Bioturbation Database for Benthic Invertebrates

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Introduction

Bioturbation, the reworking of sediment particles, can contribute to contaminant transport in marine environments[1]. Mainly through burrowing in the sediment, the invertebrates mix the particles of the sediment and consequently spread contaminants into the water. This possesses possible environmental risks as contaminants spread in the ecosystem to other organisms and can spread outside of the marine environment. Bioturbation could also potentially help remediate a polluted area depending on how the contaminant's particles are dispersed by burrowing. Understanding how bioturbation affects each area is, therefore, crucial in order to understand the marine ecosystem and how contaminants may be transported. However, assessing collective bioturbation at an area is challenging due to that a benthic community comprise of diverse macroinvertebrates, and species-specific bioturbation information rarely exists.

In this study, we adopted standard trait-based rating system proposed by Solan et al. to estimate community-level bioturbation and modified further to enhance its applicability[2]. The original potential of community-level bioturbation (BP_c) proposed by Solan et al.[2] as

$$BP_c = \sum_{i}^{n} \sqrt{\frac{B_i}{A_i}} \times A_i \times M_i \times R_i$$

where B_i is the biomass (g), A_i is the abundance, M_i is the discrete mobility score (1-4), R_i is the modes of sediment reworking (1-5) of a taxon i, and n is the number of different species. The BP_c index uses those bioturbation trait scores together with biomass and abundance information to estimate the extent to bioturbation intensity at a site and compare different sites[1]. Later, Queiros et al. expanded these bioturbation trait scores to the 1033 European macroinvertebrates (Euro DB, hereafter)[3]. Although Solan et al.'s community-level bioturbation potential is certainly attractive concept, there is still an obstacle for its wider application. First, European database of bioturbation traits is still insufficient to cover such a diverse benthic macrofauna of other places. Secondly, species-specific biomass information of a benthic community is not easily available, and much harder to obtain than abundance data. To overcome the hurdles, this study developed a strategy to assign bioturbation traits to a species unlisted in Euro DB, using taxonomical proximity. Further, we proposed a modified community-level bioturbation index (BP_c'), where we use average body size data assigned for each species instead of biomass data that should be measured for each site. The modified potential of community-level bioturbation (BP_c') is defined as

$$BP_c' = \sum_{i}^{n} {L_i}^{\alpha} \times A_i \times M_i \times R_i$$

where L_i, is the size of the taxon (cm) and α is the scaling exponent (-). Unit biomass of a taxon will correlate with its body size, although the scaling exponent may vary from 0.5 to 1.5 depending on actual allometry between biomass and body size for each taxon. Particularly in this summer, I focused on the expansion of EuroDB with body size information.

Methodology

The database of benthic invertebrate originates from Euro DB, which assigns semi-quantitative bioturbation traits for 1033 benthic invertebrates in northwest Europe. First, we extended Euro DB with full taxonomic information extracted from World Register of Marine Species (WoRMs)[4] using Aphia ID. If there was a match, the full taxon would be attach to the Aphia ID.

Some data did not match at first because the scientific name was "unaccepted" or out of use and is under a different name now. Those organisms were matched by hand using data in WoRMs.

Then, the size data of each organism was collected from various sources. Main sources used in this study were the Marine Macrofauna Genus Trait Handbook[5], the World Register of Marine Species (WoRMs)[4], and the Marine Species Identification Portal[6]. The first used source was the Genus Trait Handbook, which had the size of organisms based on their genus. Using that information, some of the EuroDB organisms matched and had size data. Then, search the scientific name of each organism without size data using both the WoRMs and Marine Species Identification portal. These two databases can be searched simultaneously since one database could have information, but not the other. Also, the Identification portal only had data on organisms with species taxon, meaning WoRMs had to be used if there was no species name. After collecting all the size data, the data had to be made into a range that consisted off a lower and upper limit. The range of the size could have been either given or created by hand. Each range created by hand depends on the raw data and is usually guided by the Marine Macrofauna Genus Trait Handbook's size ranges. The ranges (all in cm.) are <0.1, 0.1-1, 1-10, 11-20, and >20[4]. This results in an extended EuroDB (**Figure 1**). Only a few organisms had no size data after going through the web databases. For those, we matched with organisms with size data based on their taxon. A size range was created based on the size range for those in the same taxon.

Scientific Name	Aphia ID	Ri	Mi	Fti	Kingdom	Phylum	Class	Order	Family	Genus	lower_limit_(cm)	upper_limit_(cm)	Size range (cm)	Size source	Raw Data (cm)
Eulalia	129445	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Eulalia	11	20		GTH	11- 20 cm
Eumida bahusiensis	130641	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Eumida	5	15		GTH	5-15 cm
Eumida sanguinea	130644	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Eumida	5	15		GTH	5-15 cm
Eumida	129446	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Eumida	5	15		GTH	5-15 cm
Hesionura elongata	130649	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Hesionura	0.1	1		GTH	< 1 cm
Hypereteone foliosa	152250	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Hypereteon	6	30	6 to 30	WoRMS	6 to 30
Mysta picta	147026	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Mysta	1	2.5	1 to 2.5	MSIP	up to 2.5
Nereiphylla rubiginosa	130659	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Nereiphylla	1	10	1 to 10	WoRMS	1 to 10
Paranaitis kosteriensis	130662	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Paranaitis	1	8.5	1 to 8.5	MSIP	up to 8.5
Phyllodoce (Anaitides) gro	130668	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	1	30	1 to 30	family taxon	made from 334508
Phyllodoce groenlandica	334506	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	1	30	1 to 30	family taxon	made from 334508
Phyllodoce laminosa	130670	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	1	30	1 to 30	family taxon	made from 334508
Phyllodoce lineata	334508	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	10	20	10 to 20	MSIP	up to 20
Phyllodoce longipes	130673	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	1	3	1 to 3	MSIP	up to 3
Phyllodoce maculata	334510	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	1	10	1 to 10	MSIP	up to 10
Phyllodoce mucosa	334512	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	10	15	10 to 15	MSIP	up to 15
Phyllodoce rosea	334514	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	1	3.5	1 to 3.5	MSIP	up to 3.5
Phyllodoce	129455	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce	1	25	1 to 25	genus taxon	made from 334508
Pirakia punctifera	147104	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Pirakia	20	25	20 to 25	MSIP	up to 25
Pseudomystides limbata	130683	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Pseudomys	0.6	1		GTH	0.6 -1 cm
Sige fusigera	130690	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Sige	1	5	1 to 5	MSIP	up to 5
Phyllodocidae	931	4	3	B	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae		1	30	1 to 30	family taxon	made from 334508

Figure 1. Extended European database (Euro DB): scientific name, Aphia ID (blue), bioturbation traits (green), taxonomic classification (orange), and size traits (purple).

Using the code established for the extended EuroDB, we move to the first case study in the Northeast of the United States. The Northeast Fisheries Science Center (NEFSC) from the National Oceanic and Atmospheric Administration (NOAA) constructed huge database of benthic survey data, which were collected from more than 20,000 sampling sites, during 1881 to present. The master list of invertebrates consists of over 3000 species[7]. First, we cleaned the database for mistakes, abbreviations, unaccepted names, etc of each data entry. Using the corrected names, the Aphia IDs were identified via WoRMs' search engine. Then, we imported full taxon of each data from WoRMs using the Aphia IDs. Then, we developed a R code to find the taxonomically closest match between the extended EuroDB and NEFSC data and assign biotraits and size data into the NEFSC data.

Cast Study Results

Figure 2 shows partial NEFSC data table with bioturbation traits and size information assigned. The table also displays match mode of each data, what level of taxonomic proximity was found between extended Euro DB and NEFSC data. The database continuous growth will lead to some of the "NoMatch" organisms to having a match, so that the community-level bioturbation potential will become more accurate.

	AphiaID	Phylum	Class	Order	Family	Genus	Ri	Mi	MatchMode	Lower	Upper	MatchMode_Size
1	1436202	Mollusca	Gastropoda	Littorinimorpha	Rissoidae	Frigidoalvania	2	3	Family	0.1	0.414285714285714	Family
2	1436202	Mollusca	Gastropoda	Littorinimorpha	Rissoidae	Frigidoalvania	2	3	Family	0.1	0.414285714285714	Family
3	1424673	Arthropoda	Malacostraca	Decapoda	Pinnotheridae	Tubicolixa	2.42857142857143	3.74603174603175	Order	1.85396825396825	5.95555555555556	Order
4	1424659	Arthropoda	Malacostraca	Decapoda	Pinnotheridae	Rathbunixa	2.42857142857143	3.74603174603175	Order	1.85396825396825	5.95555555555556	Order
5	1424477	Arthropoda	Hexanauplia	Scalpelliformes	Scalpellidae	Weltnerium	0	0	NoMatch	0	0	NoMatch
6	1424477	Arthropoda	Hexanauplia	Scalpelliformes	Scalpellidae	Weltnerium	0	0	NoMatch	0	0	NoMatch
7	1424477	Arthropoda	Hexanauplia	Scalpelliformes	Scalpellidae	Weltnerium	0	0	NoMatch	0	0	NoMatch
8	1379630	Cnidaria	Anthozoa	Pennatulacea	Pennatulidae	Ptilella	2	2	Family	50	60	Family
9	1355594	Annelida	Polychaeta	Terebellida	Flabelligeridae	Bradabyssa	3	2	Exact	1	6	Exact
10	1346052	Annelida	Polychaeta		Orbiniidae	Leodamas	4	3	Family	10.4	32	Family
11	1342053	Mollusca	Gastropoda	Cephalaspidea	Haminoeidae	Haminella	2	3	Order	0.8	3.08888888888889	Order
12	1328406	Arthropoda	Malacostraca	Amphipoda	Talitridae	Speziorchestia	1.94047619047619	2.7202380952381	Order	0.35297619047619	1.71785714285714	Order
13	1307579	Arthropoda	Malacostraca	Cumacea	Lampropidae	Alamprops	2	3	Family	0.1	0.8	Family
14	1297885	Annelida	Polychaeta	Eunicida	Eunicidae	Paucibranchia	4	3	Exact	20	50	Exact
15	1297885	Annelida	Polychaeta	Eunicida	Eunicidae	Paucibranchia	4	3	Exact	20	50	Exact
16	1264347	Arthropoda	Malacostraca	Decapoda	Pinnotheridae	Pinnixulala	2.42857142857143	3.74603174603175	Order	1.85396825396825	5.95555555555556	Order
17	1255502	Arthropoda	Malacostraca	Amphipoda	Tryphosidae	Wecomedon	2	3	Family	0.5	0.922222222222222	Family
18	1255501	Arthropoda	Malacostraca	Amphipoda	Tryphosidae	Wecomedon	2	3	Family	0.5	0.922222222222222	Family
19	1252733	Arthropoda	Malacostraca	Decapoda	Epialtidae	Minyorhyncha	2.42857142857143	3.74603174603175	Order	1.85396825396825	5.95555555555556	Order
20	1061759	Arthropoda	Malacostraca	Decapoda	Portunidae	Portunus	2.42857142857143	3.74603174603175	Order	1.85396825396825	5.95555555555556	Order
21	1059632	Arthropoda	Malacostraca	Amphipoda	Ischyroceridae	Siphonoecetes	1.66666666666667	1	Genus	0.233333333333333	0.733333333333333	Genus
22	1059478	Bryozoa	Gymnolaemata	Cheilostomatida	Cribrilinidae	Cribrilina	0	0	NoMatch	0	0	NoMatch
23	1056517	Arthropoda	Malacostraca	Decapoda	Sergestidae	Robustosergia	2.42857142857143	3.74603174603175	Order	1.85396825396825	5.95555555555556	Order
24	1053399	Arthropoda	Malacostraca	Amphipoda	Epimeriidae	Epimeria	1.94047619047619	2.7202380952381	Order	0.35297619047619	1.71785714285714	Order

Figure 2. Northeastern invertebrate database

Conclusion/Future Work

The overall goal is to construct one comprehensive database on bioturbation of benthic invertebrates that can be globally used. In the future, using the same collection method, data will be collected from different coasts of this country (East Coast and Gulf of Mexico) and continue on until it is a global database. The dataset can be used to understand how bioturbation affects an area which helps understand contaminant transport of the same area if contaminated. The database will be utilized to further study the marine ecosystem and contaminant transport in marine environments.

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