Recent Cephalopods of the German Oceanographic Museum and the Zoological Collection Rostock

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Abstract. The malacological collections of the German Oceanographic Museum (GOM) in Stralsund and the Zoological Museum of the University Rostock (ZSRO) keep Cephalopod specimens from all over the world. The inventory and taxonomic revision presented in this study provides an overview of the cephalopod samples present in both collections. The total of 252 specimen records (GOM: 193, ZSRO: 59) represent 51 different species, mainly from northern Atlantic, Mediterranean and western Pacific locations. Special reference is made to species collected from the North Sea.

Kurzfassung. In den wissenschaftlichen Mollusken-Sammlungen des Deutschen Meeresmuseums (DMM) in Stralsund und der Zoologischen Sammlung Rostock (ZSRO) werden Cephalopoden-Exemplare aus allen Teilen des Weltmeeres aufbewahrt. Die vorliegende Inventur und taxonomische Revision gibt einen Überblick über das vorhandene Sammlungsmaterial. Unter insgesamt 252 Sammlungspositionen (DMM: 193, ZSRO: 59) liegen Belege von 51 verschiedenen Arten vorwiegend aus dem nördlichen Atlantik, dem Mittelmeer und dem westlichen Pazifik vor. Sammlungsobjekte aus der Nordsee werden gesondert diskutiert.

Key words: Mollusca, Cephalopoda, malacological collection, species catalogue, North Sea

Introduction

The malacological collections of the German Oceanographic Museum (GOM) and Zoological Museum of the University of Rostock (ZSRO) differ in their histories. Compared to the ZSRO, the collection of the GOM has a relatively short history, beginning with the establishment of the museum in 1951 by Professor O. DIBBELT. One of the principle duties of the GOM, which developed against the social and political backdrop of the German Democratic Republic, was to design and display attractive exhibitions for the public. Scientific emphasis was placed on ornithology and marine mammal research. Contributions to the pool of exhibits and collection lots were provided by associate institutions (e. g. VEB Hochseefischerei Rostock) and friends of the museum. Since German reunification, key aspects of the collection have been systematically extended, focus on its original areas of emphasis has been deepened, and new areas of focus have come into play.
In contrast, the ZSRO looks back on a 232 year history which began when the museum was established in 1775 by Professor O. G. TYCHSEN. After relocation of the collection from Bützow to Rostock, the exhibits were stored at today's zoological museum in historical glass cabinets dating from 1880, where they have been on display right up to the present day, first only to students, but now also to the public.

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The ZSRO collection provides type and collection specimen references for research purposes, as well as for the education of students. The collection focuses on aquatic animals, molluscs, birds and insects. Most recent acquisitions include polychete worms from A. BICK, insects, scorpions and freshwater bivalves from R. KINZELBACH, and fishes, especially sturgeons, from H. WINKLER. Today, the ZSRO collection consists of approximately 100,000 items or series (R. KINZELBACH, personal communication).
Molluscs have been a focus area of both collections since the beginning, and especially of the ZSRO which dates back to the era of "naturalia cabinets" and conserves the type species series of F. LINK (1806). The malacological departments of GOM and ZSRO therefore intend to compile representative collections of voucher specimens and to establish reference collections of molluscs especially for the Mecklenburg-Western Pomerania and Baltic Sea regions. The GOM malacological collection aims to completely represent the species inventory of German coastal and sea areas including the North and Baltic Sea (HOPPE 1992). It is (with a few exceptions) limited to marine molluscs, but includes brackish regions of marginal seas and coasts as well. As with the ZSRO, other focus regions include the Mediterranean and the Red Sea.
The GOM systematic collection aims at the best possible representation of species and documentation of the mollusc fauna of selected regions over relatively long time scales. Since cephalopods are purely marine animals which are only vagrants in the Baltic and do not generate reproductive stocks, special emphasis in this study was placed on voucher specimens of North Sea cephalopod fauna. A revision and inventory of the GOM's collection stocks was last conducted in the early 1990s, and a successive inventory of the ZSRO has been being conducted since 1995. No systematic review had been carried out prior to this inventory.
In order to consider and register new cephalopod material and lost collection lots in both institutions, a revision and digitization of the cephalopod material was conducted in the course of a zoological student internship in 2005.

The cephalopod fauna of the North Sea

The North Sea is an epicontinental sea with an average water depth of 93 m (OTT 1996), but mostly depth ranges of 40-50m. It is delimited towards the northern Atlantic by an imaginary line between Scotland and Norway (62°N, 5°W) and in the western approach to the English Channel (5°W) as well as by coastlines of adjoining coastal states (WALDAY & KROGLUND 2002). Due to the low water depth of the continental shelf basin, the limited diversity of the bottom relief and the predominantly sandy sediment, only three cephalopod life-forms occur. STEIMER (1993) defines them as: (1) nekto-benthic forms which are regular residents of the North Sea on their spawning and foraging migrations, such as the Loligonid family and *Sepia officinalis*; (2) purely benthic forms such as *Eledone cirrhosa* and *Bathypolypus arcticus*, which permanently inhabit the area, and (3) oegopsid high-pelagic forms (oceanic squids) such as *Onychoteuthis banksi*, which sporadically stray into the North Sea because of currents or while hunting swarms of fishes.
Despite the limited diversity of habitats, the North Sea does not represent a uniform zoogeographical region but can be divided into a northern and southern component (JAECKEL 1958). As a result of topographical conditions, Nordic forms predominate because of the wider passage way they have compared to the English Channel

(VOSS 1973, JAECKEL 1958). Furthermore, the composition of the cephalopod fauna of the North Sea is permanently subject to large fluctuations (STEIMER 1993).
According to STEIMER (1993), 32 cephalopod species have been recorded in the geographic range of the North Sea and the adjacent waters Skagerrak, Kattegat and Belt Sea. These species are highlighted in table 1 (see below). 16 of these are classified as immigrants at regular intervals or permanent inhabitants and *Alloteuthis subulata* shows the greatest abundance in the southern North Sea (STEIMER 1993). To continue the list of permanent North Sea residents, nekto-benthic species include *Loligo forbesii*, *Loligo vulgaris*, *Todaropsis eblanae* and *Todarodes sagittatus*. The benthic species recorded are *Sepia officinalis*, *Rossia macrosoma*, *Rossia glaucopis*, *Sepietta oweniana*, *Sepietta neglecta*, *Sepiola atlantica*, *Sepiola aurantiaca*, *Sepiola pfefferi*, *Octopus vulgaris*, *Eledone cirrhosa* and *Bathypolypus arcticus*. Except for the Sepiolids *Sepietta neglecta* and *Sepiola aurantiaca*, these species are frequently found in the North Sea (STEIMER 1993).

Material and Methods

Inventory and taxonomic revision. Existing items from the collections as well as supplementary details and information were digitized in spring and summer 2005. New items were inventoried into the catalogues. Missing item information was tracked down in catalogues and inventory books, which keep record of additional collection data and acknowledge collectors, donors etc. Unregistered items for which complete collection data could be retrieved and items in good condition were newly catalogued.
The taxonomic revision was based on the information provided in the cephalopod section of the Integrated Taxonomic Information System (www.itis.gov, last revised 1999), as well as relevant technical literature (see below). Upon data entry, the species name of each item was checked for taxonomic validity and updated where necessary. Invalid species names or synonyms were recorded in the database.
Information about cephalopod specimens from the North Sea was acquired separately and was supplemented by further literature.

Species identification and set-up of the collection. The correctness of species identification was checked during the revision and registration of items, on the basis of macroscopically observable diagnostic features. Undetermined specimens were analysed in detail and identified. During the identification process, species – mainly conserved with ethanol (70%) – were rinsed in tap water and examined in water filled dissecting dishes using a stereomicroscope. Identification of species was conducted referring to keys by NESIS (1987), ROPER ET AL. (1984), and JEREB & ROPER (2005) as well as the Tree of Life Web Project (YOUNG ET AL. 1996) and the database Cephbase (WOOD & DAY 2006) available via internet. Preparations were carried out where necessary. Cephalopod specimens were preserved in ethanol (70%) and displayed in the collections.

Results

The cephalopod collection of the GOM holds 193 specimen records, the ZSRO collection 59. 46 of the GOM's specimens and 21 of ZSRO's are representatives of the approximately 786 living cephalopod species currently recognized, as listed in

the Current Classification of Recent Cephalopoda from May 2001. Combining the results from both collections, a total of 51 extant cephalopod species are represented. As yet, there are no type specimens in either cephalopod collection.
Highlights of the collections are two glass models of the cephalopod species *Ancistroteuthis lichtensteini* (Ferussac, 1835) and *Octopus vulgaris* Cuvier, 1797 at the ZSRO made by the world famous Saxonian glassblowing company BLASCHKA, as well as a male specimen of the giant squid *Architeuthis dux* Steenstrup, 1857 from New Zealand, which is displayed in the GOM exhibition (see Figs. 1,2).

Fig. 1, 2. 1a-b. BLASCHKA models in ZSRO. 2. Exponate of *Architeuthis dux* in German Oceanogrphic Museum Stralsund.

The GOM's cephalopod records mainly comprise specimens from the Atlantic Ocean and the Mediterranean (collectors include L. & R. ENZENROß), which make up about 50% of the collection stock. The North Sea is represented by just two specimen

records (*Alloteuthis media*, *Alloteuthis subulata*) (Fig. 3). The cephalopod fauna of the Eastern Pacific is represented by specimens from the South Eastern Asian waters (collector: U. PIATKOWSKI).
At the ZSRO, four specimen records from the North Sea are present (*Loligo vulgaris*, 2 *Alloteuthis subulata*, *Sepia officinalis*). It is noteworthy that of these, one specimen record of *Alloteuthis subulata* was collected on the Darss peninsula (Mecklenburg Bight), which indicates that *A. subulata* is able to invade relatively deep into brackish regions of the Baltic Sea with occasional saltwater inflow from the North Sea.
For most parts of the collection stock, however, details about sampling locations are largely unknown (Fig. 4).

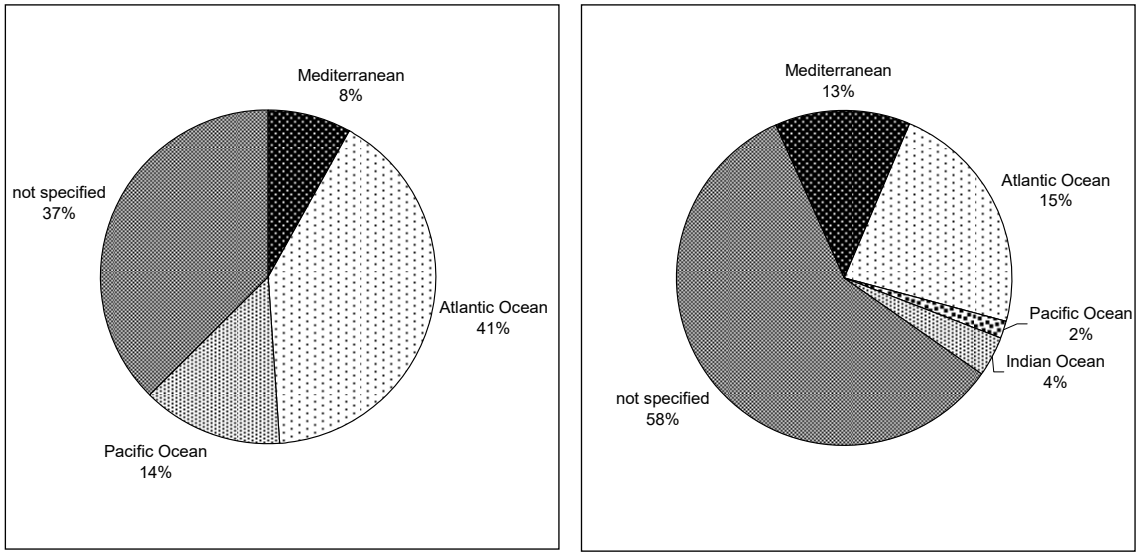

Fig. 3, 4: Proportions of Cephalopod items in both collections arranged according to sea area: Fig. 3 (left): GOM, Fig. 4 (right): ZSRO.

Most collection items with unknown locations originate from the Northern Atlantic Ocean (GOM) and from the Mediterranean and Atlantic Ocean regions (ZSRO). Figure 5 indicates the origin of the cephalopod specimens in both collections sorted by sea area.

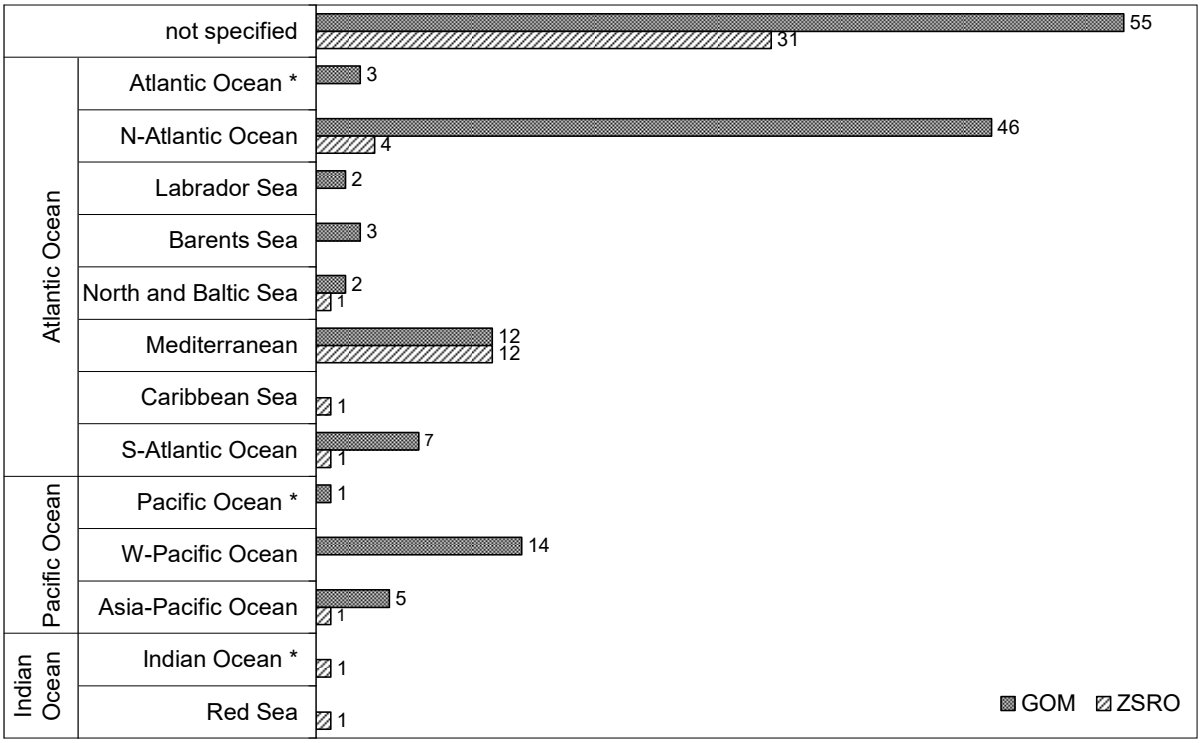

Fig. 5. Geographic origin of Cephalopod samples in the collections of the GOM and the ZSRO, arranged according to sea area. Counts refer to number of collection items. Asterisks (*) denote samples of which the origin is unknown in more detail.

Table 1 gives an overview of the cephalopod species of both collections. The list includes the species retrieved or identified during the revision of the cephalopod collections in 2005, and gives the number of collection items for each species. The latter are itemised by collection regions using FAO main fishing areas (FAO's Handbook of Fishery Statistics). The geographical classification of the areas is reviewed in table 2. For items which could not be classified according to these regions due to lack of information, collection locations are stated separately. Specimens which could not be reliably identified to species level are summarized in the attributed genus.

Tab. 1. Catalogue of cephalopod species at GOM and ZSRO. Data in parentheses refer to numbers of FAO Fishing Areas. Abbreviation n. s. is used where finding sites are not specified. Asterisks (*) denote cephalopod species which are reported for the North Sea (according to STEIMER 1993).

Cephalopoda CUVIER 1797 **Taxa arranged by families**	**GOM**		**ZSRO**	
	number of specimens	**Number (area)**	**number of specimens**	**Number (area)**
Nautilidae				
Nautilus pompilius Linné, 1758			8	8 (n. s.)
Nautilus sp.	1	1 (n. s.)	1	1 (n. s.)
Spirulidae				
Spirula spirula Linné, 1758	1	1 (n. s.)	1	1 (51)
Sepiidae				
Sepia officinalis Linné, 1758 *	28	4 (27); 4 (34); 3 (37); 1 (51); 16 (n. s.)	10	1 (27); 3 (37); 6 (n. s.)
Sepia bertheloti Orbigny, 1835			1	1 (34)
Sepia elegans Blainville, 1827 *	1	1 (37)	2	2 (37)
Sepia orbignyana Ferussac, 1826 *	1	1 (37)		
Sepia sp.	10	1 (51); 9 (n. s.)	2	1 (37); 1 (47)
Sepiolidae				
Sepiola rondeleti Leach, 1834	1	1 (n. s.)	3	2 (37); 1 (n. s.)
Sepiola sp.	1	1 (37)		
Rondeletiola minor (Naef, 1912)			1	1 (37)
Sepietta oweniana Orbigny, 1839 *	1	1 (27)		
Sepietta neglecta Naef, 1916 *	1	1 (n. s.)		
Rossia moelleri Steenstrup, 1856	1	1 (21)		
Austrorossia mastigophora Chun, 1915	1	1 (51)		
Loliginidae				
Loligo vulgaris vulgaris Lamarck, 1796 *	6	1 (21); 1 (34); 1 (37); 3 (n. s.)	3	1 (27); 2 (n. s.)
Loligo vulgaris reynaudi Orbigny, 1939 *	1	1 (47)		
Loligo (Alloteuthis) media Linné, 1758 *	1	1 (27)	1	1 (37)
Loligo (Alloteuthis) subulata Lamarck, 1798 *	3	3 (27)	2	2 (27)
Loligo opalescens Berry, 1911	1	1 (77)		
Loligo pealeii Lesueur, 1821	1	1 (21)		
Sepioteuthis lessoniana Ferussac, 1830	1	1 (71)		
Uroteuthis bartschi Rehder, 1945	2	1 (71); 1 (n. s.)		
Uroteuthis (Photololigo) chinensis (Gray, 1849)	1	1 (71)		
Uroteuthis (Photololigo) duvauceli (Orbigny, 1835)	1	1 (71)		
Loligo forbesii Steenstrup, 1856 *	2	2 (n. s.)		
Loligo sp.	1	1 (n. s.)	2	2 (21)
Architeuthidae				
Architeuthis dux Steenstrup, 1857 *	1	1 (81)		

Cranchiidae				
*Taonius pavo (*Lesueur, 1821)	2	2 (27)		
Enoploteuthidae				
Abralia multihamata Sasaki, 1929	1	1 (71)		
Gonatidae				
Gonatus steenstrupi Kristensen, 1981	1	1 (27)		
Histioteuthidae				
Histioteuthis eltaninae Voss, 1969	3	3 (51)		
Ommastrephidae				
Illex illecebrosus (Lesueur, 1821) *	2	1 (21); 1 (n. s.)	1	1 (27)
Illex argentinus (Castellanos, 1960)	1	1 (41)		
Illex coindetii (Verany, 1839) *	7	3 (34); 1 (37); 3 (n. s.)	1	1 (37)
Illex sp.	6	2 (21); 1 (41); 3 (n. s.)		
Todarodes sagittatus (Lamarck, 1798) *	8	2 (27); 1 (47); 1 (51); 2 (S-Atlantic); 1 (34); 1 (n. s.)	1	1 (n. s.)
Todarodes angolensis Adam, 1962	3	3(51)		
Todarodes sp.	2	2 (k. A.)		
Todaropsis eblanae (Ball, 1841) *	2	1 (27); 1 (uncertain)	1	1 (n. s.)
Nototodarus sloanii (Gray, 1849)	1	1 (n. s.)		
Ommastrephes bartramii (Lesueur, 1821) *	2	2 (n. s.)		
Sthenoteuthis oualaniensis (Lesson, 1830)	1	1 (51)		
Onychoteuthidae				
Onychoteuthis banksii (Leach, 1817) *	1	1 (n. s.)	1	1 (n. s.)
Onychoteuthis sp.			1	1 (n. s.)
Ancistroteuthis lichtensteini (Ferussac, 1835)			1	1 (glass model)
Thysanoteuthidae				
Thysanoteuthis rhombus Troschel, 1857	2	2 (n. s.)		
Argonautidae				
Argonauta argo Linné, 1758	3	1 (61); 2 (n. s.)	3	1 (31); 1 (37); 1 (n. s.)
Argonauta hians Lightfoot, 1786			1	1 (n. s.)
Argonauta sp.	1	1 (n. s.)		
Octopodidae				
Octopus vulgaris Cuvier, 1797 *	31	1 (27); 19 (34); 4 (37); 2 (aquarium); 5 (n. s.)	2	1 (glass model); 1 (n. s.)
Octopus defilippi (Verany, 1851)	1	1 (n. s.)		
Octopus macropus Risso, 1826	1	1 (uncertain)		
Octopus tehuelchus Orbigny, 1834	1	(41)		

Octopus sp.	19	3 (21); 1 (37); 15 (n. s.)	1	1 (37)
Eledone moschata (Lamarck, 1798)	5	1 (37); 4 (n. s.)	6	3 (37); 3 (n. s.)
Eledone cirrhosa (Lamarck, 1798) *	1	1 (n. s.)	1	1 (n. s.)
Eledone thysanophora Voss, 1962	3	3 (51)		
Eledone sp.	3	3 (n. s.)		
Pareledone sp.	1	1 (Antarctica)		
Graneledone verrucosa (Verrill, 1881) *	1	1 (27)		
Bathypolypus arcticus (Prosch, 1847) *	3	2 (27); 1 (n. s.)		
Ocythoidae				
Ocythoe tuberculata Rafinesque, 1814	4	4 (n. s.)		
Total number of specimen records	**193**		**59**	
Number of species	**46**		**21**	

Tab. 2. FAO's Major Fishing Areas for statistical purposes.

Number	Area	Abbreviation
18	Arctic Sea	ARC
21	Atlantic, Northwest	WNA
27	Atlantic, Northeast	ENA
31	Atlantic, Western Central	WCA
34	Atlantic, Eastern Central	ECA
37	Mediterranean and Black Sea	MED
41	Atlantic, Southwest	WSA
47	Atlantic, Southeast	EDA
48	Atlantic, Antarctic	ANC
51	Indian Ocean, Western	WIO
57	Indian Ocean, Eastern	EIO
58	Indian Ocean, Antarcic and Southern	ANE
61	Pacific, Northwest	WNP
67	Pacific, Northeast	ENP
71	Pacific, Western Central	WCP
77	Pacific, Eastern Central	ECP
81	Pacific, Southwest	WSP
87	Pacific, Southeast	ESP
88	Pacific, Antarctic	ANW

Discussion

The cephalopod collections of the GOM and the ZSRO are small scale collections with 193 (GOM) and 59 (ZSRO) collection items respectively. Both collections are mainly composed of industrial fishery catches and sporadic by-catches, single findings during field trips and expeditions, as well as market-purchased collections and donations by individuals. Besides their role as voucher samples, reference specimens and for research, the collections are used to educate students and the interested public (ZSRO), as well as occasionally as a pool of exhibits for the museum's exhibitions. In accordance with the different intentions of the institutions,

these roles have varying levels of importance, which explains the difference in scope of the two malacological collections.

As stated above, highlights of the collections are glass models made by BLASCHKA (ZSRO), as well as a 6 m long male specimen of the giant squid *Architeuthis dux* Steenstrup, 1857 (GOM), which are both displayed in the public exhibitions of the museums. In addition, another interesting find was made in the GOM collection, where an old sealed container from the Comparative Anatomical Collection of the Royal Institute for Anatomy Greifswald holds eleven individuals identified to be *Uroteuthis bartschi*. Rehder described this species for the first time in 1945 and according to ROPER ET AL. (1984), it occurs in the Asia-Pacific region. However, efforts to pinpoint the collection site of this sample have not yet been successful and should be continued. This specimen is inventoried under the catalogue number IIE-13046 at the GOM.
The collection locations of many items could not be retrieved by comparing them with sample acquisition registers either. Thus, for a certain proportion of the cephalopod material, exact collection sites remain unknown, so that this part of the collection is not suitable for use in studies of comparative biology or biogeographic patterns.
Regarding the representativeness of the North Sea cephalopod collections, it can be stated that 17 of 32 species reported by STEIMER (1993) and JAECKEL (1958) are represented in the collections of the GOM and the ZSRO. With reference to STEIMER's classification (1993), 16 of these species are permanent inhabitants or regular immigrants on spawning and foraging migrations. With regard to the GOM's objective of complete representation of cephalopod species from the North Sea and Baltic Sea regions (HOPPE 1992), it can be summarized that 15 confirmed North Sea species are not yet available in either collection. If only the 16 species which, according to STEIMER (1993), are permanent inhabitants of the North Sea are considered, there are five species missing in the collections to date: (1) *Rossia macrosoma* (Chiaie, 1830), (2) *Rossia glaucopis* Loven, 1845, (3) *Sepiola atlantica* Orbigny, 1839, (4) *Sepiola aurantiaca* Jatta, 1896 and (5) *Sepiola pfefferi* Grimpe, 1921. These species at least should be included to provide a complete collection of cephalopod species native to the North Sea and adjacent waters in Mecklenburg-Western Pomerania.

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