 6.49 | 8.30e-11 |
| fixed | cond | | lifestylebenthopelagic | 0.59 | 0.42 | 1.41 | 1.58e-01 |
| fixed | cond | | lifestylepelagic | 1.26 | 0.54 | 2.31 | 2.11e-02 |
| fixed | zi | | (Intercept) | -0.01 | 0.49 | -0.03 | 9.79e-01 |
| fixed | zi | | scale(individualsByGroupRate) | -4.98 | 1.82 | -2.74 | 6.16e-03 |
| fixed | zi | | scale(maxEfficiency) | -0.21 | 0.27 | -0.78 | 4.33e-01 |
| fixed | zi | | spawningByMonthUKTRUE | -0.31 | 0.12 | -2.53 | 1.15e-02 |
| fixed | zi | | lifestylebenthopelagic | 0.24 | 0.56 | 0.43 | 6.68e-01 |
| fixed | zi | | lifestylepelagic | 0.05 | 0.73 | 0.07 | 9.45e-01 |
| ranpars | cond | sampleHash:(localitySite:temporalGroup) | sd(Intercept) | 0.00 | | | |
| ranpars | cond | localitySite:temporalGroup | sd(Intercept) | 0.17 | | | |
| ranpars | cond | temporalGroup | sd(Intercept) | 0.35 | | | |
| ranpars | cond | species:(family:order) | sd(Intercept) | 1.24 | | | |
| ranpars | cond | family:order | sd(Intercept) | 0.00 | | | |
| ranpars | cond | order | sd(Intercept) | 0.00 | | | |
| ranpars | zi | sampleHash:(localitySite:temporalGroup) | sd(Intercept) | 0.25 | | | |
| ranpars | zi | localitySite:temporalGroup | sd(Intercept) | 0.31 | | | |
| ranpars | zi | temporalGroup | sd(Intercept) | 0.88 | | | |
| ranpars | zi | species:(family:order) | sd(Intercept) | 1.00 | | | |
| ranpars | zi | family:order | sd(Intercept) | 1.12 | | | |
| ranpars | zi | order | sd(Intercept) | 0.00 | | | |

Supplementary Table S4: Average number reads by library after bioinformatic processing and taxonomic assignment, including mean and standard deviation (sd). Samples total $n = 200$; reads $n = 8,633,309$.

| Library | Samples (n) | Reads (mean) | Reads (sd) |
|---------|-----------------|--------------|------------|
| lib1 | 36 | 45,803 | 30,447 |
| lib2 | 53 | 46,015 | 24,577 |
| lib3 | 72 | 28,742 | 23,627 |
| lib4 | 39 | 63,573 | 80,704 |

Supplementary Table S5: Summary of control samples by library ($n = 93$).

| Library | Control type | Sample ID | Number reads |
|---------|------------------|---------------|--------------|
| lib1 | Extraction blank | aa00a01558fc | 115 |
| lib1 | Extraction blank | fc7e08b091ba | 43 |
| lib1 | Field blank | 0047ab44449d | 62 |
| lib1 | Field blank | fb41386052ce | 0 |
| lib1 | PCR blank | e41eef009613 | 83 |
| lib2 | Extraction blank | 2723335dd699 | 75 |
| lib2 | Extraction blank | 1d6a9604b69a | 35 |
| lib2 | Extraction blank | 18e13d408025 | 1 |
| lib2 | Extraction blank | e56ed77c409c | 0 |
| lib2 | Field blank | 60574c8b9eba | 7,076 |
| lib2 | PCR blank | a802ceaed424 | 23 |
| lib2 | Tag blank | fd9979c924ea | 43 |
| lib2 | Tag blank | 837dffdd2089f | 31 |
| lib2 | Tag blank | ee8208a32209 | 26 |
| lib2 | Tag blank | 6e39d4ff8cc0 | 22 |
| lib2 | Tag blank | e421fcbbf3d9 | 19 |
| lib2 | Tag blank | 66dcca9289f0 | 7 |
| lib2 | Tag blank | 98be275d78bd | 7 |
| lib2 | Tag blank | 273b42d31b7d | 5 |
| lib2 | Tag blank | c92254f55b76 | 3 |
| lib2 | Tag blank | 6385960f439b | 2 |
| lib3 | Extraction blank | ab51842343ee | 0 |
| lib3 | Extraction blank | ad48ae2c8844 | 0 |
| lib3 | Field blank | 5b418dd9a365 | 6,695 |
| lib3 | Field blank | 6ef9609590d0 | 0 |
| lib3 | PCR blank | 5c16cb6d6673 | 0 |
| lib3 | PCR blank | 45e5b060e9a6 | 0 |
| lib3 | PCR blank | aae911df243d | 0 |
| lib3 | PCR blank | fa599638a519 | 0 |
| lib3 | Tag blank | bc171adbdb4a | 0 |
| lib3 | Tag blank | 5907f3ea2903 | 0 |
| lib3 | Tag blank | f5c0f9c31109 | 0 |
| lib3 | Tag blank | a1face388953 | 0 |
| lib3 | Tag blank | 3de083adb338 | 0 |
| lib3 | Tag blank | defe144e2282 | 0 |
| lib3 | Tag blank | b999389d8ce7 | 0 |
| lib3 | Tag blank | 8f2cf8de203f | 0 |
| lib3 | Tag blank | a1875aaaf2da | 0 |
| lib3 | Tag blank | 2d27a3ee1f02 | 0 |
| lib3 | Tag blank | 855cbc8af0d0 | 0 |
| lib3 | Tag blank | 2958706ff8f2 | 0 |
| lib3 | Tag blank | be6d9f88dc9f | 0 |
| lib3 | Tag blank | 0befac7a352d | 0 |
| lib3 | Tag blank | 5dad9ae4982b | 0 |
| lib3 | Tag blank | 785f96048ec4 | 0 |
| lib4 | Extraction blank | 8d7d1a314a0d | 0 |
| lib4 | Extraction blank | 6c91ad5ee0a6 | 0 |
| lib4 | Field blank | a448daac3e5e | 1,105 |
| lib4 | Field blank | c420024be825 | 1,096 |
| lib4 | Tag blank | c8bf098fc98b | 0 |
| lib4 | Tag blank | 88ec6aebca28 | 0 |
| lib4 | Tag blank | c3edbae02aff | 0 |
| lib4 | Tag blank | 140141bf6315 | 0 |
| lib4 | Tag blank | d62693c7cfb0 | 0 |
| lib4 | Tag blank | 15f304f0eb64 | 0 |
| lib4 | Tag blank | 3c2964eefd5c | 0 |
| lib4 | Tag blank | 2d0519ce967f | 0 |
| lib4 | Tag blank | 64a858406351 | 0 |
| lib4 | Tag blank | 1f5538f9345c | 0 |
| lib4 | Tag blank | 01a25be35e22 | 0 |
| lib4 | Tag blank | d1f5b2446f09 | 0 |
| lib4 | Tag blank | b72a233792db | 0 |
| lib4 | Tag blank | e422478bcee9 | 0 |
| lib4 | Tag blank | cb4acdc15c90 | 0 |
| lib4 | Tag blank | 4a99e71fc03b | 0 |
| lib4 | Tag blank | 9ca2fc590464 | 0 |
| lib4 | Tag blank | f136beeadf8b | 0 |
| lib4 | Tag blank | b0cec63878a3 | 0 |
| lib4 | Tag blank | dc22e1b82e37 | 0 |
| lib4 | Tag blank | 950236cfaa59 | 0 |
| lib4 | Tag blank | aebd388759f1 | 0 |
| lib4 | Tag blank | 0cc22a1a1497 | 0 |
| lib4 | Tag blank | 69c12c4a2362 | 0 |
| lib4 | Tag blank | c64b68fa8a1b | 0 |
| lib4 | Tag blank | 74ae607effb5 | 0 |
| lib4 | Tag blank | ba4c134f870f | 0 |
| lib4 | Tag blank | cce48ca850ac | 0 |
| lib4 | Tag blank | 8a18852f4533 | 0 |
| lib4 | Tag blank | 2ebbe5f3151e | 0 |
| lib4 | Tag blank | 4226a7249142 | 0 |
| lib4 | Tag blank | 92b29f0ec50c | 0 |
| lib4 | Tag blank | f1d036b2dc7c | 0 |
| lib4 | Tag blank | 442363d7f0ea | 0 |
| lib4 | Tag blank | 4486f8f53fab | 0 |
| lib4 | Tag blank | 5005696b37f8 | 0 |
| lib4 | Tag blank | 4a3198fc1bf4 | 0 |
| lib4 | Tag blank | bed1533422e4 | 0 |
| lib4 | Tag blank | fb00d702c29b | 0 |
| lib4 | Tag blank | cceb0b3241d2 | 0 |
| lib4 | Tag blank | 81ac963d71f3 | 0 |
| lib4 | Tag blank | 9304480254b6 | 0 |
| lib4 | Tag blank | 4e617b435cd9 | 0 |
| lib4 | Tag blank | 9b9ca0e27633 | 0 |