

# German MarBIT (Marine Biotic Index Tool) approach

## Water type N5-Helgoland

### Macrozoobenthos of the rock-platform at Helgoland



Modified after Hagmeier, 1930

Katharina Reichert\* and Friedrich Buchholz

Biological Station Helgoland, Foundation Alfred Wegener Institute for Polar and Marine Research, 27498 Helgoland, Germany

\* Corresponding author: [Katharina.Reichert@awi.de](mailto:Katharina.Reichert@awi.de)

#### **In Cooperation with:**

MariLim aquatic research  
Thorsten Berg  
Heinrich-Wöhlk-Straße 14  
24232 Schönkirchen, Germany

#### **Principal:**

State Agency for Nature and Environment in Schleswig-Holstein  
Hamburger Chaussee 25  
24220 Flintbek, Germany

---

## Contents

<i>Summary</i> .....	1
<i>General Introduction</i> .....	2
<i>The rocky shore communities of Helgoland</i> .....	3
<i>Objectives</i> .....	4
<i>Literature Research</i> .....	5
<i>Taxonomic Revision</i> .....	6
<i>Data sources of the macrozoobenthos at Helgoland and their consideration</i> .....	6
<i>Data Input</i> .....	14
<i>Concluding Remarks</i> .....	17
<i>References</i> .....	18
<i>Appendix</i> .....	22

## Summary

Evaluation methods are a prerequisite to assess the ecological status of a specific water body according to the Water Framework Directive (WFD). Regarding the water body around the island of Helgoland (German Bight, North Sea; water type N5) there are two assessment models which describe the current water quality status on the basis of littoral macrophytes and invertebrates. However, a valuation method, such as the German Marine Biotic Index Tool (MarBIT), that reflects the ecological condition of a water body by a comprehensive statistical analysis had not yet been developed for N5 Helgoland.

Therefore, the aim of the present project was to create a well founded database which is indispensable for an assessment of the water quality status by the MarBIT approach. The macrozoobenthos of the rocky intertidal of Helgoland is a suitable medium to develop a database for MarBIT since there is a considerable quantity of historical and current literature about the macrozoobenthos. Moreover, the hard-bottom assemblages are suitable for the realisation of a regular sampling scheme on a long-term schedule in the future.

For the database conception a two-stage literature research was carried out. As a first step, all investigations which mention invertebrates of the Helgoland intertidal were surveyed. The complete species list included 242 invertebrate species from in total 36 investigations which were published between 1829 and 2008. In addition to the species spectra and abundance data, a thorough literature research was carried out to record ecological parameters for each invertebrate species. Here, a total of 255 studies were consulted. Then, the whole data record was added to the MarBIT database.

On the basis of the newly created macrozoobenthos database the MarBIT tool can be applied and thus the current project contributes to the required realization of a water quality management of the water body N5 Helgoland according to the WFD.

## General Introduction

The Water Framework Directive (WFD) demands an assessment of all European surface water bodies on an ecological basis (Europäische Union, 2001). The ecological classification system has five categories, from high to bad, and uses biological, hydro-morphological and physicochemical parameters for the assessment of water status. To reflect the ecological status of water bodies and to show important factors of influence evaluation methods are a prerequisite (Nehring & Leuchs, 2001).

Within a contract of the State Agency for Nature and Environment in Schleswig-Holstein, Germany, such an evaluation method was developed by the company MariLim and was already tested for the biological assessment of the Baltic macrozoobenthos (Meyer et al., 2005 and 2006). This German approach, called MarBIT (Marine Biotic Index Tool), is based on the normative definitions of ecological status given in Annex V of the WFD: (1) species composition, (2) abundance, (3) proportion of taxa sensitive to disturbance and (4) proportion of taxa that are pollution indicators. For the assessment of a specific water body, the species, their abundances and several autecological parameters (e.g. r-/k-strategy, distribution patterns) serve as database for the MarBIT approach (see Tab. 1; Appendix). The autecological features of the taxa are divided into eight categories where each category in turn summarizes similar ecological features. For example, the 2<sup>nd</sup> category “habitat” summarizes salinity tolerance, zonation, substrate/habitat preference, habitat/living horizon and exposure as ecological features.

Besides the MarBIT approach, originally developed to assess the ecological quality of the Baltic macrozoobenthos as biological assessment component, also evaluations of the water quality status for the Helgoland water body (German Bight, North Sea; water type N5; Fig. 1) were carried out. Bartsch & Kuhlenkamp (2004) developed an evaluation method that reflects the ecological condition of the Helgoland water body on the basis of historical and present data of littoral macrophytes. At the same time, Boos et al. (2004) generated a concept for the categorisation of invertebrates in littoral and sublittoral habitats at Helgoland. The assessment by Bartsch & Kuhlenkamp (2004) and Boos et al. (2004) revealed that the current quality class for the water body of Helgoland ranges between “good” and “moderate”. However, a valuation method, such as the MarBIT, that reflects the ecological condition of the water body of Helgoland by a comprehensive statistical analysis had not yet been developed.

Regarding the existing historical and current literature as well as the implementation of a monitoring programme the macrozoobenthos of the rocky intertidal of Helgoland has become apparent as a suitable medium to start a well founded assessment of the Helgoland water body

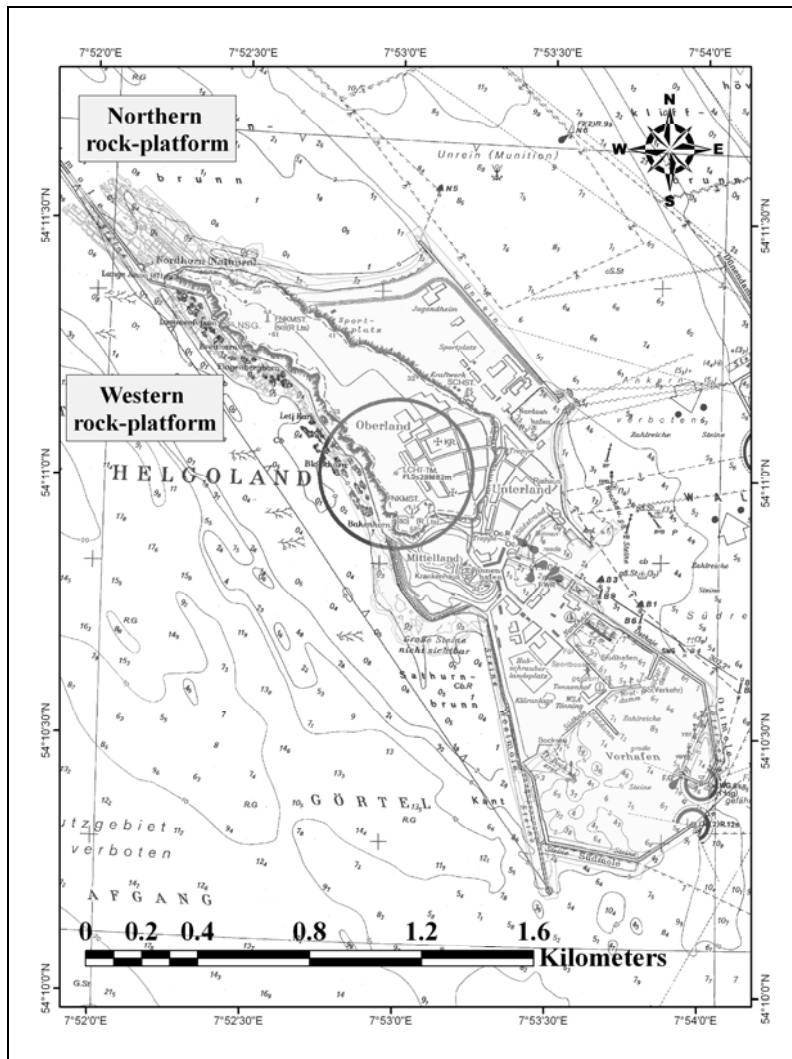
by the MarBIT approach. Such an assessment of the water quality status in turn demands an extensive database of the species spectra and the autecological parameters of the individual taxa. However, such a database had not yet been created. To date, the literature of the Helgoland macrozoobenthos and their autecology only exist in parallel. Most of the literature deals with only one particular species or taxonomic group or are related to a specific location. All told, there is no extensive database which includes all invertebrates of the intertidal rock-platform with a description of their autecology.

### The rocky shore communities of Helgoland

At Helgoland, hard-bottom communities have been studied for more than a century (Harms, 1993). The earliest investigation which described the intertidal macrozoobenthos was done by Hoffmann (1829). Several further studies were published in the 19th century which described different taxonomic groups mainly within the scope of the journal „*Beiträge zur Meeresfauna von Helgoland*“. For example, Heincke (1894) has studied the molluscs, Hartlaub (1894) the hydroids and sea anemones, Weltner (1897) the barnacles and Sokolowsky (1900) the amphipods of Helgoland. However, semi-quantitative or quantitative investigations regarding the macrobenthos of Helgoland were carried out for the first time in the 20th and 21st century. Here, the studies which were done by Janke (1986), Wendt (2005), Reichert & Buchholz (2006) or Reichert (2008) can be mentioned.

Regarding habitats as a suitable medium for ecological long-term research, rocky shores are often preferred compared to terrestrial ecosystems or offshore marine systems mainly due to the simplicity of studying these shores (Raffaelli & Hawkins, 1996). In general, rocky shores are well accessible and are clearly arranged as a consequence of their overall two-dimensional nature. The intertidal at Helgoland, the northern and western rock-platform, additionally has a relatively small extent covering about 2 km<sup>2</sup> (see Fig. 1) and is geographically isolated from other hard substrates located in the North Sea by surrounding soft sediments. Therefore, the species spectra can be relatively well recorded and processes of change occur in a focused way. Plants and animals at rocky shores mostly have a sessile lifestyle and even those with potential mobility are generally slow moving. The limited locomotive potential or sessile lifestyle prevents the organisms to avoid short-term disturbances in the marine environment (e.g. toxic algal blooms) or long-term changes (e.g. input/accumulation of harmful substances/nutrients). Moreover, several benthic organisms have a perennial lifespan so that natural community variation, i.e. the background noise

against which any human-induced changes may be detected, is more easily to grasp compared to plankton organisms; in addition there is a respectable chance to detect accumulated harmful substances which emerge time-delayed and can influence the reproduction or physiology of species, and thus in turn can have an effect on the whole population or community.



**Figure 1** Helgoland with the northern and western rock-platform.

## Objectives

According to the MarBIT approach, the aim of the present project was to create the necessary database for an assessment of the macrozoobenthos of Helgoland. As a first step, all investigations about invertebrates of the rocky intertidal at Helgoland were surveyed. In addition, the species spectra and abundance data, a thorough literature research was carried out to record ecological parameters for each of in total 242 invertebrate species. Then, the whole data record was added to the MarBIT database. The newly created database is a

prerequisite for the analysis and assessment of the Helgoland macrozoobenthos by the MarBIT tool which will be carried out by the company MariLim in the near future. Furthermore, the MarBIT approach could serve as a sound valuation basis for a regular sampling, e.g. a surveillance or operational monitoring, at the rocky intertidal of Helgoland.

## Literature Research

A two-stage literature research was carried out for the macrozoobenthos of the Helgoland intertidal. As a first step, all investigations which mention invertebrates of the rocky intertidal species spectra at Helgoland were surveyed.

A total of 242 invertebrate species in 11 phyla were listed for the Helgoland intertidal (see Table 2, Appendix). The highest number of species (57 species) occurred within the annelids followed by the arthropods (56 species) and the molluscs (52 species). Within the other phyla between three species (echinoderms) and 27 species (cnidarians) were noted. The kamptozoans and sipunculans were represented by only one species.

The complete species list was collected from in total 36 investigations which were published between 1829 and 2008 (see below). The earliest investigation which described macrozoobenthos species was done by Hoffmann (1829). Seventeen further studies were published in the 19th century. Eight investigations were carried out in both the 20<sup>th</sup> and 21<sup>st</sup> century. The latest investigation about the intertidal invertebrates of Helgoland was carried out by Reichert (2008) and the dataset is stored additionally in a database of LargeNet, a responsive mode project undertaken within the MarBEF EU network of excellence. The data of the former publications will serve as a cross reference listing, whereas on the basis of the recent studies the actual status of the intertidal macrozoobenthos will be analyzed by the MarBIT tool.

In addition to the investigations reported about invertebrates of the Helgoland intertidal, hundreds and hundreds of publications about the autecology of rocky shore invertebrates was surveyed. In the end, a total of 255 studies were consulted for the MarBIT database. 74 % of the cited literature was published in scientific journals, 2 % were diploma or PhD theses and 24 % were citations from the Internet. Attention was paid to cite predominately investigations which studied species of the Helgoland intertidal. However, there were only a couple of studies (20 out of 255) which stated about the ecology of intertidal populations at Helgoland. Therefore, studies which focused on autecological topics of intertidal invertebrates along the North Sea or the Atlantic coastline were also cited.

## Taxonomic Revision

To make a comparison possible between former and recent studies, decisions on species taxonomy were necessary. Some of the species names, which were identified in former studies, were updated based on subsequent taxonomic revisions. Several online databases, such as the EU Register of Marine Species (ERMS) or the Integrated Taxonomic Information System (ITIS), were used to identify the valid species names. All species were listed with their valid names in the MarBIT database. In Table 2 the species were also listed with their synonyms.

In a few cases, taxonomic changes required unification of recent species. For example, the hydrozoans *Kirchenpaueria pinnata* and *K. similis* were united as *K. pinnata*. Furthermore, some species were combined into a complex if the morphological distinctions between two species were difficult to quantify. For example, the definite taxonomic differentiation between the bryozoans *Alcyonidium gelatinosum* and *A. mytili* involves electrophoresis, and between the periwinkle *Littorina mariae* and *L. obtusata* requires preparation of the penis (Hayward, 1985; Willmann, 1989).

### Data sources of the macrozoobenthos at Helgoland and their consideration

For the literature research it had to be decided if studies with vague information about the sampling design should be considered for the database or not; this was important to guarantee a comparison between former and recent studies. Particularly, former investigations often give no or vague details about the sampling design, such as the exact sampling location. If it was well-known that individual taxa occur in intertidal areas, former studies were cited even in the case of no details about the exact location of Helgoland where a particular species was sampled. Moreover, former studies were also cited even if another Helgoland location (e.g. harbours, the Dune) than the rocky intertidal platform was sampled. However, the latter case was only considered if a certain species could not be cited by other former studies; only the species presence was listed then and frequency data, if available, were not used.

In the following, the investigations which reported about macrozoobenthos species of Helgoland are listed in alphabetical order and details about the sampling design are given.



Ehrenbaum (1897)

\* acts as referee for one taxon only (*Bodotria scorpioides*)

- **Sampling location:** water surface in the immediate vicinity of Helgoland
- **Sampling date:** summer (Jun., Jul., Aug.) before the publication in 1897
- **Frequency data:** presence/absence data for an unknown number of stations in the immediate vicinity of Helgoland

Ehrenberg (1836)

\* acts as referee for one taxon only (*Clava multicornis*)

- **Sampling location:** Helgoland
- **Sampling date:** no data available
- **Frequency data:** presence/absence data for an unknown number of stations

Gegenbauer (1853)

\* acts as referee for the genus *Littorina* only

- **Sampling location:** Helgoland
- **Sampling date:** no data available
- **Frequency data:** presence/absence data

Gillandt (1979)

- **Sampling location:** 5 stations at the northern and north-eastern intertidal (soft- and hard-bottom habitats)
- **Sampling date:** monthly sampling in 1973 and 1974
- **Frequency data:** Number of individuals out of a particular number of samples; the number of samples differ between the individual taxa

Harms (1993)

\* acts as referee for one taxon only (*Crassostrea gigas*)

- **Sampling location:** hard-bottom habitats in the immediate vicinity of Helgoland
- **Sampling date:** in the 1980s
- **Frequency data:** presence/absence data

Hartlaub (1894)

- **Sampling location:** northern and western rock-platform; deep channel; North Harbour; Helgoland Roads
- **Sampling date:** before the publication in 1894; dredge and trawl samplings between 1892 and 1894
- **Frequency data:** descriptive data relating to both exact locations or habitats and to Helgoland as location in general; however, it is uncertain if all locations were sampled for each taxon

Hartmeyer (1908)

- **Sampling location:** western rock-platform; immediate vicinity of Helgoland
- **Sampling date:** no data available
- **Frequency data:** descriptive data for an unknown number of stations

Heincke (1894)

- **Sampling location:** northern and western rock-platform; chalk and lime cliffs of the Dune; North and South Harbour; deep channel
- **Sampling date:** no data available
- **Frequency data:** descriptive data relating to an exact location or habitat; however, different locations or habitats were sampled for each taxon

Hoffmann (1829)

- **Sampling location:** Helgoland (inter- and subtidal locations)
- **Sampling date:** no data available
- **Frequency data:** descriptive data for an unknown number of stations in the immediate vicinity of Helgoland

Janke (1986)

- **Sampling location:** 4 habitats at the northern rock-platform which are not influenced by rocks that fall occasionally from the vertical cliffs above (the *Enteromorpha*- and the *Fucus serratus*-zone, the channels and the *Laminaria*-zone)
- **Sampling date:** monthly sampling (March to September 1984)

- **Frequency data:** semi-quantitative data (details about the abundance estimation see Reichert & Buchholz, 2006)
- **Calculation of species abundance:** all habitats over all sampling months were pooled and the mean estimated abundance for each species was calculated; in total 5 habitats were pooled, namely the 4 habitats stated in Janke (1986; see above) and in addition individuals of *Laminaria digitata* as an own habitat. Janke (1986) considered individuals of *L. digitata* as a micro-habitat within the *Laminaria*-zone. However, to compare the mean estimated abundance for each species between Janke (1986) and Reichert & Buchholz (2006) a separate consideration of the *L. digitata* habitat was necessary.

#### Leuckart (1847)

- **Sampling location:** Helgoland (inter- and subtidal locations)
- **Sampling date:** two-month sampling (May and June)
- **Frequency data:** descriptive data for an unknown number of stations at Helgoland

#### Loman (1928)

- **Sampling location:** Helgoland
- **Sampling date:** no data available
- **Frequency data:** only presence/absence data are cited in the database since it is uncertain if inter- or subtidal habitats were considered

#### Menke (1845)

- **Sampling location:** Helgoland
- **Sampling date:** no data available
- **Frequency data:** descriptive data for an unknown number of stations

#### Metzger (1871)

\* acts as referee for one taxon only (*Patella vulgata*)

- **Sampling location:** Helgoland
- **Sampling date:** no data available
- **Frequency data:** presence/absence data for an unknown number of stations

Metzger (1872)

\* acts as referee for one taxon only (*Skeneopsis planorbis*)

- **Sampling location:** rock-platform
- **Sampling date:** no data available
- **Frequency data:** presence/absence data for an unknown number of stations

Metzger (1875)

- **Sampling location:** Helgoland; North Harbour; details about the type of substrate and the sampling depth
- **Sampling date:** no data available
- **Frequency data:** presence/absence data for an unknown number of stations

Metzger (1891)

- **Sampling location:** Helgoland (inter- and subtidal locations)
- **Sampling date:** no data available
- **Frequency data:** descriptive data for an unknown number of stations

Metzger et al. (1875)

- **Sampling location:** Helgoland; details about the type of substrate and the sampling depth
- **Sampling date:** no data available
- **Frequency data:** presence/absence data for an unknown number of stations

Michaelsen (1897)

- **Sampling location:** Helgoland; details about the type of substrate and the sampling depth
- **Sampling date:** no data available
- **Frequency data:** Number of individuals, but neither volume- nor area-related

Michaelsen (1923)

- **Sampling location:** Helgoland; western platform
- **Sampling date:** summer 1885; July 1914; September 1919, July - August 1920

- **Frequency data:** descriptive data for an unknown number of stations

#### Möbius (1871)

- **Sampling location:** northern and western rock-platform; subtidal locations
- **Sampling date:** no data available
- **Frequency data:** presence/absence data for an unknown number of stations

#### Pfeffer (1887)

- **Sampling location:** Helgoland and the Dune
- **Sampling date:** no data available
- **Frequency data:** presence/absence data for an unknown number of stations

#### Philippi (1836)

- **Sampling location:** Helgoland
- **Sampling date:** no data available
- **Frequency data:** presence/absence data for an unknown number of stations

#### Reichert (2003)

- **Sampling location:** 5 habitats at the northern rock-platform which are not influenced by rocks that fall occasionally from the vertical cliffs above (the *Enteromorpha*-, the *Mytilus*- and the *Fucus serratus*-zone, the channels, the *Laminaria*-zone and individuals of *Laminaria digitata*)
- **Sampling date:** monthly sampling (April to September 2002)
- **Frequency data:** semi-quantitative data
- **Calculation of species abundance:** all micro-habitats within each habitat over all sampling months were pooled and the mean estimated abundance for each species was calculated; to compare the mean estimated abundance for each species between Janke (1986) and Reichert (2003), the divisor to calculate the mean estimated abundance for each species did not include the *Mytilus*-zone. This zone was sampled as an additional habitat in 2002. The *Mytilus*-zone had clearly dissociated as a separate zone from the *F. serratus*-zone, while in the sampling year of Janke's study the *Mytilus*-beds were still inside the *F. serratus*-zone and were sampled as part of this zone.

Reichert (2008)

- **Sampling location:** area of in total 93 m<sup>2</sup> at the rock-platform (northern rock-platform: 80 m<sup>2</sup>; western rock-platform: 13 m<sup>2</sup>)
- **Sampling date:** summer 2004
- **Frequency data:** percentage cover
- **Calculation of species abundance:** the mean percentage cover of the species was pooled over the analyzed communities and the mean percentage cover for each species per 0.25 m<sup>2</sup> was calculated

Reichert, LargeNet Database (2008)

- **Sampling location:** area of in total 20 m<sup>2</sup> at the rock-platform (northern rock-platform: 13.75 m<sup>2</sup>; western rock-platform: 6.25 m<sup>2</sup>)
- **Sampling date:** summer 2004 - spring 2006 (in total 8 seasons)
- **Frequency data:** percentage cover
- **Calculation of species abundance:** all replicated quadrates (size: 0.25 m<sup>2</sup>) at the rock-platform over all sampling months were pooled and the mean percentage cover for each species per 0.25 m<sup>2</sup> was calculated

Reichert & Buchholz (2006)

- **Sampling location:** see Reichert (2003)
- **Sampling date:** monthly sampling (April to September 2002)
- **Frequency data:** semi-quantitative data; average conspicuousness of each species

Rietdorf (2001)

- **Sampling location:** northern and western rock-platform
- **Sampling date:** May 2000 - February 2001
- **Frequency data:** presence/absence data

Schlottke (1932)

- **Sampling location:** western rock-platform; immediate vicinity of Helgoland
- **Sampling date:** 1921; 1925; 1928; August and September 1931
- **Frequency data:** descriptive data for an unknown number of stations at Helgoland

Schubert (2003)

- **Sampling location:** northern rock-platform
- **Sampling date:** April - October 2002
- **Frequency data:** number of individuals and semi-quantitative data; each species was listed with both parameters and with the sampled location(s). Abundance data were only cited if the parameters were related to only one location, the northern rock-platform, and were not add up to several locations.

Semper (1874)

\* acts as referee for one taxon only (*Phoxichilidium femoratum*)

- **Sampling location:** Helgoland
- **Sampling date:** August and September 1873
- **Frequency data:** presence/absence data for an unknown number of stations

Sokolowsky (1900)

- **Sampling location:** northern and western rock-platform; water surface in the immediate vicinity of Helgoland
- **Sampling date:** April, May and November 1892; May and June 1893; March and September 1894 and 1895; August 1899
- **Frequency data:** presence/absence and descriptive data for an unknown number of stations at Helgoland for an unknown number of stations

Sokolowsky (1925)

- **Sampling location:** western rock-platform
- **Sampling date:** July 1920
- **Frequency data:** number of individuals and descriptive data for an unknown number of stations at Helgoland

Weltner (1897)

\* acts as referee for one taxon only (*Semibalanus balanoides*)

- **Sampling location:** rock-platform
- **Sampling date:** no data available
- **Frequency data:** descriptive data for an unknown number of stations at Helgoland

Wendt (2005)

- **Sampling location:** area of in total 52.5 m<sup>2</sup> at the rock-platform (northern rock-platform: 42.5 m<sup>2</sup>; western rock-platform: 10 m<sup>2</sup>)
- **Sampling date:** November 2004 - May 2005
- **Frequency data:** percentage cover
- **Calculation of species abundance:** all stations at the rock-platform were pooled and the mean percentage cover for each species per 0.25 m<sup>2</sup> was calculated

Ziegelmeier (1966)

- **Sampling location:** rock-platform
- **Sampling date:** only the date of the *Patella vulgata* finding was available: February 1913
- **Frequency data:** number of individuals and descriptive data for an unknown number of stations

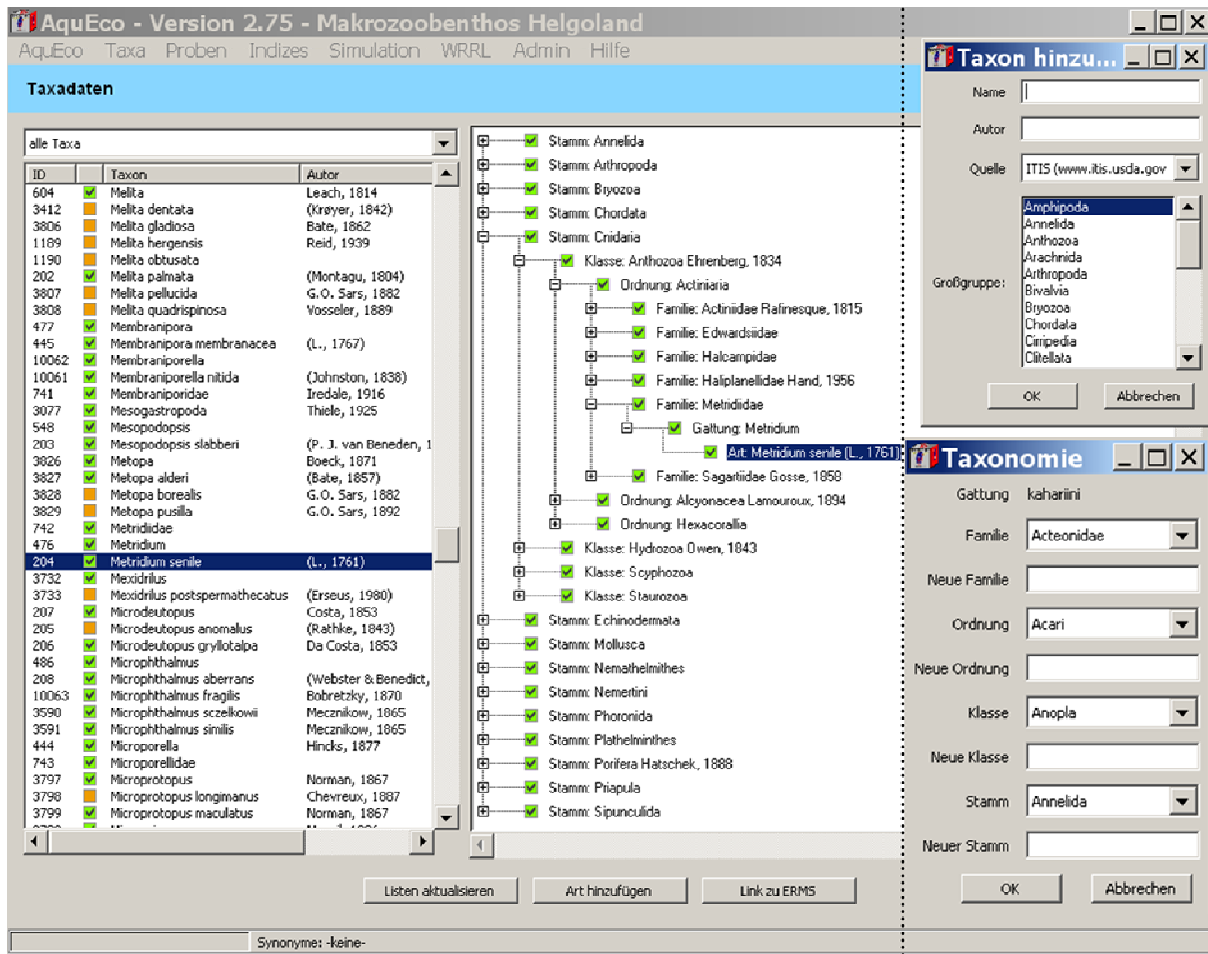
### Data Input

First of all, the invertebrate species which were not already listed in the MarBIT programme were entered. The individual species have to be entered separately in a certain input mask of MarBIT (see right-hand side of Fig. 2). Thus, the species were available for the following input of the autecological data. Furthermore, some autecological parameters especially regarding life strategies of intertidal hard-bottom invertebrates have become apparent during the literature research. These parameters were added to the set of parameters in MarBIT by the programme developer Thorsten Berg (company MariLim).

As a next step, the literature references of species findings or of autecological parameters, which were not already listed in the literature database, were entered into the MarBIT programme (Fig. 3). The literature was imported from the EndNote programme and was available for the following input of the species and their autecology.

Finally, the autecological data with the appropriate literature reference were entered separately in a certain input mask of MarBIT. Figure 4 shows an example for the anthozoan species *Metridium senile*. Here, in the 2<sup>nd</sup> category “habitat” the autecological characteristic “exposure” was entered as “sheltered to semi-exposed” and Janke (1986) was given as literature reference.





**Figure 2** Left-hand side of the dotted line: screenshot of the whole MarBIT taxa list and the taxonomic classification of each species, from phylum to species level; the small green boxes imply that a certain species goes into the MarBIT evaluation model, while the species which are indicated with a small orange box are ignored; right-hand side of the dotted line: screenshot of the input mask for species which are not added yet in MarBIT list.

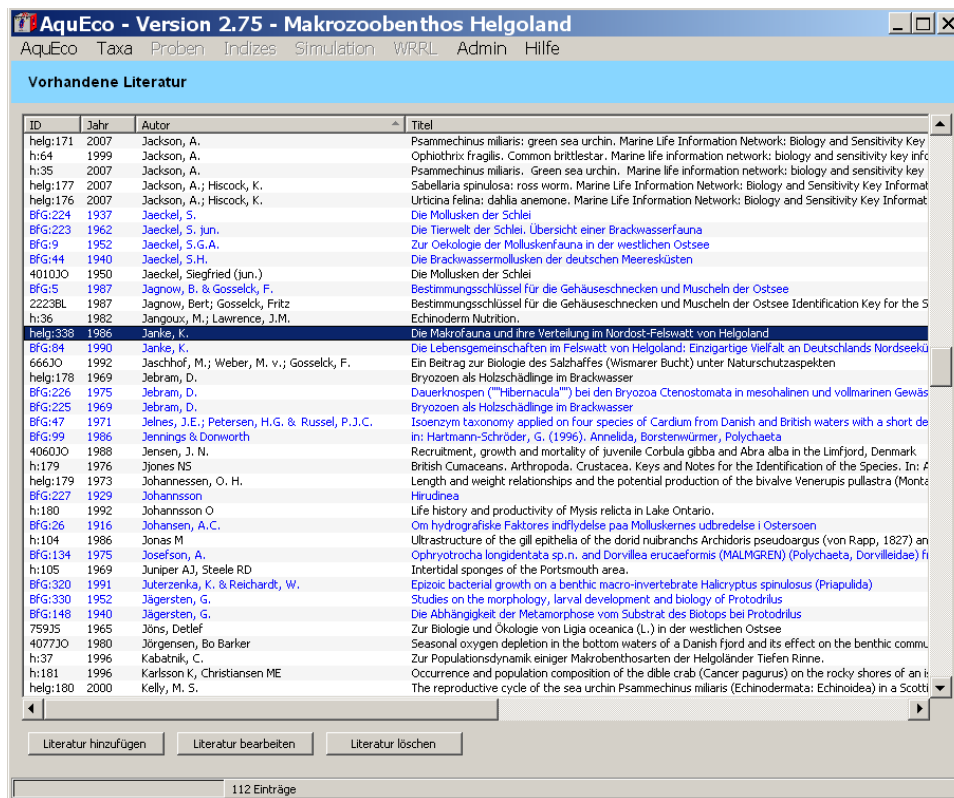


Figure 3 Screenshot of the MarBIT literature database.

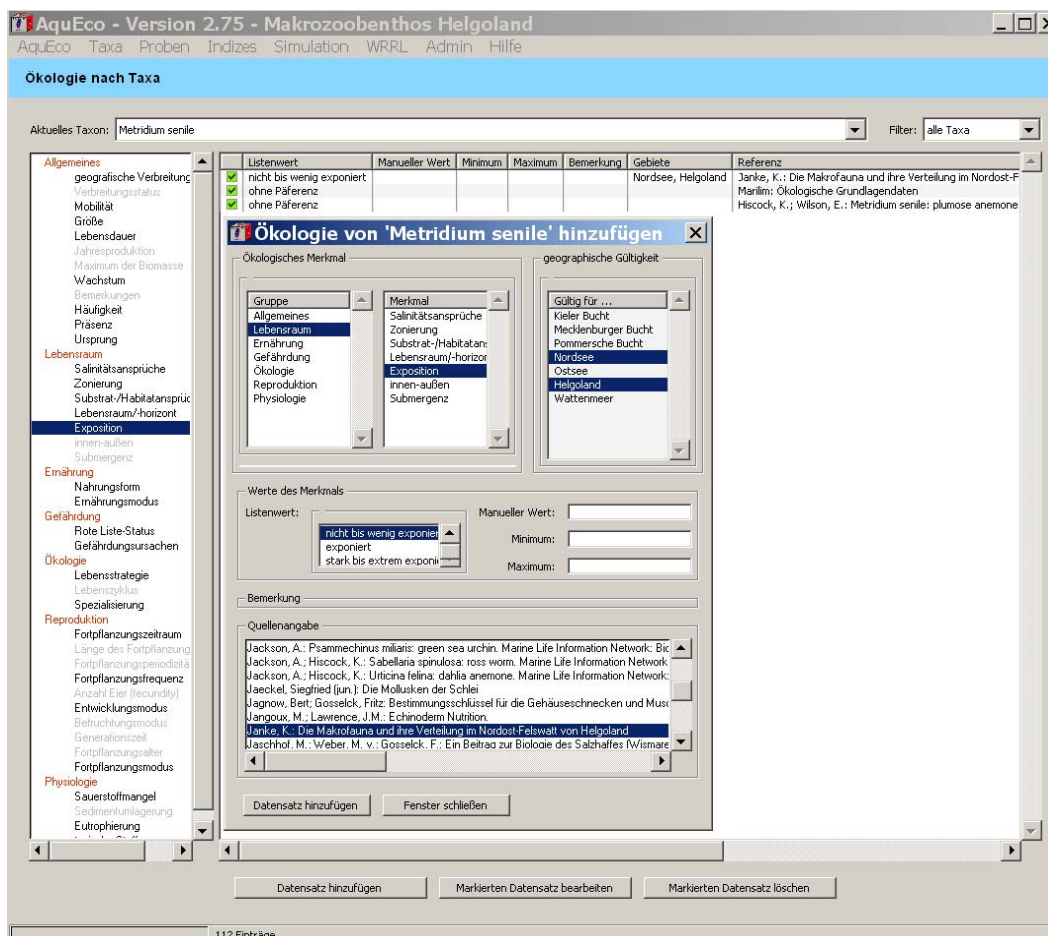


Figure 4 Screenshot of the MarBIT input mask for the autecological database.

## Concluding Remarks

The current project has contributed to the required realization of a water quality management according to the WFD by the establishment of the macrozoobenthos database of Helgoland. This database allows in turn the assessment of the current status of N5 Helgoland by the statistically based MarBIT approach. Since the MarBIT approach was developed originally for the Baltic macrozoobenthos the set of autecological parameters were expanded by additional parameters regarding life strategies of intertidal hard-bottom invertebrates. Nevertheless, further databases of habitats around Helgoland should be analysed by the MarBIT tool to validate the application of the approach for the North Sea. If the MarBIT tool proves itself to be applicable for the N5 Helgoland water body it could be applied as a sound valuation basis for a regular sampling, e.g. a surveillance or operational monitoring, at the rocky intertidal of Helgoland. A fixed statistical approach next to a consistent sampling design would be a considerable progress particularly for a long-term monitoring where several observers are involved. Thus, the risk that changes in the macrozoobenthos community occur to a certain degree due to statistical or sampling error might be reduced and the detection of any natural or human-induced changes may be enhanced.

## References

- Bartsch, I. & Kuhlenkamp, R. (2004). WRRL-Klassifizierungssystem WK Helgoland: Historisches Leitbild der Makrophytenvegetation Helgolands. Klassifizierungsvorschlag der Helgoländer Makrophytenvegetation. Monitoring als Grundlage der Umsetzung der europäischen Wasserrahmenrichtlinie. Bericht im Auftrag des Landesamtes für Natur und Umwelt Schleswig-Holstein, 113 S.
- Boos, K., Buchholz, C., Buchholz, F. & Gutow, L. (2004). Bericht über die Zusammensetzung des Helgoländer Makrozoobenthos im Vergleich historischer und aktueller Quellen. Klassifizierungsvorschlag nach der WRRL und Empfehlungen zum Monitoring. Bericht im Auftrag des Landesamtes für Natur und Umwelt Schleswig-Holstein, 74 S.
- Costello, M.J., Bouchet, P., Boxshall, G., Emblow, C. & Vanden Berghe, E. (2004). European Register of Marine Species, <http://www.marbef.org/data/erms.php>.
- Ehrenbaum, E. (1897). Beiträge zur Meeresfauna von Helgoland. VIII. Die Cumaceen und Schizopoden von Helgoland nebst neueren Beobachtungen über ihr Vorkommen in der deutschen Bucht und in der Nordsee. *Wiss. Meeresunters.* 2, 403-435.
- Ehrenberg, C. G. (1836). Thiere aus Helgoland. *Mittheil. Verhandl. Gesellsch. Naturf. Freunde Berlin*, 1-5.
- Europäische Union (2001). Richtlinie 2000/60/EG des Europäischen Parlaments und des Rates vom 23. Oktober 2000 zur Schaffung eines Ordnungsrahmens für Maßnahmen der Gemeinschaft im Bereich der Wasserpolitik. *ABl. L 327* vom 22.12.2000.
- Gegenbauer, C. (1853). Über die Penisdrüsen von *Littorina*. *Zeitschr. wissensch. Zool.* 4, 232-235.
- Gillandt, L. (1979). Zur Ökologie der Polychaeten des Helgoländer Felslitorals. *Helgoländer wiss. Meeresunters.* 32, 1-35.
- Harms, J. (1993). Check list of species (algae, invertebrates and vertebrates) found in the vicinity of the island of Helgoland (North Sea, German Bight) – a review of recent records. *Helgoländer Meeresunters.* 47, 1-34.
- Hartlaub, C. (1894). Beiträge zur Meeresfauna von Helgoland. IV. Die Coelenteraten Helgolands. *Wiss. Meeresunters.* 1, 161-206.
- Hartmeyer, R. (1908). Beiträge zur Meeresfauna von Helgoland. XIV. Die Ascidien von Helgoland. *Wiss. Meeresunters.* 8, 117-127.
- Hayward, P.J. (1985). Ctenostome bryozoans. In: *Synopses of the British Fauna (New Series)* (Kermack, D.M. & Barnes, R.S.K., eds.), No. 33. London: E.J. Brill/Dr. W. Backhuys.

- Heincke, F. (1894). Beiträge zur Meeresfauna von Helgoland. II. Die Mollusken Helgolands. *Wiss. Meeresunters.* 1, 121-153.
- Hoffmann, F. (1829). Einige Bemerkungen über die Vegetation und die Fauna von Helgoland. *Verhandl. Gesellsch. Naturforsch. Freunde Berlin.* I, 228-260.
- Integrated Taxonomic Information System on-line database, <http://www.itis.gov>.
- Janke, K. (1986). Die Makrofauna und ihre Verteilung im Nordost-Felswatt von Helgoland. *Helgoländer Meeresunters.* 40, 1-55.
- Leuckart, R. (1847). Verzeichnis der zur Fauna Helgoland's gehörenden wirbellosen Seethiere. In: Beiträge zur Kenntnis wirbelloser Tiere mit besonderer Berücksichtigung der Fauna des norddeutschen Meeres (Frey, H. & Leuckart, R., eds.). Braunschweig: Friedrich Vieweg und Sohn, 136-168.
- Loman, J.C.C. (1928). Spinnentiere oder Arachnoidea. III. Opiliones - Pseudoscorpionida - Pantopoda – Pentastomida. In: Die Tierwelt Deutschlands und der angrenzenden Meeresteile nach ihren Merkmalen und nach ihrer Lebensweise (Dahl, F., ed.), 8 (3) Jena: Gustav Fischer Verlag, 73-83.
- Menke, K. T. (1845). Übersicht der Mollusken der deutschen Nordsee. *Z. Malakozoologie*, 49-61.
- Metzger, A. (1871). Die wirbellosen Meeresthiere der ostfriesischen Küste. Ein Beitrag zur Fauna der deutschen Nordsee. *Jahresber. naturhist. Gesellsch. Hannover* 20, 22-36.
- Metzger, A. (1872). Die wirbellosen Meeresthiere der ostfriesischen Küste. Zweiter Beitrag: Ergebnisse der im Sommer 1871 unternommenen Exkursionen. *Jahresber. naturhist. Gesellsch. Hannover* 21, 20-34.
- Metzger, A. (1875). X. Crustaceen aus den Ordnungen Edriophthalmata und Podophthalmata. *Jahresber. Commission Wiss. Unters. Dtsch. Meere Kiel: 1872 u. 1873.* II. und III. Jahrgang, 277-309.
- Metzger, A. (1891). Nachträge zur Fauna Helgolands. *Zool. Jahrb. Abt. Syst. Ökol. Geogr. Tiere*, 5, 907-920.
- Metzger, A. Dunker, W. & Meyer, H. A. (1875). VIII. Mollusca. *Jahresbericht der Jahresber. Commission Wiss. Unters. Dtsch. Meere, Kiel: 1872 u.1873.* II. und III. Jahrgang, 229-264.
- Meyer, T., Reincke, T., Fürhaupter, K. & Krause, S. (2005). Ostsee-Makrozoobenthos-Klassifizierungssystem für die Wasserrahmenrichtlinie. Technical report. Bericht im Auftrag des Landesamtes für Natur und Umwelt Schleswig-Holstein.

- Meyer, T., Reincke, T. & Fürhaupter, K. (2005). Ostsee-Makrozoobenthos-Klassifizierungssystem für die Wasserrahmenrichtlinie. Teilprojekt 1: Referenzartenliste; Teilprojekt 2: Bewertungsmodell. Bericht im Auftrag der Universität Rostock.
- Michaelsen, W. (1897). Beiträge zur Fauna der südöstlichen und östlichen Nordsee. II. (V.) Die Polychaeten-Fauna der deutschen Meere einschließlich der benachbarten und verbindenden Gebiete. *Wiss. Meeresunters.* 2, 219 S.
- Michaelsen, W. (1923). Die Botrylliden und Didemniden der Nordsee und der zur Ostsee führenden Meeresgebiete. *Wiss. Meeresunters.* 14, 97-124.
- Möbius, K. (1871). Das Thierleben am Boden der deutschen Ost- und Nordsee. Berlin: Lüderitz'sche Verlagsbuchhandlung, 32 S.
- Nehring, S. & Leuchs, H. (2001). Ansätze und Perspektiven einer ökologischen Bewertung des Makrozoobenthos in Übergangs- und Küstengewässern - Eine Einführung -. BfG Veranstaltungen 5/2001, 5-10.
- Pfeffer, G. (1887). Beitrag zur Meeres-Mollusken-Fauna von Helgoland. *Verh. Ver. naturwiss. Unterhaltung Hamburg* 6, 98-99.
- Philippi, A. (1836). Beschreibung einiger neuen Conchylien-Arten und Bemerkungen über die Gattung *Lacuna* von Turton. *Arch. Naturgeschichte* 2 (1), 224-235.
- Raffaelli, D. & Hawkins, S. (1996). *Intertidal Ecology*, 1st edn. London: Chapman and Hall.
- Reichert, K. (2003). Die Makrofauna und ihre räumliche Verteilung und saisonale Veränderung im Felswatt von Helgoland. Diploma thesis, University of Hamburg, Germany.
- Reichert, K. (2008). Temporal and spatial scales in species assemblages of the rocky intertidal at Helgoland (German Bight, North Sea). PhD thesis, University of Hamburg, Germany.
- Reichert, K. (2008). The macrozoobenthos of the intertidal zone at Helgoland. LargeNet integrated database. LargeNet: Large scale and long term networking on the observation of global change and its impact on marine biodiversity. Responsive mode project within the MarBEF EU Network of Excellence under the 6<sup>th</sup> Framework programme of the European Union. <http://www.marbef.org/projects/largenet>.
- Reichert, K. & Buchholz, F. (2006). Changes in the macrozoobenthos of the intertidal zone at Helgoland (German Bight, North Sea): a survey of 1984 repeated in 2002. *Helg. Mar. Res.*, 60, 213-223.

- Rietdorf, D. (2001). Studien zur Taxonomie und Physiologie der Ascidien vor Helgoland (Nordsee). Diploma thesis, University of Hannover, Germany.
- Schlottke, E. (1932). Die Pantopoden der deutschen Küsten. *Wiss. Meeresunters.* 18, 1-10.
- Schubert, P. (2003) Wechselwirkungen zwischen Opisthobranchiern und ihren Beuteorganismen. Diploma thesis, University of Kiel, Germany.
- Semper, C. (1874). Über die Pycnogoniden und ihre in Hydroiden schmarotzenden Larvenformen. In: *Arbeiten aus dem zoologisch-zootomischen Institut* (Semper, C., ed.), Würzburg: Stahel'schen Buch- & Kunsthandlung, 264-286.
- Sokolowsky, A. (1900). Beiträge zur Meeresfauna von Helgoland. XI. Die Amphipoden Helgolands. *Wiss. Meeresunters.* 4, 141-166.
- Sokolowsky, A. (1925). Nachträge zur Amphipoden-Fauna Helgolands. *Wiss. Meeresunters.* 16, 1-6.
- Weltner, W. (1897) Beiträge zur Meeresfauna von Helgoland. IX. Die Cirripeden Helgolands. *Wiss. Meeresunters.* 2, 437-447.
- Wendt, T. (2005). Ökologische Untersuchungen an Cirripedia (Crustacea) im Felswatt von Helgoland. Eine Bestandsaufnahme mit ergänzenden Laboruntersuchungen zu Frosttoleranz und Aktivität. Diploma thesis, University of Hamburg, Germany.
- Willmann, R., (1989). Muscheln und Schnecken der Nord- und Ostsee. Melsungen: Neumann-Neudamm.
- Ziegelmeier, E. (1966). Die Schnecken (Gastropoda, Prosobranchia) der deutschen Meeresgebiete und brackigen Küstengewässer. *Helgoländer wiss. Meeresunters.* 6, 1-61.

## Appendix

**Table 1** Autecological parameters and its definitions in the German MarBIT approach.

### General data

Geographical distribution (both former and current findings)	N5-Helgoland (rocky intertidal)
Distribution pattern	Native (originally from the area) Endemic (only occurring in the area) Guest (occurring for a short time in the area; migrant) Neozoic (immigrated in the area)
Mobility	Sessile (attaching permanently to the substrate; not mobile) Hemi-sessile (attaching not permanently to the substrate; mobile over short distances) Vagile (Mobile)
Size (body height)	
Age	< 1 year 1-2 years 2-5 years > 5 year
Annual production (biomass production in g per m <sup>2</sup> and year)	
Maximum biomass (time of highest biomass in the year)	
Growth	Fast Slow
Notes (miscellaneous about the taxon)	
Abundance	
Presence	
Origin	Lusitanian (Mediterranean) Arctic Boreal (temperate zone)

### Habitat

Salinity tolerance	β-oligohaline (0,5-3 psu) α-oligohaline (3-5 psu) β-mesohaline (5-10 psu) α-mesohaline (10-18 psu) polyhaline (18-30 psu) euryhaline (all salinities) oligohaline (only low salinities, brackish (0,5-5 psu) limnic euhaline (> 30 psu)
Zonation (vertical distribution; depths in m)	Supralittoral (Splash water zone)  Upper intertidal Mid intertidal Lower intertidal Upper subtidal Lower subtidal Intertidal Subtidal < 15 m water depth > 15 m water depth



**Table 1** (contd.)**Habitat**

Substrate/habitat preference	<ul style="list-style-type: none"> <li>Rock, boulders, hard substrate</li> <li>Gravel</li> <li>Sand</li> <li>Mud (silt, clay)</li> <li>Wood</li> <li>Phytal (referring to epifauna only)</li> <li>Blue mussel bed</li> <li>Fine sandy mud</li> <li>Muddy fine sand</li> <li>Clay</li> <li>Coarse sand</li> <li>Without preference</li> </ul>
Habitat/living horizon	<ul style="list-style-type: none"> <li>Epibenthos (organisms that live on the surface of the substrate)</li> <li>Endobenthos (organisms that live in the sediment)</li> <li>Mesolithion (organisms that live in crevices, holes or under stones)</li> <li>Mesobenthos (organisms that live between the grains; meiobenthos)</li> </ul>
Exposure	<ul style="list-style-type: none"> <li>Sheltered (sheltered bays, estuaries, bodden and lagoons)</li> <li>Exposed (outer coastline)</li> <li>Very to extremely exposed (headlands and tip of islands; often with a strong current)</li> <li>Without preference</li> </ul>

**Feeding**

Food preference	<ul style="list-style-type: none"> <li>Herbivore (feeding on plants)</li> <li>Carnivore (feeding on animal tissues)</li> <li>Detrivore (feeding on decomposing organic matter)</li> <li>omnivore (feeding on both animal and vegetable substances)</li> </ul>
Feeding strategy	<ul style="list-style-type: none"> <li>Predator (prey selectively on another organism)</li> <li>Grazer (feeding selectively on plants)</li> <li>Suspension feeder (feeding on particles suspended in the water column)</li> <li>Active suspension feeder (catching food on a filter from water by actively sweeping or pumping)</li> <li>Passive suspension feeder (catching food on a filter held into flowing water or collecting the 'rain' of detritus on sticky apparatus other than a filter)</li> <li>Deposit feeder (feeding on fragmented particulate organic matter from the substratum)</li> <li>Selective deposit feeder (only feeding on food)</li> <li>Non-selective deposit feeder (feeding on both food and sediment)</li> <li>Parasite</li> <li>Commensal (obtaining food or other benefits from another organism without damaging or benefiting it)</li> <li>Scavenger</li> </ul>

**Endangerment**

Red List - status	<ul style="list-style-type: none"> <li>Critically endangered</li> <li>Endangered</li> <li>Vulnerable</li> <li>Reproduction migrant</li> <li>Vulnerable migrant</li> </ul>
-------------------	---

**Table 1** (contd.)**Endangerment**

	Extinct Near threatened Data deficient Very rare species (species with a geographical restriction; extremely rare) Premonition list Least concern
Reason for endangerment	Dredge activity (actions of sustentation, e.g. deepening of waterways) Eutrophication (incl. water turbidity, acidification, siltation, oxygen deficiency) Fishery, direct effects of catch Fishery, indirect effects of by-catch, beam trawl or similar Habitat degradation by structural measures or destruction Hunt and pursuit Climate change Military Waste (ocean dumping, waste combustion, average etc.) Utilization of resources (intensive utilization/cultivation of the habitat, land improvement) Parasites and diseases Extraction of raw materials (extraction of gravel, stone fishery, oil drillings) Harmful substances (direct or by accumulation; also herbicides) Tourism (tourism that utilize land) unknown Replacement by other species or changes by invasive or introduced species

**Ecology**

Survival strategy	r-strategist (opportunist) k-strategist
Life cycle	Holobenthos (whole life cycle at the sea bottom) Merobenthos (parts of the life cycle as planktonic stages)
Ecological specialization (vs. generalists)	Habitat (specialized to a particular habitat) Food (specialized to a particular food)

**Reproduction**

Reproduction period (season or month)	Spring Summer Autumn Winter All-season
Lengths of the reproduction period	Permanent A couple of months A couple of weeks A couple of days A couple of hours
Reproduction periodicity	Inter-annual (not annual) Annual (once per year) Annual, episodic (several times per year)

**Table 1** (contd.)**Reproduction**

Reproduction frequency	Iterparous (several breeding during life span) Semelparous (breeding only once then dying)
Fecundity (number of eggs)	< 50 50-1000 1000-10.000 10.000-1.000.000 > 1.000.000
Developmental mechanism	Viviparous (embryos develop within the maternal body and derive nourishment or not) Direct development (development without a larval stage) Planktotrophic larvae (living in the water column and feeding at least in part on materials captured from the plankton) Lecitotrophic larvae (living in the water column, but do not feeding on materials captured from the plankton) Demersal larvae (larvae which staying at the sea bottom after hatch, but are mobile) Brooding Mixed development (first brooding, then larvae stage)
Fertilisation mechanism	intern extern
Generation time	Till 1 month 1-3 months 3 months - 1 year More than 1 year
Age at maturity	Till 1 month 1-3 months 3 months - 1 year More than 1 year

**Reproduction mechanism**

asexual	
sexual	sexual asexual - vegetative asexual - parthenogenetic sexual, dioecious sexual, monoecious

**Physiology**

Oxygen deficiency	tolerant sensitive
Substratum relocation	tolerant sensitive
Eutrophication	tolerant sensitive
Toxic substances	tolerant



Table 2 (contd.)

Phylum	Species	Author	Synonym	Reference																								
				1800												1900										2000		
				`29	`36	`45	`47	`53	`71	`72	`75	`87	`91	`94	`97	`00	`08	`23	`25	`28	`32	`66	`79	`79	`93	`96	`01	`03
	<i>Hartlaubella gelatinosa</i>	(Pallas, 1766)																					J					RaB
	<i>Hydractinia echinata</i>	Fleming, 1823	<i>Hydractinia grisea</i>				Le						Htl															
	<i>Hydrallmania falcata</i>	(Linnaeus, 1758)					Le	Mö					Htl										J					RaB
	<i>Kirchenpaueria pinnata</i>	(Linnaeus, 1758)	<i>Plumularia pinnata</i>										Htl												R			R
	<i>Laomedea flexuosa</i>	Alder, 1857	<i>Campanularia flexuosa</i>										Htl										J					RaB R
	<i>Obelia dichotoma</i>	(Linnaeus, 1758)	<i>Campanularia dichotoma</i> ; <i>Sertularia geniculata</i>	Ho			Le						Htl															R
	<i>Obelia geniculata</i>	(Linnaeus, 1758)	<i>Campanularia geniculata</i> ; <i>Laomedea geniculata</i>				Le	Mö					Htl										J					RaB
	<i>Plumularia setacea</i>	(Linnaeus, 1758)											Htl															RaB
	<i>Sertularia cupressina</i>	Linnaeus, 1758											Htl										J					RaB
<b>Nemertea</b>																												
	<i>Amphiporus lactifloreus</i>	(Johnston, 1828)																					J					RL
	<i>Cephalothrix rufifrons</i>	(Johnston, 1837)																					J					RaB
	<i>Emplectonema gracile</i>	(Johnston, 1837)																					J					
	<i>Lineus bilineatus</i>	(Renier, 1804)																					J					RaB RL
	<i>Lineus ruber</i>	(Müller, 1774)																					J					RaB RL
	<i>Lineus viridis</i>	(Müller, 1774)																					J					
	<i>Micrura fasciolata</i>	Ehrenberg, 1828																					J					
	<i>Oerstedia dorsalis</i>	(Abildgaard, 1806)																					J					RaB RL
	<i>Procephalothrix filiformis</i>	(Johnston, 1828)																					J					
	<i>Tetrastemma candidum</i>	(Müller, 1774)	<i>Polia quadrioculata</i>				Le																J					RaB
	<i>Tetrastemma vermiculus</i>	(Quatrefages, 1846)																					J					RaB
<b>Mollusca</b>																												
Polyplacophora	<i>Leptochiton asellus</i>	(Gmelin, 1791)																					J					
	<i>Lepidochitona cinerea</i>	(Linnaeus, 1767)	<i>Chiton cinereus</i> ; <i>Chiton laevis</i>	Ho	Ph		Le						He										J			Wen	RaB	R
Gastropoda	<i>Acanthodoris pilosa</i>	(Abildgaard in Müller, 1789)	<i>Doris pilosa</i>				Le						He										J		Schu		RaB	R
	<i>Aeolidia papillosa</i>	(Linnaeus, 1761)	<i>Eolidia papillosa</i>				Le						He										J		Schu			RL
	<i>Aeolidiella glauca</i>	(Alder & Hancock, 1845)																							Schu			
	<i>Ancula gibbosa</i>	(Risso, 1818)	<i>Ancula cristata</i>										He															
	<i>Archidoris pseudoargus</i>	(Rapp, 1827)	<i>Archidoris tuberculata</i>										He										J		Schu			

Table 2 (contd.)

Phylum	Species	Author	Synonym	Reference																															
				1800														1900										2000							
				`29	`36	`45	`47	`53	`71	`72	`75	`87	`91	`94	`97	`00	`08	`23	`25	`28	`32	`66	`79	`79	`93	`96	`01	`03	`05	`06	`08				
	<i>Buccinum undatum</i>	Linnaeus, 1758		Ho	Ph		Le					Met et al.	Pf		He									Z				J					RaB	R	
	<i>Calliostoma zizyphinum</i>	(Linnaeus, 1758)	<i>Trochus zizyphinus</i>												He													J							
	<i>Crepidula fornicata</i>	(Linnaeus, 1758)																						Z										R	
	<i>Cuthona foliata</i>	(Forbes & Goodsir, 1839)																															RaB		
	<i>Dendronotus frondosus</i>	(Ascanius, 1774)	<i>Dendronotus arborescens</i>													He												J							
	<i>Doto coronata</i>	(Gmelin, 1791)														He												J							
	<i>Elysia viridis</i>	(Montagu, 1804)														He												J		Schu		RaB	R		
	<i>Epitonium clathrum</i>	(Linnaeus, 1758)	<i>Scalaria communis</i>				Le						Pf																				RaB		
	<i>Facelina auriculata</i>	(Müller, 1776)	<i>Facelina coronata</i>																									J		Schu		RaB			
	<i>Facelina bostoniensis</i>	(Couthouy, 1838)																												Schu					
	<i>Flabellina pedata</i>	(Montagu, 1815)	<i>Coryphella pedata</i>																									J		Schu					
	<i>Flabellina verrucosa</i>	(M. Sars, 1829)	<i>Coryphella rufibranchialis</i> ; <i>Coryphella verrucosa</i>													He													J					RaB	
	<i>Gibbula cineraria</i>	(Linnaeus, 1758)	<i>Trochus cinerarius</i>		Ph		Le					Met et al.	Pf		He									Z				J			Wen	RaB	R		
	<i>Goniodoris nodosa</i>	(Montagu, 1808)													He																				
	<i>Hydrobia ulvae</i>	(Pennant, 1777)										Met et al.																	J					RaB	
	<i>Lacuna pallidula</i>	(da Costa, 1778)			Ph							Met et al.	Pf		He														J					RaB	RL
	<i>Lacuna vincta</i>	(Montagu, 1803)	<i>Lacuna divaricata</i>		Ph							Met et al.	Pf		He														J					RaB	R
	<i>Lamellaria perspicua</i>	(Linnaeus, 1758)													He									Z										RaB	
	<i>Limapontia capitata</i>	(Müller O.F., 1774)	<i>Limapontia nigra</i>				Le																											RaB	
	<i>Limapontia senestra</i>	(de Quatrefages, 1844)																																RaB	RL
	<i>Littorina littorea</i>	(Linnaeus, 1758)	<i>Turbo littoreus</i>		Ph	Men	Le	Ge				Met et al.	Pf		He										Z				J			Wen	RaB	R	
	<i>Littorina obtusata</i> / <i>Littorina mariae</i> complex	(Linnaeus, 1758) / Sacchi and Rastelli, 1966			Ph		Le	Ge				Met et al.	Pf		He										Z				J			Wen	RaB	R	
	<i>Littorina saxatilis</i> complex	(Olivi, 1792)	<i>Littorina arcana</i> ; <i>L. neglecta</i> ; <i>L. nigrolineata</i> ; <i>L. rudis</i> ; <i>L. tenebrosa</i>									Met et al.	Pf		He											Z				J				RaB	R
	<i>Melarhappe neritoides</i>	(Linnaeus, 1758)	<i>Littorina neritoides</i>																							Z									
	<i>Nucella lapillus</i>	(Linnaeus, 1758)	<i>Purpura lapillus</i>		Ph		Le					Met et al.	Pf		He											Z				J			Wen	RaB	R
	<i>Onchidoris muricata</i>	(Müller O.F., 1776)	<i>Lamellidoris muricata</i>												He														J						
	<i>Onoba aculeus</i>	(Gould, 1841)																											J					RaB	R

Table 2 (contd.)

Phylum	Species	Author	Synonym	Reference																											
				1800												1900												2000			
				`29	`36	`45	`47	`53	`71	`72	`75	`87	`91	`94	`97	`00	`08	`23	`25	`28	`32	`66	`79	`79	`93	`96	`01	`03	`05	`06	`08
	<i>Palio nothus</i>	(Johnston, 1838)	<i>Polycera fusca</i>				Le						He																		
	<i>Patella vulgata</i>	Linnaeus, 1758						Met											Z			Har									
	<i>Polycera quadrilineata</i>	(Müller O.F., 1776)				Men							He										J					RaB	RL		
	<i>Pusillina inconspicua</i>	(Alder, 1844)																					J						RaB		
	<i>Raphitoma linearis</i>	(Montagu, 1803)																											RaB		
	<i>Retusa truncatula</i>	(Bruguère, 1792)																					J								
	<i>Rissoa parva</i>	(da Costa, 1778)									Met et al.		He										J					RaB	R		
	<i>Skeneopsis planorbis</i>	(Fabricius O., 1780)	<i>Skenea planorbis</i>						Met		Met et al.		He					Z					J								
	<i>Tectura virginea</i>	(Müller O.F., 1776)	<i>Acmaea virginea</i> ; <i>Patelloidea virginea</i>								Met et al.	Pf	He										J								
	<i>Tergipes tergipes</i>	(Forskål, 1775)	<i>Tergipes despectus</i>										He																		RL
Bivalvia	<i>Anomia ehippium</i>	Linnaeus, 1758	<i>Anomia cepa</i>		Ph		Le						Pf	He									J					RaB			
	<i>Crassostrea gigas</i>	(Thunberg, 1793)																													RL
	<i>Hiatella arctica</i>	(Linnaeus, 1767)	<i>Saxicava striata</i> ; <i>Saxicava arctica</i>																					J							
	<i>Hiatella rugosa</i>	(Linnaeus, 1767)	<i>Hiatella gallicana</i> ; <i>Saxicava gallicana</i>		Ph		Le						Pf	He										J				RaB	RL		
	<i>Mytilus edulis</i>	Linnaeus, 1758			Ph		Le				Met et al.	Pf	He															Wen	RaB	R	
	<i>Pholas dactylus</i>	Linnaeus, 1758			Ph		Le						Pf	He															RaB	R	
	<i>Venerupis senegalensis</i>	(Gmelin, 1791)	<i>Venerupis pullastra</i> ; <i>Tapes pullastra</i>								Met et al.		He										J				Wen	RaB			
	<i>Zirfaea crispata</i>	(Linné, 1767)											He																		
Sipuncula																															
	<i>Nephasoma minutum</i>	(Keferstein, 1862)	<i>Golfingia minuta</i>																					J					RaB		
Kamptozoa																															
	<i>Pedicellina cernua</i>	(Pallas, 1774)																						J							
Annelida																															
Polychaeta	<i>Alitta succinea</i>	(Frey & Leuckart, 1847)	<i>Nereis succinea</i>				Le																	Gi							
	<i>Alitta virens</i>	(M. Sars, 1835)	<i>Nereis virens</i> ; <i>Neanthes virens</i>																					Gi	J						
	<i>Anaitides maculata</i>	(Linnaeus, 1767)												Mi									Gi	J				RaB			
	<i>Arenicola marina</i>	(Linnaeus, 1758)	<i>Arenicola piscatorum</i>	Ho			Le																	Gi	J						
	<i>Brania pusilla</i>	(Dujardin, 1851)																						Gi							











Table 2 (contd.)

Phylum	Species	Author	Synonym	Reference																										
				1800														1900										2000		
				`29	`36	`45	`47	`53	`71	`72	`75	`87	`91	`94	`97	`00	`08	`23	`25	`28	`32	`66	`79	`79	`93	`96	`01	`03	`05	`06
	<i>Conopeum reticulum</i>	(Linnaeus, 1767)																						J				RaB		
	<i>Cribrilina punctata</i>	(Hassall, 1841)																					J							
	<i>Cryptosula pallasiana</i>	(Moll, 1803)																					J				RaB	R		
	<i>Electra pilosa</i>	(Linnaeus, 1767)	<i>Flustra pilosa</i> ; <i>Membranipora pilosa</i>	Ho			Le																J			Wen	RaB	R		
	<i>Escharella immersa</i>	(Fleming, 1828)																					J				RaB			
	<i>Escharella variolosa</i>	(Johnston, 1838)																					J				RaB			
	<i>Flustrellidra hispida</i>	(O. Fabricius, 1780)																					J				RaB	R		
	<i>Membranipora membranacea</i>	(Linnaeus, 1767)	<i>Flustra membranacea</i>	Ho			Le																J				RaB	RL		
	<i>Schizoporella errata</i>	(Waters, 1878)																					J				RaB			
	<i>Scrupocellaria scruposa</i>	(Linnaeus, 1758)	<i>Cellularia scruposa</i>				Le																					RL		
	<i>Walkeria uva</i>	(Linnaeus, 1758)																					J				RaB	RL		
<b>Echino- dermata</b>																														
	<i>Amphipholis squamata</i>	(Delle Chiaje, 1828)	<i>Ophiolepis squamata</i>				Le																J				RaB	R		
	<i>Asterias rubens</i>	Linnaeus, 1758	<i>Asteracanthion rubens</i>	Ho			Le																J			Wen	RaB	R		
	<i>Psammechinus miliaris</i>	(P.L.S. Müller, 1771)																					J				RaB			
<b>Chordata</b>																														
Ascidiacea	<i>Aplidium turbinatum</i>	(Savigny, 1816)	<i>Sidnyum turbinatum</i>																				J	Ri			RaB	R		
	<i>Botrylloides leachi</i>	(Savigny, 1816)																					J				RaB			
	<i>Botryllus schlosseri</i>	(Pallas, 1766)																					J	Ri			RaB	R		
	<i>Ciona intestinalis</i>	(Linnaeus, 1758)																						Ri						
	<i>Clavelina lepadiformis</i>	(Müller, 1776)					Le	Mö															J	Ri			RaB	R		
	<i>Dendrodoa grossularia</i>	(Van Beneden, 1846)	<i>Cynthia depressa</i>				Le																	Ri						
	<i>Didemnum maculosum</i>	(Milne-Edwards, 1841)	<i>Didemnum helgolandicum</i> ; <i>Leptoclinium candidum</i> ; <i>Leptoclinium durum</i>				Le																	Htm	Mi		Ri		R	
	<i>Molgula citrina</i>	Alder & Hancock, 1848																					J							
	<i>Molgula complanata</i>	Alder & Hancock, 1870																						Ri			RaB	R		
	<i>Polyclinum aurantium</i>	Milne-Edwards 1841																						Ri			RaB			