

Emodnet Project Final Report

Integrating biological traits of European marine benthic taxa into the World Register of Marine Species

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1. List of the targeted traits and their definitions.

Body Size - linear dimension (e.g. shell height (snails), total body width (crabs) or total length (shrimps, worms) (Tyler dataset metadata)). 'Type' indicates whether the size measurement is minimum, maximum, unknown, or average size of a mature individual, or the midpoint of a BIOTIC size category. BIOTIC categories are <1cm, 1-2cm, 3-10cm, 11-20 cm, 21-50cm; 50+cm, so we use values of 1cm (recorded as maximum), 1.5cm, 6.5cm, 15.5cm, 35.5cm, (all recorded as midpoint of BIOTIC category), and 50cm (recorded as minimum). Extra information is included in the notes field (eg. 'includes proboscis', 'disk diameter' for echinoderms). Units are defined in the 'units' field. Micrometres are represented as 'um'.

Feeding method - the mode of feeding, rather than what is eaten, e.g. predator, browser, suspension feeder (Tyler dataset metadata). This is a hierarchical system, with (for example) 'active suspension feeder' and 'passive suspension feeder' being subcategories of the more generic 'suspension feeder'. We record the most detailed description available. 'Filter feeder' and 'suspension feeder' are defined in the same way in the Tyler dataset, yet both terms are used throughout the dataset, so we used the terms as provided in the dataset. Note: we think it may be beneficial to collapse both of the terms 'filter feeder' and 'suspension feeder' into a single term, probably 'suspension feeder' as there is no obvious difference between the two (see below). However, we would like to ensure there is no obvious difference in morphology between the two groups before implementing this change.

- Predator - An organism that feeds by preying on other organisms, killing them for food (Lincoln et al., 1998) (BIOTIC glossary).
- Deposit feeder - Any organism which feeds on fragmented particulate organic matter from the substratum; detritivores (from Lincoln, et al., 1998) (BIOTIC glossary).
 - Surface deposit feeder - Obtaining food from the surface of the substratum (e.g. *Corophium volutator*) (BIOTIC glossary).
- Filter feeder – defined in Tyler metadata as being equivalent to suspension feeding, so see definition below.
- Suspension feeder - Any organism which feeds on particulate organic matter, including plankton, suspended in the water column (from Lincoln et al., 1998) (BIOTIC glossary).
 - Active suspension feeder - Catching food on a filter from water by actively sweeping (e.g. *Porcellana platychelyes*) or pumping (e.g. sea squirts, many bivalve molluscs) (BIOTIC glossary).

- Passive suspension feeder - Catching food on a filter held into flowing water (e.g. hydroids, sea fans, sea pens), or collecting the 'rain' of detritus on sticky apparatus other than a filter (e.g. *Cucumaria frondosa*) (BIOTIC glossary).
- Scavenger - Any organism that actively feeds on dead organic material (e.g. crabs, whelks) (BIOTIC glossary).
- Browser – an animal which browses (Oxford English Dictionary); NB distinction from Grazer unclear – terrestrial equivalent would be something that browses on leaves rather than grazing grass, so possibly relevant for macrophyte-feeders? We have kept it as a category as it is used in Tyler et al.
- Grazer - Animals which rasp benthic algae (or sessile animals, such as bryozoan crusts), (BIOTIC glossary).

Diet – specific dietary components (Tyler dataset metadata). We entered the terms as provided in the dataset, and used a notes field to record specific dietary components within a category. Note: Higher classifications are included in this list of definitions eg. 'neuston', 'nekton' where they are not directly entered in our new database.

- Omnivore - Animal which feeds on a mixed diet including plant and animal material (from Lincoln et al., 1998) (BIOTIC glossary).
- Algae – diet consists of algae. Only entered if there was no further information on the type of algae (below).
 - Macroalgae – algae of macroscopic size (multicellular), (includes algal spores).
 - Microalgae – algae of microscopic size (unicellular), (includes diatoms).
- Plankton – feeds on organisms living in the water column but not actively moving (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte). Only entered where there is no further information on the type of plankton (below).
 - Zooplankton – animal plankton.
 - Phytoplankton – planktonic algae.
- Suspended particles/material – feeds on particles or material held floating in the water column. Falls under 'seston'.
- Seston – feeds on suspended particles (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer and Dr Leen Vandepitte).
- Sediment particles – feeds on non-living matter settled on the sea floor.
- Benthic organisms – feeds on flora and/or fauna on the sea bed.
- Detritus – feeds on decaying organic matter (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte), (includes organic matter, particles or suspended organic matter, in line with Tyler metadata).
- Microorganisms – feeds on microscopic (unicellular) organisms, (including bacteria).
- Nekton – feeds on organisms that swim actively in the water column (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte).
- Neuston - feeds on organisms living at the surface of the water (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte).

Lifespan - expected total lifespan expressed in years (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte). For the majority of cases, we entered the actual value, and also

recorded under 'type' whether this value refers to minimum, maximum, average, or unknown (unspecified) lifespan. Where BIOTIC is the source, we used the midpoint of the appropriate range and recorded 'midpoint of BIOTIC category' under 'type', except for the BIOTIC category '100+y' where we entered '100' and 'minimum'. The unit is years in all cases. Where a range is given, we include both ends of the range in two separate entries, setting the 'type' field to minimum and maximum respectively. If a single value is given, but no indication of whether this was a single measurement or an average, we set type to 'unknown'. Where the lifespan was given as a range from 0-x (mostly done in Heidi Tillin and Julie Bremner data, references 5 and 6) the lower was omitted and the trait was entered as 'x' and 'maximum'.

Age at maturity - the age at which an average individual becomes sexually mature (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte). As for lifespan, we enter the actual value and record its 'type' as minimum, maximum, average, unknown. For cases where BIOTIC is the source, we use the midpoint of the range, recording 'type' as 'midpoint of BIOTIC category'. Units are years. Where a range is given from a source other than BIOTIC, we include both ends of the range in two separate entries, setting the 'type' field to minimum and maximum respectively. If a single value is given, but no indication of whether this was a single measurement or an average, type is 'unknown'. Where the age at maturity was given as a range from 0-x (mostly done in Heidi Tillin and Julie Bremner data, references 5 and 6) the lower was omitted and the trait was entered as 'x' and 'maximum'.

Reproductive frequency - the number of breeding attempts per year. Breeding is defined as the release of eggs, larvae or gametes externally from the parent (which stage is released can depend on how much brooding occurs) (Tyler dataset metadata).

- Semelparous - Breeding only once then dying (Barnes et al., 1993) (BIOTIC glossary).
- Annual – breeds every year (BIOTIC glossary).
- Biannual – breeds twice in any one year.
- <Annual – breeds less than once a year (e.g. every 2 years).

Reproductive period - the length of time over which breeding/spawning takes place (Tyler dataset metadata; this definition was originally given to the trait 'reproductive duration', but we have renamed this trait).

- Episodic – breeds in one or more discrete periods initiated by some trigger (for example a lunar cycle) (BIOTIC glossary). Includes 'one seasonal peak per year'.
- Protracted – breeds over an extended or drawn out period (BIOTIC glossary).

Reproductive timing - the months or season in which breeding/spawning takes place (Tyler dataset metadata; this definition was originally given to the trait 'reproductive season', but we have renamed this trait). The starting and ending month of the reproductive season are recorded as two separate entries. We record 'continuous' as starting in January and ending in December. Where seasons are given, we record this information. Two breeding seasons, e.g. 'winter and summer', are recorded as two entries: "winter-winter" and "summer-summer". Where information on the geographical region is given, this is included in a notes field.

Fecundity - number of eggs, embryos or hatchlings produced in any one reproductive event (Tyler dataset metadata). This is documented in the same way as body size, lifespan and age at maturity, except that BIOTIC does not use categories for fecundity. All ranges are documented as separate entries for minimum and maximum. A 'notes' field records 'number of what', which is usually 'eggs', but could also be 'embryos', 'hatchlings' or 'oocytes'.

Size of eggs – egg diameter (Tyler dataset metadata). Documented in the same way as body size, lifespan and age at maturity, except that BIOTIC does not use categories for data associated with this trait. All ranges are documented as separate entries for minimum and maximum. Units are also recorded in a separate field, and are usually mm or micrometres (represented as um).

Developmental mechanism - the presence (or not) of a larval stage, defined (following Pechenik 99) as a 'free living developmental dispersive stage that is morphologically and ecologically distinct from the adult' (Tyler dataset metadata). This trait is hierarchical, however, unlike previous traits, only the larger groups are entered as the developmental mechanism, and the lower groups are entered in a 'notes' field.

- Direct development - Development without a larval stage (Barnes et al., 1993) (BIOTIC glossary).
 - Brooding - the incubation of eggs either inside or outside the body. Eggs may be brooded to a variety of developmental stages. Males or females may be responsible for brooding (adapted from Ruppert & Barnes, 1994) (BIOTIC glossary).
 - Ovoviviparous - a type of reproduction in animals in which the embryo(s) develop in persistent membranes and hatch within the maternal body. No nutrition is derived from the mother (BIOTIC glossary).
 - Viviparous - a type of reproduction in animals in which the embryo(s) develop within and derive nourishment from the maternal body (BIOTIC glossary).
- Fission - A form of asexual multiplication involving division of the body into two or more parts each or all of which can grow into new individuals (Barnes et al., 1993) (BIOTIC glossary).
- Larval development – development involving a larval stage.
 - Pelagic larval development – development involving a larval stage of, or relating to the open sea, as distinguished from the shallow water near the coast, (Oxford English Dictionary). Includes 'larvae develop within the plankton' and 'planktonic development'.
 - Benthic larval development – development involving a larval stage of, or relating to the sea floor. Includes 'benthic development'.
- Unknown
 - Oviparous - a type of reproduction in animals in which the fertilized eggs are laid or spawned by the mother (BIOTIC glossary).

Larval feeding strategy – mode of feeding during the larval stage. Only relevant for species with larval development (see previous trait).

- Planktotrophic - Feeding at least in part on materials captured from the plankton (Barnes et al., 1993) (BIOTIC glossary).

- Lecithotrophic - Development at the expense of internal resources (i.e. yolk) provided by the female (Barnes et al., 1993) (BIOTIC glossary).

Larval duration - length of time existing as larva (Tyler dataset metadata), measured in days, with one month was taken as 30 days following the Tyler dataset metadata. All ranges are recorded as separate entries for minimum and maximum.

Movement method – mode of movement (Tyler dataset metadata). All information for each species are recorded, even if apparently contradictory in some species.

- Sessile – the organism does not move.
 - Permanent attachment - Non-motile; permanently attached at the base (Lincoln et al., 1998) (e.g. *Caryophyllia*), (BIOTIC glossary).
- Motile – an organism that is capable of independent movement (ie. not sessile).
 - Temporary attachment - Temporary / sporadic attachment. Attached to a substratum but capable of movement across (or through) it (e.g. *Actinia*) (BIOTIC glossary).
 - Burrower - An organism that lives or moves in a burrow (e.g. *Arenicola*) (BIOTIC glossary).
 - Crawler - An organism that moves along on the substratum via movements of its legs, appendages or muscles (e.g. *Carcinus*) (BIOTIC glossary).
 - Swimmer - An organism that moves through the water column via movements of its fins, legs or appendages, via undulatory movements of the body or via jet propulsion (e.g. *Gadus*, *Loligo*) (BIOTIC glossary).
 - Floater - An organism whose movement is dependent on wind or water currents (e.g. *Aurelia*) (BIOTIC glossary).
 - Tube-dwelling – an organism that lives or moves in a tube ie. tubicolous (Barnes et al., 1993) (BIOTIC Glossary).

Migration - defined as significant movement outside normal daily movements post first settlement. Does not include diel movements, or movements up and down the water column. Does include life stage and seasonal migration, migration for reproduction and movement from nursery to other habitats, even if these only occur once in the lifespan (Tyler dataset metadata).

- Non-migratory - Remaining within the same area (from Lincoln et al., 1998), (BIOTIC glossary).
- Migratory
 - Irregular – no specific or obvious pattern to the migration.
 - Single migration – migrates once in a lifetime.
 - No evidence – where there is no evidence that migration occurs.

Sociability - local aggregation of individuals (Tyler dataset metadata).

- Solitary - Living alone, not gregarious (Thompson, 1995) (BIOTIC glossary).
- Sometimes gregarious – sometimes living in groups or communities, growing in clusters (Thompson, 1995) (BIOTIC glossary).

- Gregarious - Living in groups or communities, growing in clusters (Thompson, 1995) (BIOTIC glossary).
- Colonial - Descriptive of organisms produced asexually which remain associated with each other; in many animals, retaining tissue contact with other polyps or zooids as a result of incomplete budding (Barnes et al., 1993) (BIOTIC glossary).

Habitat - Whether a species is infaunal (living in the substrate) or epifaunal (living on the substrate), (Tyler dataset metadata; this trait was originally called 'inf_epi', but we have renamed it).

- Epifaunal – living on the substrate (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte).
 - Epilithic – living on a rock or other hard inorganic substrate (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte).
 - Epibenthic – living on the seabed (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte).
 - Epizoic – living on another organism without being a parasite eg. anemone living on a shell (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte).
 - Epiphytic – living on the surface of plants (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte).
- Infaunal – living in the substrate (discussion with Dr Tom Webb, Dr Stefanie Dekeyzer, and Dr Leen Vandepitte).
- Demersal - Living at or near the bottom of a sea or lake, but having the capacity for active swimming (from Lincoln et al., 1998) (BIOTIC glossary).

2. Number of species with trait data entered

The total number of species with data for each of the 17 traits considered is shown in fig 1. Note that some species have multiple records for certain traits, so the total number of records in the database do not match the numbers here. For example, there are 3789 individual body size records for 2076 valid species. Around half of these species (N = 1015) have a single body size record, but some have multiple records, with 56 species having 5 or more body size records. For the single best-known trait, maximum body size, we also show the distribution of trait values across all 2076 species with data (fig 2). Table 1 shows the distribution of trait values across categories for several of the categorical traits.

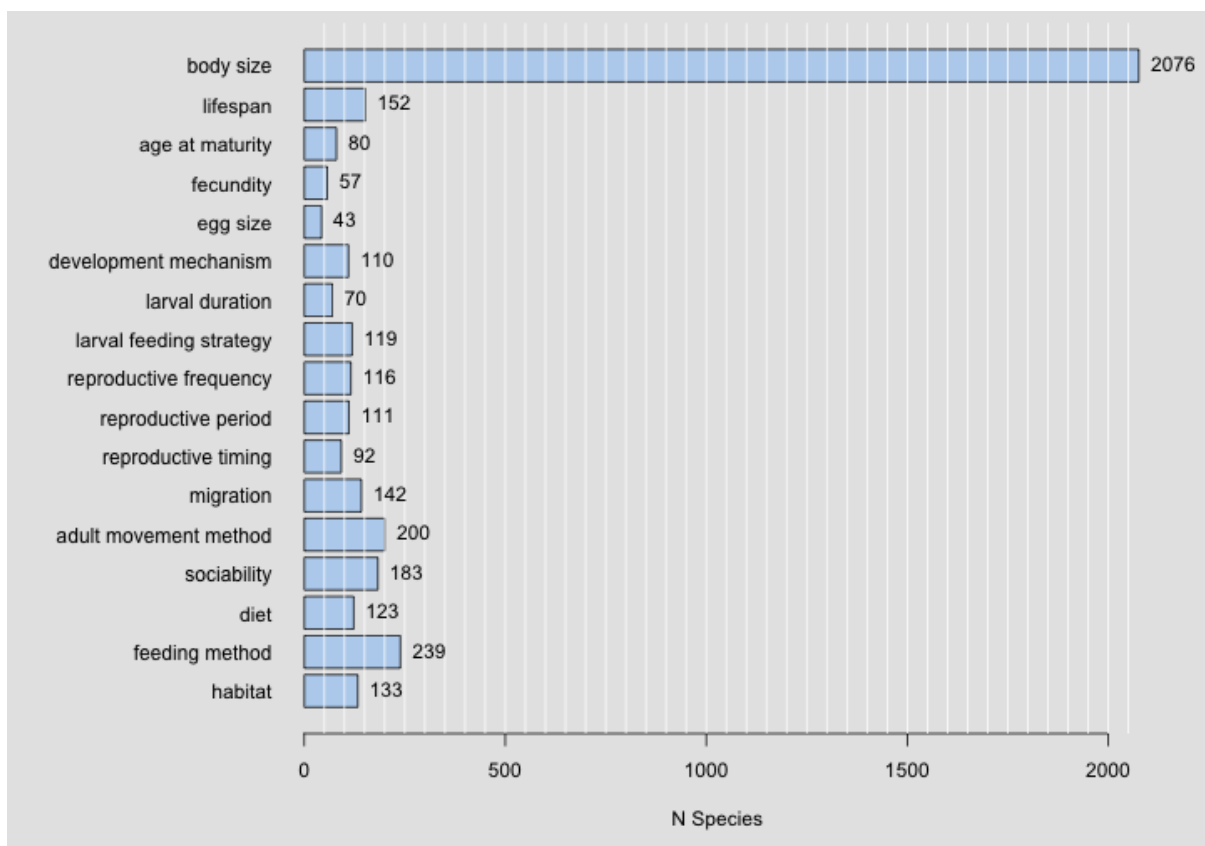


Figure 1. Total number of species (N Species) for which we have entered data for each of 17 traits.

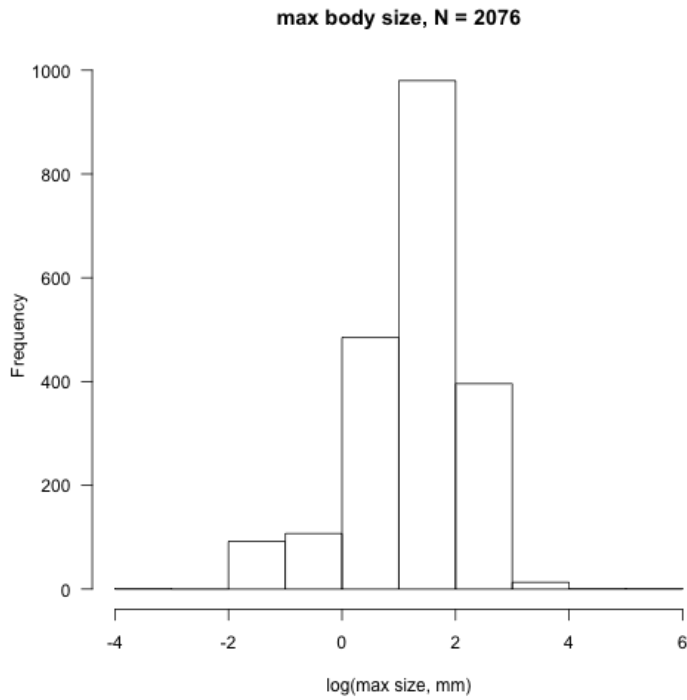


Figure 2. The frequency distribution of (\log_{10}) maximum body sizes across the 2076 species with at least one body size estimate.

Table 1. Number of records for each category for a number of key categorical traits.

Trait	Categories	Count
Development Mechanism	Benthic larval development	22
	Direct development	39
	Fission	2
	Larval development	1
	Oviparous	1
	Pelagic larval development	74
	Unknown	5
Diet	Algae	7
	Benthic organisms	53
	Detritus	61
	Macroalgae	5
	Meiobenthic organisms	1

	Micro-organisms	13
	Microalgae	12
	Omnivore	2
	Phytoplankton	25
	Plankton	11
	Sediment particles	3
	Suspended particles/material	16
	Zooplankton	12
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Feeding method	Active suspension feeder	63
	Browser	1
	Deposit feeder	85
	Filter feeder	28
	Grazer	3
	Passive suspension feeder	36
	Predator	94
	Scavenger	67
	Surface deposit feeder	54
	Suspension feeder	43
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Adult movement method	Burrower	148
	Crawler	104
	Floater	3
	Motile	3
	Permanent attachment	38
	Sessile	13
	Swimmer	67
	Temporary attachment	19
	Tube-dwelling	2
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3. Publications used for trait data

Bachelet, G. (1988). Recruitment in *Abra tenuis* (Montagu) (Bivalvia, Semelidae), a species with direct development and a protracted meiobenthic phase. In 23rd European Marine Biology Symposium (eds J.S. Ryland & P.A. Tyler), pp. 23-30. Olsen & Olsen, University of Wales, Swansea.

Bartolomaeus, T. (1998) Head kidneys in hatchlings of *Scoloplos armiger* (Annelida : Orbiniida): Implications for the occurrence of protonephridia in lecithotrophic larvae. *Journal of the Marine Biological Association of the United Kingdom*, 78(1), 183-92.

BIOTIC database accessed 21.08.13 <http://www.marlin.ac.uk/biotic/>

BIOTIC database accessed 05.07.10 and additional information from queries <http://www.marlin.ac.uk/biotic/>

BIOTIC database accessed 02.09.09 <http://www.marlin.ac.uk/biotic/>

BIOTIC database accessed 22.10.2008 <http://www.marlin.ac.uk/biotic/>

Blake, J.A. & Maciolek, N.J. (1987) A redescription of *Polydora cornuta* Bosc (Polychaeta: Spionidae) and designation of a neotype. *Bulletin of the Biological Society of Washington*, 7, 11-15.

Bousfield, E.L. (1973) *Shallow-water Gammaridean Amphipoda of New England* Cornell University Press, London.

Bremner, J. (2005). Assessing ecological functioning in marine benthic communities. School of Marine Science & Technology, University of Newcastle.
<https://theses.ncl.ac.uk/dspace/handle/10443/153>

Brown, R.A. & Seed, R. (1977). *Modiolus Modiolus* (L.)- an autecological study. In *Biology of Benthic Organisms* (eds B.F. Keegan, P.O. Ceidigh & P.J.S. Boaden), Vol. First edition, pp. 93-100. Pergamon Press, Oxford.

Chambers, S.J. & Garwood, P.R. (1992) *Polychaetes from Scottish Waters: Part 3 Family Nereidae* National Museums of Scotland.

Chambers, S. (1985) *Polychaetes from Scottish Waters: Part 2 Families Aphroditidae, Sigalionidae and Polyodontidae* Royal Scottish Museum Studies.

Coasts and seas of the United Kingdom (1997). Edited by J. H. Barne, C. F. Robson, S. S. Kaznowska, J. P. Doody, N. C. Davidson & A. L. Buck. JNCC

Downloaded from <http://www.ukbap.org.uk/newprioritylist.aspx> on 12.03.10- spreadsheet of all priority species and habitats. On UK BAP list' (for species), or 'Changes since original UK BAP list of habitats' (for habitats) that indicates if the species or habitat was part of the original UKBAP action plans, published 1995 - 1999. If no plan is listed (species) or the habitat is stated as new (habitats) then the species or habitat was added in the 2007 review and there is - as yet - no published UK action plan for that species or habitat. Need to pull out marine species

Eckert, G.L. (2003) Effects of the planktonic period on marine population fluctuations. *Ecology*, 84(2), 372-83.

Emson, R.H., Jones, M.B. & Whitfield, P.J. (1988). Habitat and latitude differences in reproductive pattern and life-history in the cosmopolitan brittle-star *Amphipholis squamata* (Echinodermata).

Emson, R.H. (1977). The polychaete *Eulalia viridis* (O. F. Muller) as an element in the energy dynamics of intertidal mussel clumps. In *Biology of Benthic Organisms* (eds B.F. Keegan, P.O. Ceidigh & P.J.S. Boaden), Vol. First edition, pp. 209-14. Pergamon Press, Oxford.

Examples of UK biogenic reef species protected by EU habitats directive as stated by the JNCC (2007) Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17.

Gerdes, D. (1977). The re-establishment of an *Amphiura filiformis* (O. F. Muller) population in the inner part of the German Bight. In *Biology of Benthic Organisms* (eds B.F. Keegan, P.O. Ceidigh & P.J.S. Boaden), Vol. First edition, pp. 277-84. Pergamon Press, Oxford.

Hart, B., Shillabeer, N. & Tapp, J.F. (1984). The feeding types of marine and estuarine animals- A bibliography. In, p 91. Brixham Laboratory.

Hayward, P.J. & Ryland, J.S., eds. (2007) *Handbook of the marine fauna of North-West Europe* Oxford University Press, Oxford, UK.

Hayward, P.J. & Ryland, J.S. (1990) *The marine fauna of the British Isles and north-west Europe* (2 vols) Clarendon Press, Oxford.

Larvalbase access date 21.07.10 <http://www.larvalbase.org/>

Mortensen, T.H. (1927) *Handbook of the Echinoderms of the British Isles* Humphrey Milford Oxford University Press, London.

Rees, H.L. & Dare, P.J. (1993). Sources of mortality and associated life-cycle traits of selected benthic species: a review. In *Fisheries Research Data Report*, p 36. Ministry for Agriculture, Fisheries and Food, Lowestoft.

Ref: EU habitats directive, Annex II, Animal and plant species of community interest whose conservation requires the designation of special areas of conservation

Relini, L.O. & Relini, G. (1988). Reproduction of *Nephrops norvegicus* L. in isothermal Mediterranean waters. In *23rd European Marine Biology Symposium* (eds J.S. Ryland & P.A. Tyler), pp. 153-60. Olsen & Olsen, University of Wales, Swansea.

Tillin, H. M., Hiddink, J. G., Jennings, S., & Kaiser, M. J. (2006). Chronic bottom trawling alters the functional composition of benthic invertebrate communities on a sea-basin scale. *Marine Ecology Progress Series*, 318, 31-45.

4. Problems encountered whilst documenting the trait information.

One of the major problems I encountered whilst entering trait data was that I noticed no pattern to the BIOTIC categories for the traits fecundity, larval duration and egg size. I am not convinced that BIOTIC documents these traits as categorical ranges, and think it is done as the raw data. I therefore went back through the Access file and changed any that had a "midpoint of BIOTIC category" under "type" and replaced these with maximum and minimum values.

Diet was quite difficult to convert to a simple and quantifiable format, and I had to add in a few more categories to take account of all the dietary components recorded in the Tyler dataset. These can be seen in the metadata, along with their definitions above.

Virtually all other problems were more to do with the datasets themselves, such as missing references, and inconsistencies in categories, rather than with the methods of entering the data itself.

5. My findings in general about the trait documentation in general and recommendations for the future.

I think it would certainly be very useful to create a universal template which can be used by anyone in the field looking to collect trait data. This would contain pre-discussed and agreed categories, and methods of measurement, similar to those that have been agreed in this project. That way, all trait data for marine species would be consistent. There would of course need to be some variation for different groups of living organisms, and habitats.

I also think that using categorical ranges to document continuous data overcomplicates the use of that data. For example, a category such as "0-5" would technically include values such as "0.2" which is obviously very different from 5. However, for our purposes, this has had to be recorded as "5, maximum" when no individual of this species has ever reached 5cm long, or 5 years old, or whatever the trait might happen to be. In addition, different publications and sources of data adopt different categories, which very often are not exchangeable, which makes data inconsistent when data from many sources are combined, such as in WoRMS. It would be interesting to look into the statistical issues this may cause.