

**Sponges from the 2010-2014 *Paamiut* Multispecies Trawl Surveys, Eastern Arctic and Subarctic: Class Demospongiae, Subclass Heteroscleromorpha, Order Poecilosclerida, Families Microcionidae, Acarnidae and Esperiopsidae**

Mariève Bouchard Marmen, Gabrielle Tompkins, Nicole Harrington, Alexis Savard-Drouin, Molly Wells, Emily Baker, Brigid Odenthal, Wojciech Walkusz, Tim Siferd and Ellen Kenchington

Ocean and Ecosystem Sciences Division  
Maritimes Region

Fisheries and Oceans Canada  
Bedford Institute of Oceanography  
PO Box 1006  
Dartmouth, Nova Scotia  
Canada B2Y 4A2

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Microcionidae, Acarnidae and Esperiopsidae

by

Mariève Bouchard Marmen, Gabrielle Tompkins<sup>1</sup>, Nicole Harrington<sup>1</sup>, Alexis Savard-Drouin<sup>1</sup>,  
Molly Wells<sup>1</sup>, Emily Baker, Brighid Odenthal, Wojciech Walkusz<sup>2</sup>, Tim Siferd<sup>2</sup> and  
Ellen Kenchington

Ocean and Ecosystem Sciences Division  
Maritimes Region  
Fisheries and Oceans Canada  
Bedford Institute of Oceanography  
P.O. Box 1006  
Dartmouth, N.S.  
Canada B2Y 4A2

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<sup>1</sup> Integrated Science Program  
Dalhousie University  
1355 Oxford Street, Halifax, Nova Scotia, Canada  
B3H 4R2

<sup>2</sup> Freshwater Institute, Central and Arctic Region  
Fisheries and Oceans Canada  
501 University Crescent, Winnipeg, Manitoba, Canada  
R3T 2N6

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## ABSTRACT

Bouchard Marmen, M., Tompkins, G., Harrington, N., Savard-Drouin, A., Wells, M., Baker, E., Odenthal, B., Walkusz, W., Siferd, T. and Kenchington, E. 2019. Sponges from the 2010-2014 *Paamiut* Multispecies Trawl Surveys, Eastern Arctic and Subarctic: Class Demospongiae, Subclass Heteroscleromorpha, Order Poecilosclerida, Families Microcionidae, Acarnidae and Esperiopsidae. Can. Tech. Rep. Fish. Aquat. Sci. 3349: v + 76 p.

Sponges (phylum Porifera) are benthic filter feeding animals that play an important role in nutrient cycling and habitat provision in the deep sea. Sponges collected between 2010 and 2014 during annual multispecies trawl surveys conducted by Fisheries and Oceans Canada in Baffin Bay, Davis Strait and portions of Hudson Strait were taxonomically examined. In total ~2500 specimens were identified, comprising ~100 known sponge taxa. Sponges from the order Poecilosclerida comprised nearly half of the identified species. Sponges from the poecilosclerid families Coelosphaeridae, Crellidae, Dendoricellidae, Myxillidae and Tedaniidae are described in previous reports. This report adds descriptions of eight sponge species from three poecilosclerid families: Microcionidae, Acarnidae and Esperiopsidae (class Demospongiae, subclass Heteroscleromorpha, order Poecilosclerida). Described species include *Artemisina lundbecki*, *Artemisina arcigera*, and *Clathria (Clathria) barleei* from the family Microcionidae, *Iophon piceum* and *Iophon koltuni* from the family Acarnidae, and *Esperiopsis villosa*, *Esperiopsis* sp. 1, and *Semisuberites* cf. *cribrosa* from the family Esperiopsidae. Descriptions include physical description of the sponges, descriptions and dimensions of their spicules, and taxonomic discussion.

## RÉSUMÉ

Bouchard Marmen, M., Tompkins, G., Harrington, N., Savard-Drouin, A., Wells, M., Baker, E., Odenthal, B., Walkusz, W., Siferd, T. and Kenchington, E. 2019. Sponges from the 2010-2014 *Paamiut* Multispecies Trawl Surveys, Eastern Arctic and Subarctic: Class Demospongiae, Subclass Heteroscleromorpha, Order Poecilosclerida, Families Microcionidae, Acarnidae and Esperiopsidae. Can. Tech. Rep. Fish. Aquat. Sci. 3349: v + 76 p.

Les éponges (phylum Porifera) sont des animaux filtreurs benthiques qui jouent un rôle important dans le cycle des éléments nutritifs et qui augmentent la disponibilité d'habitats benthiques en eaux profondes. Les éponges collectées au cours des relevés plurispécifiques annuels au chalut effectués entre 2010 et 2014 par Pêches et Océans Canada dans la baie de Baffin, le détroit de Davis et certaines portions du détroit d'Hudson ont été examinées sur le plan taxonomique. Au total, environ 2500 spécimens ont été identifiés, appartenant à ~100 taxons d'éponges connus. Presque la moitié des espèces recensées appartiennent à l'ordre Poecilosclerida. Parmi elles, les éponges des familles Coelosphaeridae, Crellidae, Dendoricellidae, Myxillidae et Tedaniidae ont été décrites dans nos précédents rapports. Ce présent rapport ajoute les descriptions de huit espèces d'éponges de trois familles de poeciloscélérides : Microcionidae, Acarnidae et Esperiopsidae (classe Demospongiae, sous-classe Heteroscleromorpha, ordre Poecilosclerida). Les espèces décrites sont *Artemisina lundbecki*, *Artemisina arcigera* et *Clathria (Clathria) barleei* de la famille Microcionidae, *Iophon piceum* et *Iophon koltuni* de la famille Acarnidae, et *Esperiopsis villosa*, *Esperiopsis* sp. 1 et *Semisuberites cf. cribrosa* de la famille Esperiopsidae. Les descriptions comprennent la description physique des éponges, la description de leurs spicules incluant les dimensions de celles-ci, ainsi qu'une discussion taxonomique.

## INTRODUCTION

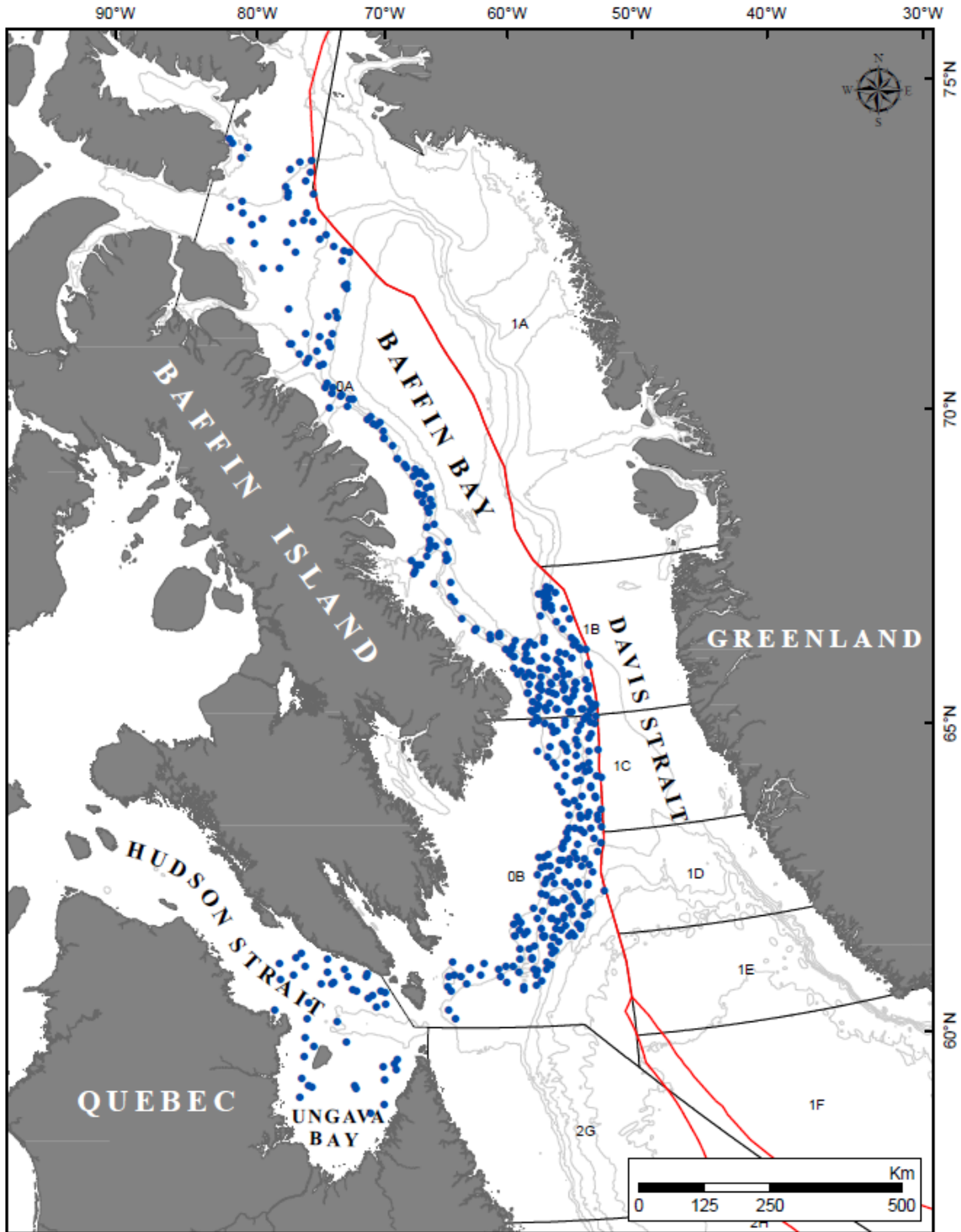
Sponges are mostly benthic filter feeding animals that play an important role in nutrient cycling (reviewed in Maldonado et al. 2012, 2017). They also create biogenic structures which provide important habitats in deep-sea ecosystems and locally increase the diversity of epibenthic megafauna (Beazley et al., 2013, 2015). Despite these key functional roles, sponge communities in the eastern Canadian Arctic are still poorly known. In the eastern Canadian Arctic, particularly western Baffin Bay, Davis Strait, and portions of Hudson Strait and Ungava Bay, invertebrate species, including sponges, are routinely collected during Fisheries and Oceans Canada (DFO) shrimp and Greenland halibut multispecies trawl surveys. We examined approximately 2500 sponge specimens from 479 trawl sets (Figure 1) collected between 2010 and 2014 on the research vessel (RV) *Paamuit*. Sponges from the order Poecilosclerida (class Demospongiae) comprised nearly half of the ~100 species identified. Three previous reports presented the morphological and spicule descriptions of poecilosclerid sponge species from the eastern Arctic, along with DNA barcodes for some species. Tompkins et al. (2017) documented sixteen species from genera *Forcepia* and *Lissodendoryx* (class Demospongiae, subclass Heteroscleromorpha, order Poecilosclerida, family Coelosphaeridae). Baker et al. (2018a) detailed six species from genus *Crella* (class Demospongiae, subclass Heteroscleromorpha, order Poecilosclerida, family Crellidae) and genera *Melonanchora* and *Myxilla* (class Demospongiae, subclass Heteroscleromorpha, order Poecilosclerida, family Myxillidae). Baker et al. (2018b) described six species from genera *Dendoricella* (class Demospongiae, subclass Heteroscleromorpha, order Poecilosclerida, family Dendoricellidae) and *Tedania* (class Demospongiae, subclass Heteroscleromorpha, order Poecilosclerida, family Tedaniidae). This fourth report in our series provides descriptions of eight further species from the families Microcionidae (genera *Artemisina* and *Clathria*), Acarnidae (genus *Iophon*), and Esperiopsidae (genera *Esperiopsis* and *Semisuberites*). Species include: *Artemisina lundbecki*, *Artemisina arcigera*, *Clathria (Clathria) barleei*, *Iophon piceum*, *Iophon koltuni*, *Esperiopsis villosa*, *Esperiopsis* sp. 1, and *Semisuberites* cf. *cribrosa*. Both *Iophon piceum* and *Esperiopsis villosa* have been previously identified as indicator species of Vulnerable Marine Ecosystems (VMEs) by the Northwest Atlantic Fisheries Organization (NAFO, 2019). In keeping with the previous reports, our intent is to provide a resource to facilitate accurate, consistent and efficient identification of eastern Canadian Arctic sponges for the purpose of monitoring and mapping species distributions.

### **Taxonomic Background on order Poecilosclerida**

Sponges described in this report all belong to the class Demospongiae, subclass Heteroscleromorpha and order Poecilosclerida. The class Demospongiae includes sponges with a skeleton composed of siliceous spicules and/or spongin fibers (Hooper and Van Soest, 2002).



Spicules of demosponges are very diverse, but always have one, two or four axes (never triaxonic) (Hooper and Van Soest, 2002). The subclass Heteroscleromorpha is the most speciose group of demosponges and includes sponges with a large diversity of spicule types, from which it derives its name (Cardenas et al., 2012). Of the 15 orders under Heteroscleromorpha, Poecilosclerida is the largest order, including 2335 accepted species classified within 20 families: **Acarnidae\***, Chondropsidae, **Cladorhizidae**, **Coelosphaeridae\***, Crambeidae, **Crellidae\***, **Dendoricellidae**, Desmacididae, **Esperiopsidae**, Guitarridae, Hymedesmiidae\*, **Iotrochotidae**, **Isodictyidae**, Latrunculiidae, **Microcionidae**, **Mycalidae\***, **Myxillidae**, Phellodermidae, Podospongiidae, and **Tedaniidae** (Van Soest et al., World Porifera Database, Accessed July 11<sup>th</sup>, 2019). Families represented within the 2010-2014 *Paamiut* Arctic collections are **bolded**, and those marked by an asterisk (\*) may be non-monophyletic, according to recent molecular phylogenetic studies (Morrow and Cardenas, 2015). Poecilosclerid sponges are distinguished by the presence of chelae. However, chelae may be missing in some taxa, including *Semisuberites cf. cribrosa* which is described in this report. Other microsclere spicules may include sigmas, sigmancistra-derivatives, toxas, forceps, raphides, onychaetes, microrhabds, discorhabds, spinorhabds, thraustoxeas, spirosigmata, thraustosigmata or microstyles (Hooper and Van Soest, 2002). Skeletons of poecilosclerids are known to show megasclere differentiation between the outer ectosome and inner choanosome, forming at least two (but up to five) morphologically distinct regions. Sponges from this order are distributed worldwide, from intertidal habitats to abyssal depths, and are mostly viviparous (Hooper and Van Soest, 2002). Four suborders within order Poecilosclerida are listed in the Systema Porifera (Hooper and Van Soest, 2002): Microcionina, Mycalina, Myxillina and Latrunculina. These suborders are no longer accepted (Morrow and Cardenas, 2015) and are therefore not referred to in this report.



**Figure 1.** Locations of *Paamiut* 2010-2014 trawl sets (N=479) with sponge catch, spanning Baffin Bay, Davis Strait, Ungava Bay and Hudson Strait. Northwest Atlantic Fisheries Organization (NAFO) Divisions are indicated in black. The exclusive economic zones of Canada and Greenland are delimited in red. Depth contours at 500 m intervals (500 to 3000 m) are in light gray. Note that the species listed in this report were found in a subset of these locations.

## Family Microcionidae (Carter, 1875)

According to the original description of Carter (1875), sponges from the family Microcionidae were characterized by their external morphology, described as a thin and hirsute lamellate structure, developing in a spreading or encrusting pattern. However, the revision from Hooper (2002a) includes some lobate, arborescent and flabellate growth forms as well. Generally, the ectosomal layer of Microcionidae sponges is characterized by erect bundles of subtylostyles or anisoxeas. The spongin fibres structuring the choanosome are composed of smooth large styles in most cases and small acanthose styles (partially or completely spined) are echinating the choanosomal fibres. Microscleres are palmate isochelae (exceptionally modified, arcuate-like or anchorate-like forms) and spiny or smooth toxas with diverse shapes. (Carter, 1875; Hooper, 2002a)

Hooper (2002a) defined the family Microcionidae as sponges typically divided in three skeletal regions (choanosomal, subectosomal and ectosomal) formed by the distribution of the different megascleres. Microcionidae sponges are divided in two subfamilies, Ophlitaspongiinae and Microcioninae. While the choanosome of Microcioninae sponges consists of only a single primary skeleton (no subectosome), Ophlitaspongiinae sponges have a choanosome divided in two distinct regions: a renieroid choanosomal skeleton and a subectosomal reticulate, plumose or hymedesmioid skeleton (Hooper, 2002a). Ophlitaspongiinae subfamily regroups the five following genera: *Antho*, *Artemisina*, *Echinoclathria*, *Ophlitaspongia* and *Sigmeurypon*. Microcioninae subfamily includes the four following genera: *Clathria*, *Echinochalina*, *Holopsamma* and *Pandaros*. (Van Soest et al., World Porifera Database, Accessed July 11<sup>th</sup>, 2019)

Of the genera listed above, only specimens from the genera *Artemisina* and *Clathria* have been identified within our collections (*Paamiut* 2010-2014): specifically, *Artemisina lundbecki*, *Artemisina arcigera* and *Clathria (Clathria) barleei*. However, we cannot say with certainty that other species and/or genera from Microcionidae are not present in the area surveyed, as the sampling methodology may bias our collections toward the identification of larger and/or more robust taxa. Therefore, a list of the defining characteristics of each genus, as given by Hooper (2002a), is provided below.

### **Microcionidae with a primary renieroid choanosomal skeleton and a secondary subectosomal skeleton (subfamily Ophlitaspongiinae)**

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*Antho*: Various growth forms. Renieroid choanosomal skeleton with acanthose styles and/or strongyles. Subectosomal skeleton with smooth principal styles. Echinating spicules present or absent. Microscleres include isochelae and toxas.

*Artemisina*: Various growth forms. Absence of well-defined spongin fibres and no echinating spicules. Subectosomal skeleton is organized in a radial fashion and ectosomal region is membrane-like. Spicule complement includes smooth subtylostyles as principal megascleres in the choanosome and smooth ectosomal styles. Microscleres include isochelae (palmate or arcuate forms) and toxas with acanthose or smooth ends.

*Echinoclathria*: Various growth forms. Renieroid reticulate choanosomal skeleton with the same kind of smaller and smooth styles both coring and echinating the fibres. Vestigial radial subectosomal skeleton composed of larger smooth styles disposed in brushes. Ectosomal skeleton with auxiliary subtylostyles. Microscleres include palmate isochelae and toxas.

*Ophlitaspongia*: Encrusting sponges with an isodictyal reticulate skeleton composed of ascending spongin fibres organized along parallel lines with other fibres doing cross-connections (ladder-like) arising from a hymedesmioid choanosomal fibre skeleton. Smooth subtylostyles are the only megascleres present and are organized in plumose tracts along fibres, although only a few are on the transverse ones. Absence of true echinating spicules, even though choanosomal subtylostyles protrude through the ectosome in some cases.

*Sigmeurypon*: Thinly encrusting. Compressed choanosomal skeleton including raphides and sigmas. Subectosomal skeleton composed of long smooth styles and acanthostyles. Ectosomal skeleton with raphides.

### **Microcionidae with a single choanosomal skeleton, no subectosome (subfamily Microcioninae)**

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*Clathria*: Various growth forms. Ectosomal region characterized by various structures (palisade of brushes, membranous or paratangential) formed by one or two categories of auxiliary styles. Choanosomal skeleton hymedesmioid to reticulate and mainly composed of two kinds of megascleres: mostly smooth styles in spongin fibres and acanthose smaller styles making the fibres echinated (either could be secondarily lost in some cases). Microscleres include palmate isochelae and toxas, although these spicules could be modified or occasionally absent.

*Echinochalina*: Wide range of possible growth forms. Ectosome includes monactinal, quasi-monactinal or thin diactinal auxiliary megascleres (tangential or erect). Choanosome is irregularly reticulate and fibres are cored by the same auxiliary megascleres found in ectosome. Principal megascleres echinating fibres vary from styles to oxeas. Isochelae and toxas may be present.

*Holopsamma*: Honeycomb-reticulate growth form. Choanosome characterized by a simple reticulate structure. Fibres are cored and echinated by the same kind of principal spicules. Coring megascleres could be missing and replaced by detritus. Mainly represented by palmate isochelae, microscleres include only rarely toxas.

*Pandaros*: Growth form is arborescent. Reticulate choanosomal skeleton with flattened branches formed by spongin fibres. Coring auxiliary spicules are mostly smooth styles, subtylostyles to tylostyles. Fibres are usually echinated by rare acanthostyles, but it could also be smooth styles. Absence of microscleres.

### ***Artemisina* (Vosmaer, 1885)**

Regrouping 21 currently valid species of which six were described and accepted as new species in the last seven years (Van Soest et al., World Porifera Database, Accessed July 11<sup>th</sup>, 2019), the genus *Artemisina* was created by Vosmaer (1885) while he was describing *Artemisina suberitoides* (now considered as a synonymized name for *Artemisina arcigera*). The subfamily Ophlitaspongiinae, where the genus *Artemisina* belongs, is defined by the division of the choanosomal skeleton in two distinct parts: a secondary renieroid skeleton (choanosome) overlaying a primary reticulate/plumose/hymedesmioid skeleton (subectosome) (Hooper, 2002a). While these skeletal regions are still somewhat present in *Artemisina* species, their choanosome is arranged very differently than the other Microcionidae genera. Actually, one of the three apomorphies of *Artemisina* is the absence of a proper choanosomal skeleton with distinct spongin fibres (Hooper, 2002a). Skeleton structure for the choanosome is therefore reduced to spicules organized longitudinally and transversally, solidified by collagen, in a confused halichondroid reticulation. The lack of echinating spicules and the radial organisation of the ectosome are the two other apomorphies which differentiate *Artemisina* species from the other Microcionidae genera (Hooper, 2002a). However, the variability of the ectosomal skeleton within the genus *Artemisina*, and the fact that the ectosome is even missing in some cases, makes this criteria difficult to use for taxonomic purposes. External morphology is unfortunately not very helpful for characterizing this genus due to the high diversity of growth forms displayed by *Artemisina*. For example, massive, cushion-shaped, bulbous, clavulate, tubular, digitate and flabellate growth forms could be encountered (Hooper, 2002a). In summary, *Artemisina* does regroup a heterogeneous group of species which are not linked by a true morphological character, other than the fact that they do not fit within other Microcionidae genera because of missing features. Regarding the spicule complement, the *Artemisina* species usually have smooth subtylostyles as the principal megascleres in the choanosome and smooth styles in the ectosomal region. Microscleres include isochelae (palmate or arcuate forms) and toxas with acanthose or smooth ends (Hooper, 2002a).

### ***Clathria* (Schmidt, 1862)**

The genus *Clathria* (family Microcionidae, subfamily Microcioninae) was first described by Schmidt (1862) and is nowadays the largest genus of Microcionidae in terms of number of species. In the present taxonomic classification, nine subgenera are valid under *Clathria*, containing a total

of 388 accepted species (Van Soest et al., World Porifera Database, Accessed July 11<sup>th</sup>, 2019), which makes of this genus the largest of this family. Because of this high diversity, the definition of the genus *Clathria* given by Hooper (2002a) is very general in order to encompass all representatives. *Clathria* is included in the subfamily Microcioninae, which morphologically translates to the non-differentiation of the choanosome and therefore the absence of the subectosome (Hooper, 2002a). The choanosome is characterized by a hymedesmioid to reticulate skeletal structure and by the presence of two kinds of megascleres. In most cases, smooth styles core the sponging fibres and some smaller acanthose styles echinate fibres. However, there is a lot of variability in the choanosomal spicules, as the coring styles could also be basally or partially spined and the echinating styles could also be smooth (Hooper, 2002a). Furthermore, coring and echinating choanosomal styles could also be secondarily lost and replaced by detritus. *Clathria* species exhibit a wide range of different ectosomal skeletons such as membranous, paratangential or densely arranged brushes forming a barricade. The ectosomal auxiliary spicules are usually styles of one or two categories. External morphology is also extremely variable within *Clathria*, with thinly encrusting, massive, digitate, lamellate, flabellate, arborescent and fistulose forms (Hooper, 2002a).

Within *Clathria*, subgenera are mostly differentiated according to their choanosomal skeletal structure and spicule complements. All *Clathria* specimens found in our collection belong to the same subgenus, *Clathria (Clathria)*. Encompassing 123 accepted species (Van Soest et al., World Porifera Database, Accessed July 11<sup>th</sup>, 2019), the subgenus *Clathria (Clathria)* is characterized by a sparse paratangential ectosomal skeleton formed by a single category of auxiliary styles (Hooper, 2002a). The choanosome structure is plumo-reticulate and pretty uniform throughout (no distinct regions) (Hooper, 2002a). To our knowledge, no specific feature regarding spicule geometry distinguishes the subgenus *Clathria (Clathria)* from the other subgenera of *Clathria*. For more details on the other subgenera, we recommend Hooper (2002a), who proposed a key with the main characterizing features for seven of the subgenera of *Clathria*. For the two most recent accepted subgenera *Clathria (Cornulotrocha)* and *Clathria (Paresperia)*, see Van Soest et al. (2013) and Hajdu et al. (2006).

## **Family Acarnidae (Dendy, 1922)**

In 1922, Dendy published what is currently accepted as the original description of the family Acarnidae, although this decision is still controversial. Since he was exclusively describing specimens belonging to the genus *Acarnus* at this time, his description of Acarnidae is unduly focused on specific characteristics to this genus. According to Hooper (2002b), Acarnidae are mostly differentiated from the other families through an assemblage of features associated with their skeletal structure, spicule complements, and growth forms. Most Acarnidae genera have tyloles with spined bases that are tangentially arranged and form the ectosomal skeleton.

Exceptionally, these tylotes are completely smooth or replaced by acanthoxeas with spined bases. This first characteristic of Acarnidae is the most important to distinguish them from the Microcionidae family and other similar ones (Hooper, 2002b). The choanosomal skeleton of Acarnidae is reticulate or plumose, mostly depending on the growth form, and the echinating spicules could be either present or absent. In addition to the tylotes, megascleres of Acarnidae sponges include styles. Microscleres are palmate isochelae and toxas, but these are lost in some cases and other kinds could occur, such as bipocilli and modified anisochelae (Hooper, 2002b). In terms of external morphology, Acarnidae sponges are encrusting, burrowing, massive, flabellate or digitate. Among other characters, the presence of fistules characterizes several genera, whereas other genera are non-fistular. These two types of Acarnidae genera were initially separated in different families based on their different appearance. Eventually, the classification was more based on the organisation of the skeletons and the types of spicules present, and therefore the fistulose and non-fistulose genera were regrouped in the same family (Hooper, 2002b). However, the Acarnidae family is potentially polyphyletic according to recent molecular studies (Morrow and Cardenas, 2015), which increases the probability of upcoming phylogenetic changes.

The Acarnidae family includes 128 accepted species divided in the following 13 accepted genera: *Acanthorhabdus*, *Acarnus*, *Acheliderma*, *Cornulella*, *Cornulum*, *Damiria*, *Dolichacantha*, *Iophon*, *Megaciella*, *Paracornulum*, *Tedaniphorbis*, *Wigginsia* and *Zyzya* (Van Soest et al., World Porifera Database, Accessed July 11<sup>th</sup>, 2019). Of the genera listed above, only specimens from the genus *Iophon* have been identified within our collections (*Paamiut* 2010-2014): specifically *Iophon piceum* and *Iophon koltuni*. However, we cannot say with certainty that other species and/or genera from the Acarnidae family are not present in the area surveyed, as the sampling methodology may bias our collections toward the identification of larger and/or more robust taxa. For example, the encrusting sponges are often not well represented in a trawl catch. Therefore, a list of the defining characteristics of each genus, as given by Hooper (2002b), is provided below.

### **Acarnidae with ectosomal tylotes bearing apical spines**

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*Acarnus*: Encrusting to massive, non-fistular. Ectosomal tylotes and choanosomal smooth styles. Presence of cladotylote echinating spicules. Acanthostyles could be present. Microscleres are palmate isochelae and toxas.

*Acheliderma*: Fistulose growth forms. Ectosomal tylotes and choanosomal microspined styles and acanthostyles. Microscleres are elongated diamond-shaped microxeas and toxas. Absence of chelae.

*Cornulella*: Encrusting and fistular. Choanosomal structure is vestigial. Presence of single tylotes and acanthoxeas. Palmate isochelae are found and also toxas in most cases.

*Cornulum*: Massive or encrusting and could be fistulose. Tylotes or strongyles form well-structured ectosomal and choanosomal skeletons. Possible presence of choanosomal styles and aniso-strongyles. Echinating spicules absent in most cases. Palmate isochelae, toxas and microstrongyles (only for one species).

*Damiria*: Fistular. Present in ectosome and choanosome, tylotes with apical spines are the only megascleres. Microscleres include toxas in some cases.

*Dolichacantha*: Non-fistulose and could have encrusting to massive morphology. Ectosomal megascleres include long acanthostrongyles which have several spined ‘cladi’ along the shaft. Microscleres are palmate isochelae.

*Iophon*: Non-fistular with a massive, branching or encrusting growth form. Ectosomal skeleton is composed of tylotes and choanosome includes smooth or spined styles. Echinating acanthostyles could be either present or absent. Microscleres are bipocilla and palmate anisochelae with spurs. Toxas are absent.

*Megaciella*: Non-fistular. Various external morphologies (branching, lobate, flabellate or encrusting). Reticulate or confused choanosomal structure composed of primary ascending tracts of smooth styles with spiny base and secondary tracts bound with collagen. Echinating acanthostyles could be either present or absent. Microscleres are palmate isochelae. Two types of toxas are absent.

*Paracornulum*: Fistular with encrusting growth form. Ectosomal skeleton with halichondroid tracts composed of tylotes. Choanosomal skeleton with a radial or plumose arrangement of tracts. Basal hymedesmioid spongin layer with echinating acanthostyles. Palmate isochelae and toxas.

*Wigginsia*: Non-fistular encrusting lamellate growth form. Presence of smooth or basally spined styles and acanthostrongyles forming an isodictyal skeleton. Microscleres are exclusively palmate isochelae.

*Zyzya*: Fistular. Could be massive, burrowing or encrusting. Megascleres include tylotes and verticillately-spined strongyles (or strongyloxeas). Palmate isochelae and toxas, although microscleres are not always present.

### **Acarinidae with modified ectosomal spicules**

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*Acanthorhabdus*: Massive and non-fistular. Ectosome with apically-spined acanthorhabds. Choanosomal megascleres are smooth anisoxeas bearing a terminal mucron. No true echinating spicules. Spurred palmate anisochelae.



*Tedaniaphorbas*: Massive lobate and non-fistular. Completely smooth tylotes (no apical spines) dispersed in a reticulate spongin fibre skeleton, but no coring or echinating spicules. Presence of palmate isochelae and absence of toxas.

### ***Iophon* (Gray, 1867)**

The genus *Iophon* consists of 41 currently accepted species (Van Soest et al., World Porifera Database, Accessed July 11<sup>th</sup>, 2019). Among these species, seven were described within the last decade. The original description of *Iophon* was written by Gray (1867), who described these as parasitic sponges with dispersed oscules and smooth spiculose skin. In the classification of Gray (1867), the *Iophon* genus was distinct through its ‘defensive spicules unilateral bipoliated and inequianchorate free in the sarcoderm’, which translated to the presence of bipocilli and anisochelae dispersed in the choanosome. In their revision of the *Iophon* genus, Hooper (2002b) also define them based on choanosomal characteristics, more specifically their isodictyal choanosomal reticulation. The choanosome is composed of styles, which could be smooth or spined, and echinated by acanthostyles, although the latter could also be absent. The ectosome is formed from brushes of tylotes with microspined heads organized tangentially to the surface (Hooper, 2002b). Choanosome and ectosome are therefore completely distinct in terms of megascleral composition. The microscleres of the genus *Iophon* include bipocilla and spurred palmate anisochelae, as mentioned by Gray (1867). The external morphology, while is consistently non-fistular, is quite variable in terms of growth forms as it ranges from encrusting to branching, but could also be massive (Hooper, 2002b). Consequently, external morphology is unfortunately not very helpful for characterizing this genus due to the high diversity of growth forms that it exhibits.

### **Family Esperiopsidae (Hentschel, 1923)**

Sponges in the family Esperiopsidae have a skeleton made up of reticulated bundles of styles and no distinct arrangement of spicules in the surface layer. Styles are fusiform in shape, tapering toward both ends, and are referred to as mycalostyles in Systema Porifera (Van Soest and Hajdu, 2002). Microscleres are missing in some genera, but when present, include palmate chelae (isochelae, and more rarely anisochelae) and sometimes sigmas (Van Soest and Hajdu, 2002). The spicule complement of this family is closest to the family Mycalidae. However in contrast to the Esperiopsidae, most Mycalidae have palmate anisochelae (as opposed to isochelae in most Esperiopsidae), and a distinct ectosomal skeleton with clear organization. Body form is diverse among the Esperiopsidae, spanning encrusting, massive, lobate, flabellate or cup-shaped, with slightly hispid or conulose (with cone like projections) surfaces from bundles of projecting spicules. There are four accepted genera in the Esperiopsidae: *Amphilectus*, *Esperiopsis*, *Semisuberites* and *Ulosa*. *Ulosa* and *Semisuberites* have in the past been assigned to other families.

Because they lack chelae, their classification has been questioned. These genera remain tentatively assigned to Esperipsidae because of the characteristic shape of their styles and the reticulate arrangement of their skeleton (Van Soest and Hajdu, 2002). Recent phylogenetic studies found that *Ulosa* and *Amphilectus* grouped together in a clade nested within the Poecilosclerida (Hestetun et al., 2016), supporting the present classification. Of the four genera previously listed, *Esperiopsis* and *Semisuberites* are represented in our Arctic collections and described more extensively in this report.

Van Soest et al. (2012) recently reviewed Esperipsidae from northwest Africa and noted the spicule characteristics that easily distinguish the genera – but also acknowledged the possibility that these distinguishing characteristics may be artificial. To date the phylogenetic relationships within the Esperipsidae have not been explored and the spicule characteristics persist as defining characteristics. Short lists of characteristics that may be used to distinguish the Esperipsidae genera are given below, adapted from Van Soest et al. (2012) and Van Soest and Hajdu (2002).

### **Esperiopsidae lacking microscleres**

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*Ulosa*: No microscleres. Megascleres are fusiform styles (mycalostyles) in a single size category. Tropical waters.

*Semisuberites*: No microscleres. Megascleres are mycalostyles in two size categories. Temperate or colder waters.

### **Esperiopsidae with microscleres**

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*Esperiopsis*: Palmate isochelae usually in several size classes, styles longer than 400 µm, sigmas usually present.

*Amphilectus*: Palmate isochelae in single size class, sigmas usually absent, styles shorter than 400 µm and arranged in an isodictyal reticulations (forming a triangular mesh with sides only one spicule long).

### ***Esperiopsis* (Carter, 1882)**

Sponges from the genus *Esperiopsis* have dense spicule tracts that are thicker in the sponge interior and form anastomosing (branching and rejoining) branches that ultimately project from the surface, giving the sponges a slightly shaggy or hispid appearance. In between the dense tracts, the skeletal organization is described as plumoreticulate, meaning that spicules radiate obliquely from spicule tracts. Body form may be massive, pedunculate or flabellate. Megascleres are

subtylostyles (also referred to as mycalostyles) which are wider in the middle and taper toward both ends. Microscleres include palmate isochelae in up to three size classes, and sigmas in up to two size classes. In comparison, *Amphilectus* has only a single size class of isochelae and no sigmas. The type species for the genus is *Esperiopsis villosa*, which was originally described as *Esperia villosa* (Carter, 1874). Carter later replaced the genus *Esperia* with *Esperiopsis*, bringing together species with defining characteristics. There are currently 33 accepted *Esperiopsis* species (Van Soest et al., World Porifera Database, Accessed July 11<sup>th</sup>, 2019).

### ***Semisuberites* (Carter, 1877)**

This genus is currently represented by its only known accepted species, *Semisuberites cribrosa*. *S. cribrosa* is described as trumpet-shaped with a skeleton of loose spicule tracts (multiple spicules wide) running perpendicular to the surface, and other tracts running parallel to the surface and intersecting the perpendicular tracts. Individual spicules are abundant in between tracts. Tracts end at the surface in brushes which give the sponge a velvety texture. Megascleres are tapering styles with slightly swollen heads, and microscleres are absent (Van Soest and Hajdu, 2002).

## METHODOLOGY

### Sponge Collection

Sponges described in this series of reports were collected during five annual multispecies trawl surveys (2010-2014) with the Greenland Institute of Natural Resources (GINR) research vessel *Paamiut*. The missions examined were coded as PAA2010-009, PAA2011-007, PAA2012-007, PAA2013-008 and PAA2014-007. These surveys were conducted to provide fisheries-independent data on the status of Greenland halibut for stock assessments in NAFO Subdivisions 0A and 0B (Baffin Bay/Davis Strait) and with depth coverage 200-1500 m. In 2010 and 2012, a small area of the NAFO 0A referred to as the Shrimp Fishing Area 1 (SFA1) was surveyed in order to assess the stock of northern shrimp. Also, in 2011 and 2013, samples were collected during the DFO Central and Arctic survey of northern and striped shrimp in the Shrimp Fishing Area 3 (SFA3) (Hudson Strait/Ungava Bay) with depth coverage of 100-1000 m. The Greenland halibut survey was performed with an Alfredo trawl towed at 3 knots for 30 minutes at each location. The shrimp survey was performed with the Cosmos 2000 shrimp trawl towed at 2.6 knots for 15 minutes. A buffered random sampling approach designed by Kingsley et al. (2004) was employed and the areas were divided into the following depth strata: 100-200 m, 200-300 m, 300-400 m, 400-500 m, 500-750 m and > 750 m.

### Documentation of Sponge Catches at Sea

For each trawl catch, sponges were separated from other invertebrates and then divided by morphology. Each sponge morphotype was photographed with a label containing mission and set number and a tentative sponge identification, then weighed and recorded in a database along with geospatial data. If sponge catches were very large, the weight of a subsample was extrapolated to the whole catch. A sample of each sponge was placed into a plastic bag with the original label. These samples were frozen (-20°C) at sea and shipped to the Bedford Institute of Oceanography, Dartmouth, Nova Scotia, for further identification to species level.

### Sponge Identification by Spicule Analysis

Each sponge that was examined at the Bedford Institute of Oceanography has been given a collection number (Col), which was a unique number within the same cruise. Therefore, the combination of the cruise details (vessel, year, cruise) and the collection number was a unique identification code for every sponge analyzed. Sponge species were sometimes identified by

analysis of gross morphology and arrangement of the skeleton. However, in most cases, identification was based on microscopic analysis of the sponge spicules. Taxonomic resources frequently consulted for spicule comparison included, but were not limited to, Ridley and Dendy (1887), Lundbeck (1902, 1905, 1909, 1910), Topsent (1904, 1913), Koltun (1959), Ackers et al. (1992), Hooper and Van Soest (2002), the Marine Species Identification Portal - Sponges of the NE Atlantic website (Van Soest, R.W.M.) and the World Porifera Database website (Van Soest et al.).

## **Light microscopy**

Permanent microscope slides with cleaned sponge spicules were prepared for each of the specimens used in this report. Several rice-sized pieces were taken from the exterior and interior regions of the sponge and digested overnight in full strength bleach in Eppendorf tubes. After vortexing and briefly spinning down spicules (~3000 rpm for 1 min) the supernatant was replaced with distilled water. This was repeated after 30 minutes for a total of two water washes. In the final wash step the spicules were suspended in 95% ethanol. Cleaned spicules were pipetted on to glass slides, air dried and then mounted in Araldite resin as described in Tompkins et al. (2017).

Slides were viewed on a Nikon E200 Microscope and photographed with a Nikon DS-Ri1 or DS-fi1 camera operated through a Digital Sight DS-U2 or DS-U3 camera control unit. Nikon NIS Elements Documentation software was used to capture and calibrate the microscope images and to collect measurements either on live or captured images as described in Tompkins et al. (2017). Typically, 30 length and width measurements were recorded for each spicule type for a single specimen. From additional supporting specimens typically 10 length and width measurements per spicule type were obtained. Width measurements were typically taken at the midpoint of the spicule, unless mentioned otherwise in the body of the report.

## **Scanning Electron Microscopy**

For our specimens from the family Esperiopsidae, spicules were additionally prepared for scanning electron microscopy. To prepare spicules for scanning electron microscopy ~1 cm<sup>3</sup> of sponge tissue was added to 5 ml concentrated nitric acid in 20 ml glass test tubes, heated to 50°C, then digested for 2-3 hours. Next, the nitric acid was diluted by filling test tubes with distilled water. The solution was replaced with distilled water four times to further clean the spicules. Clean spicules were suspended in 70% ethanol. Spicules were mounted by pipetting spicule-containing solution onto the aluminum stubs directly, or by pipetting on to 9 × 9 mm glass cover slips which were subsequently attached to stubs using 5-minute epoxy resin. Dry spicule samples were sputter

coated for 195 seconds in a Leica EM ACE 200 with a gold-palladium coating, equating to a thickness of 15 µm. Spicules were examined and photographed using a Hitachi S-4700 Scanning Electron Microscope. Spicules in SEM images were measured using FIJI Software. Width of styles from Esperiopsidae specimens was recorded at the mid-point and at the end of the style, just inside the rounded end.

## Descriptions

The remainder of this report is comprised of descriptions of eight species collected in the multispecies trawl surveys: three from the family Microcionidae (genera *Artemisina* and *Clathria*), two from the family Acarnidae (genus *Iophon*) and three from the family Esperiopsidae (genera *Esperiopsis* and *Semisuberites*).

Each of the sponge descriptions includes the following:

- ITIS and WORMS reference numbers when available
- Specimen macro photo
- Physical description
- Habitat information including depth and geographic area
- Map of *Paamiut* 2010-2014 collection locations
- Descriptions of spicule morphology and table with spicule measurements
- Spicule figure with light or scanning electron micrographs of each spicule type
- Discussion of taxonomic literature
- Distinguishing characteristics

## RESULTS

### Family Microcionidae

For the family Microcionidae, two species of the genus *Artemisina* and one species of the genus *Clathria* were identified from our eastern Arctic collection, respectively *Artemisina lundbecki*, *Artemisina arcigera* and *Clathria (Clathria) barleei*. As detailed in the Introduction section of this report, Hooper (2002a) divided genera and subgenera of the Microcionidae family mostly based on their skeletal structure. Since we did not perform thick sections to observe the skeletal organisation, only the spicule complement and their measurements was used to identify Microcionidae specimens. It is important to mention here that the presence of toxas is a criteria that should be used cautiously, since they are not exclusive to Microcionidae sponges. It was suggested in the past that toxas with spiny extremities could be used as a distinctive feature for defining the genus *Artemisina* (De Laubenfels, 1936, cited by Ristau, 1978). However, spiny toxas are not unique to *Artemisina* species and, moreover, some *Artemisina* species have toxas with smooth ends exclusively. In a similar fashion, the genus *Clathria* includes species with spiny toxas as well as species with smooth toxas. Presence of toxas with smooth and/or spiny extremities were therefore solely used in a way to narrow the search of potential families, genera or species during the identification process. Then, for each specimen, the whole spicule complement was carefully examined and measured. In combination with the external morphology of our specimens, these data were compared with the original descriptions and to other published descriptions (see the taxonomic remarks sections of each species descriptions).

### Family Acarnidae

In our eastern Arctic collection, we identified two species that belong to the family Acarnidae: *Iophon piceum* and *Iophon koltuni*. Even though if we did not perform thick sections to observe the skeletal organisation, the presence of tylotes with microspined bases and the geometry of microscleres led us to the family Acarnidae. The *Iophon* genus was identified by the presence of spured anisochelae and bipocilli. Then, for each specimen, the whole spicule complement was carefully examined and measured. These data were compared to the original species descriptions and to other published descriptions (see the taxonomic remarks sections of each species descriptions) in order to confirm our taxonomic identifications.

### Family Esperiopsidae

For the family Esperiopsidae, one species of the genus *Semisuberites* and two species of the genus *Esperiopsis* were identified from our eastern Arctic collection: *Semisuberites cf. cribrosa*, *Esperiopsis villosa*, and *Esperiopsis* sp. 1. As with the families Microcionidae and Acarnidae, we

based our identifications on complete spicule complements and did not observe the skeletal organization in detail. Identification of *Semisuberites* cf. *cribrosa* was achieved by comparing overall morphology and size and shapes of styles with published descriptions of *Semisuberites cribrosa*, the sole species in this genus, which lacks microscleres but shared a fusiform style shape with other sponges belonging to the family Esperiopsidae. Large styles, presence of sigmas and several size classes of palmate isochelae were key features used to identify *Esperiopsis* species. The full spicule complement was carefully examined and measured for each specimen before comparing with published descriptions (see the taxonomic remarks sections of each species descriptions) to confirm our taxonomic identifications.



## Spicule key for species presented in this report

A taxonomic key based on spicule characteristics is provided to allow end users of this report to efficiently key out sponges for identification. The key should be used with caution, as our spicule characteristics are chosen to distinguish amongst the species described in this report and therefore will probably not be applicable when considering broader groups of species. To obtain dimension ranges from other descriptions and to see how they compare to our measurements, please consult the results section of this report, as well as the published descriptions from other authors. The full descriptions should be consulted, and spicule measurements or morphological characteristics compared prior to confirming identification. We recommend consulting the World Porifera Database (<http://www.marinespecies.org/porifera/>) at the time of identification to determine whether the taxa names included here are still accepted or have been replaced by alternate names.

- (1) Presence of bipocilli or toxas.....2  
Absence of bipocilli or toxas.....6
- (2) Presence of bipocilli. Absence of toxas.....3  
Absence of bipocilli. Presence of toxas.....4
- (3) Small and tightly coiled bipocilli (8-14  $\mu\text{m}$ ) (Figure 13E).....*Iophon piceum*  
Large bipocilli (13-18  $\mu\text{m}$ ) with elongated teeth and long, arcuate shafts with bend at mid-point (Figure 16D).....*Iophon koltuni*
- (4) Toxas with smooth extremities only (217-716  $\mu\text{m}$ ). Very wide angle between the two arms and abrupt flexion at the bend, conferring a flat general shape (Figure 10D). Presence of acanthostyles (Figure 10E), although considered rare and sometimes completely missing.....*Clathria (Clathria) barleei*  
Toxas have a more or less wide inverted V-shape and spiny extremities (Figures 4G-H and 7E-F). Some toxas with smooth ends are present (generally smaller than 300  $\mu\text{m}$ ) (Figures 4I and 7E). However, clear distinction between these two types of toxas is not always possible (Figure 7E). Absence of acanthostyles.....5
- (5) Long and thick smooth styles (545-833  $\times$  12-23  $\mu\text{m}$ ) (Figure 4A). Small styles (282-463  $\times$  5-13  $\mu\text{m}$ ) with microspined heads (Figure 4E-F).....*Artemisina lundbecki*  
Long subtylostyles with consistent width throughout its length (452-627  $\times$  7-12  $\mu\text{m}$ ) (Figure 7A). Short subtylostyles are fusiform with a narrow neck and the thicker part at mid-length (269-438  $\times$  9-16  $\mu\text{m}$ ) (Figure 4C-D).....*Artemisina arcigera*
- (6) Fusiform styles as megascleres (Figure 19), no microscleres.....*Semisuberites cf. cribrosa*  
Styles as megascleres, microscleres present..... 7
- (7) Large palmate isochelae (65-119  $\mu\text{m}$ ) with serrated alae (Figure 22C)....*Esperiopsis villosa*  
Palmate isochelae with smooth margins only (Figure 25D-E-F), variation in sigmas includes sigmas with recurved ends (Figure 25C).....*Esperiopsis* sp. 1

## Descriptions of Family Microcionidae

### *Artemisina*

*Artemisina lundbecki* (Morozov, Sabirov & Zimina, 2019)

ITIS TSN 48324 (genus)  
 WORMS AphiaID 1338221

#### Physical description

Our reference specimen (PAA2014-007 Set 54 Col 85) consists of a ~35 cm<sup>2</sup> fragment (7 cm long and 5 cm wide) with irregular margins (Figure 2). The colour of this massive and amorphous sponge is a yellowish brown. The consistency is soft, but the surface is rather rough. Numerous pores exhibiting a similar diameter cover the surface in a somewhat uniform pattern on one side, whereas the other side is characterized by a surface more heterogeneous with some parts significantly less porous. Four additional specimens were collected during the multispecies trawl surveys and are used as supporting specimens for this species description.

#### Habitat information

Baffin Bay and Davis Strait at 499-774 m depth (Figure 3).

#### Spicules (Table 1, Figure 4)

Megascleres: Styles are distributed in two distinct size classes, the small ones being 282-463 µm long and the large ones measuring 545-833 µm. The ranges in width measurements for these two size classes, 5-13 µm and 12-23 µm respectively, overlap when we consider all five analyzed specimens due to the variability encountered between specimens (Table 1). However, for one given specimen, the dimension ranges for styles do not overlap and therefore the two size classes are easily differentiated. Large styles are slightly curved and have faintly spined bases, a feature that is not always distinguishable under the compound microscope (60X) (Figure 4C). The small styles clearly have microspined heads (Figure 4F) and almost look like tylostyles in some cases. Several aberrant styles were observed, most of them characterized by a stout “T” or “Z” shape replacing the rounded end (Figure 4D). For most specimens analyzed, two to three extremely large toxa-looking spicules occurred (not shown in Figure 4). The shape and dimensions of these smooth and thick spicules are really similar to the large styles, which supports the idea that these spicules may also be an abnormal form of styles.

Microscleres: Palmate isochelae are 11-19 µm long. Two distinct kinds of toxas were found. Small toxas (20-280 µm, measured tip to tip in a straight line) seem completely smooth and really fine (width at the bend: 1-4 µm), whereas large toxas (210-552 µm, measured tip to tip in a straight line) have spiny extremities and are very stout (width at the bend: 4-10 µm). There is a possibility that the small smooth toxas are a developmental form of the large spiny ones, but for most

specimens no overlap was observed in the measurements. Moreover, toxas either possessed no spines or a lot of them, with a total lack of toxas with an intermediate number of spines. Toxas were sometimes difficult to find and therefore the number of measurements (n) is lower for some specimens. For the reference specimen, the angle formed by the two arms was measured for 18 small toxas and 15 large toxas and the average values are 143 and 101 degrees, respectively.

### **Distinguishing characteristics**

We do not recommend trying to identify this species without looking at the spicules, considering that the external morphology is not particularly distinctive. Toxas do not occur exclusively in Microcionidae, but their presence could be a useful criterion to quickly differentiate Microcionidae sponges from several other families of the Poecilosclerida order. Within our eastern Arctic collections, *Artemisina lundbecki* is the only taxon with two distinct kinds of toxas (Table 1, Figure 4), since we observed a wide size range for the toxas of *Artemisina arcigera* (no clear gap in the measurements). The presence of larger styles with faintly spined bases and smaller styles (approximately half the length of the long ones) with microspined bases allow confirmation of the species as *Artemisina lundbecki*.

### **Taxonomic remarks**

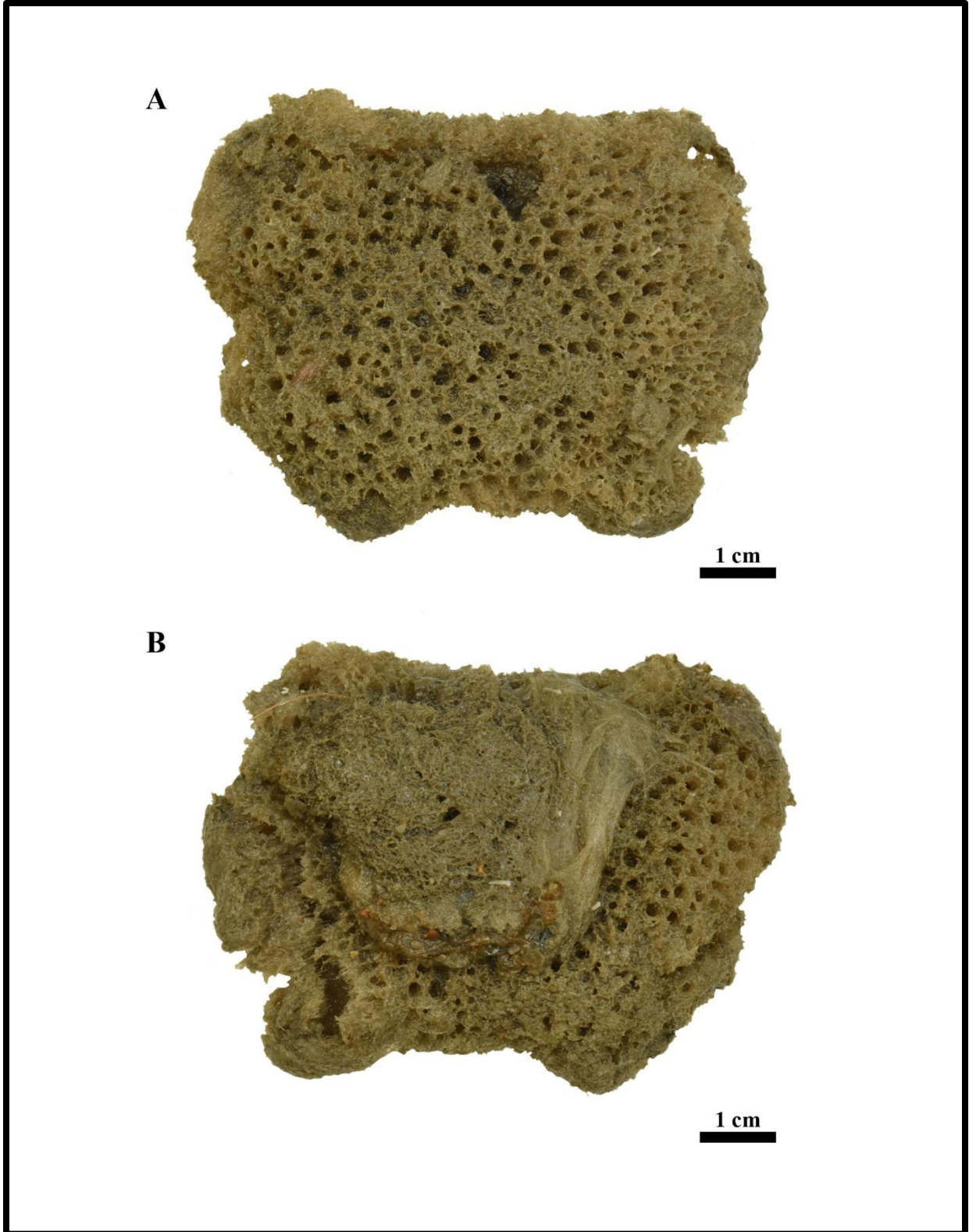
Recently accepted in the World Porifera Database (Van Soest et al., Accessed July 11<sup>th</sup>, 2019), the species name *Artemisina lundbecki* was created by Morozov et al. (2019) to differentiate Arctic and Antarctic specimens that were all regrouped under the name *Artemisina apollinis*. Originally named *Amphilectus apollinis*, *Artemisina apollinis* was described by Ridley and Dendy in 1886 (specimens from Kerguelen Islands). According to Morozov et al. (2019), the bipolar distribution of *Artemisina apollinis* needed to be addressed since the two groups of representatives for *Artemisina apollinis* had probably been geographically separated for approximately two million years. The descriptions written by Koltun (1959) and Lundbeck (1905) for *Artemisina apollinis* specimens from the northern hemisphere were recently associated to the new Arctic species *Artemisina lundbecki* (Morozov et al., 2019).

Regarding the spicule complement, the true difference between *Artemisina lundbecki* and *Artemisina apollinis* is in the morphology of the large choanosomal styles. These styles are definitely bigger in *Artemisina lundbecki* specimens, with dimensions of 548-783 × 12-20 µm according to the measurements of Morozov et al. (2019). Lundbeck (1905) found similar results with 530-800 µm for length and 13-20 µm for width. The large styles that we measured (545-833 × 12-23 µm) are in agreement with the styles of *Artemisina lundbecki*, even if our range is slightly wider. Furthermore, Koltun (1959) gave dimension ranges almost identical to the ones we observed, with styles measuring up to 842 µm. Differently, the styles of the Antarctic specimens of *Artemisina apollinis* described by Boury-Esnault and Van Beveren (1982) are 326-461 µm long and the ones measured by Ridley and Dendy (1886, 1887) are 500 µm long. Another distinguishing feature between these two *Artemisina* species is the very faint spines on the basal ends of the styles.

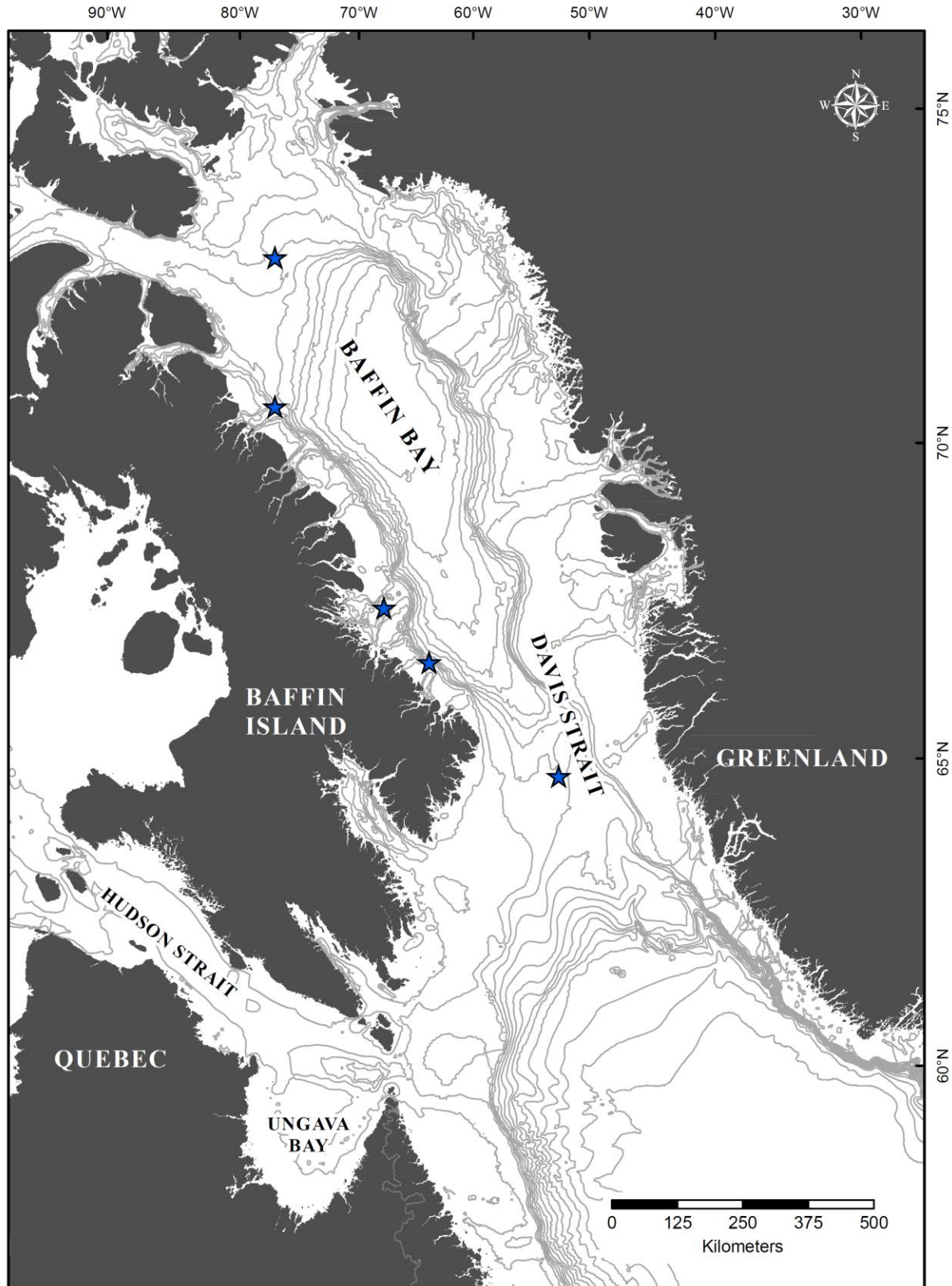
While the spines are pronounced and easily seen on the small ectosomal styles, the exceedingly small spines on the large choanosomal styles are not always distinguishable with the compound microscope (60X). However, after examination of several spicules, we were convinced of their presence, such as described by Morozov et al. (2019), Koltun (1959) and Lundbeck (1905). SEM images in the paper of Morozov et al. (2019) depict this subtle spinulation very nicely.

The megascleres and microscleres described for our specimens of *Artemisina lundbecki* showed good congruence to previous descriptions, which supports our identifications. However, as described previously, our measurements and observations support the idea that two kinds of toxas are present for *Artemisina lundbecki*. Smaller toxas were ignored, probably considered as developmental forms, in the description of Morozov et al. (2019). Koltun (1959) and Lundbeck (1905) also described two different toxas. Even for the Antarctic species *Artemisina apollinis* which is more documented, the descriptions of toxas seem to differ from each other (Ridley and Dendy, 1887; Topsent, 1907; Boury-Esnault and Van Beveren, 1982; Rios et al., 2004) and it seems that no consensus truly exists between authors concerning the presence or absence of different kinds and size classes of toxas. The high variability in dimension ranges for toxas could be partially explained by the different techniques for measuring toxas, which unfortunately are not always specified. Also, the length measurement done tip to tip is greatly influenced by the variable angle formed by the two arms of the toxas.

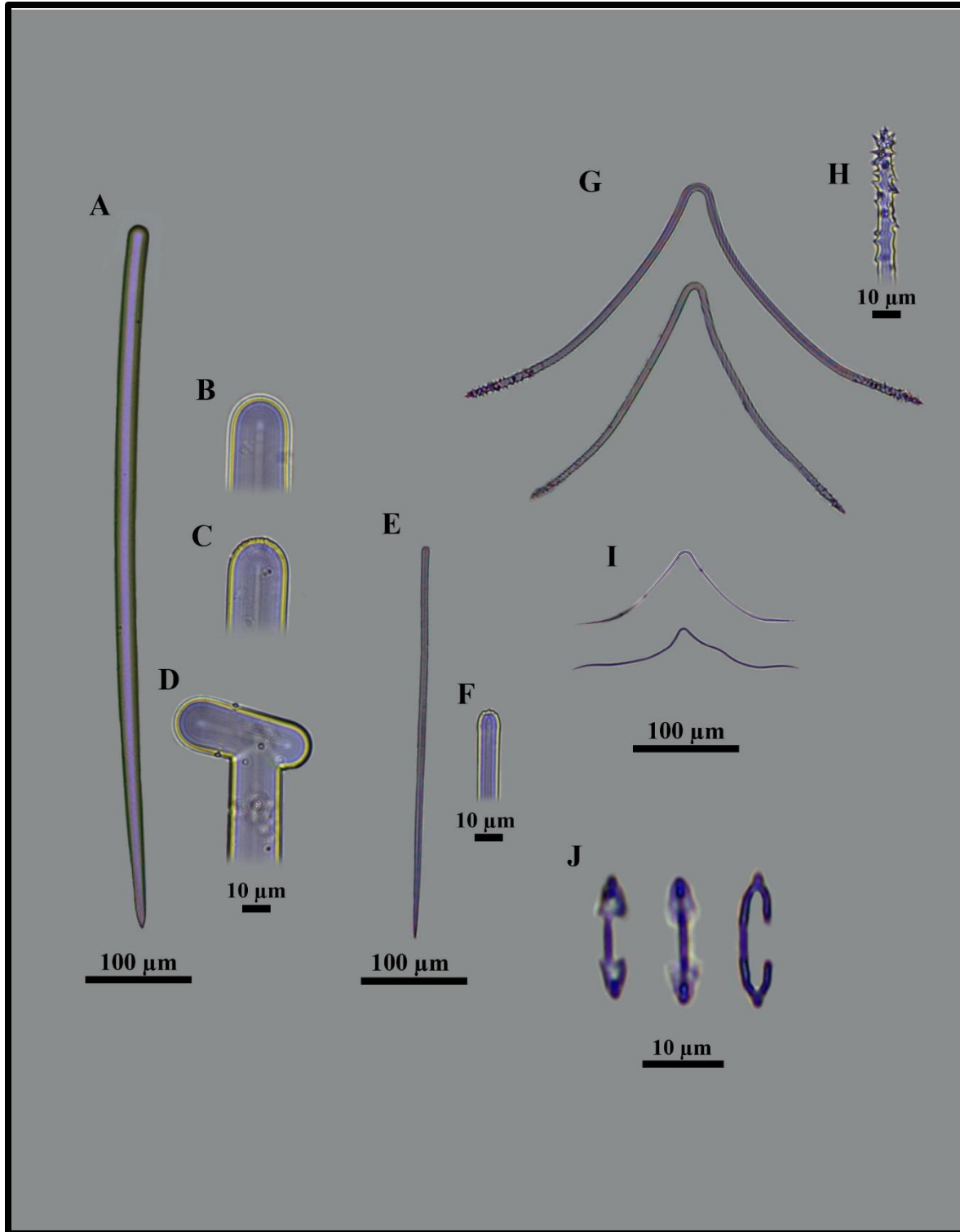
In a recent study, Murillo et al. (2018) described the sponge communities of eastern Canadian Arctic using the same specimens collected during the multispecies trawl surveys. Therefore, based on the conclusions of the present report, the species *Artemisina* aff. *apollinis* presented in Murillo et al. (2019) should be considered as *Artemisina lundbecki*.



**Figure 2.** *Artemisina lundbecki* specimen PAA2014-007 Set 54 Col 85 showing opposite sides.



**Figure 3.** *Artemisia lundbecki* collection locations.



**Figure 4.** *Artemisina lundbecki* spicules from PAA2014-007 Set 54 Col 85. Large style (A), Large style heads with faint spines, sometimes not visible (B, C), Head of a aberrant large style (D), Small style (E), Microspined head of a small style (F), Large toxas with spined extremities (G), Small toxas entirely smooth (I) and Isochelae (J).



**Table 1.** Spicule measurements from specimens of *Artemisina lundbecki* all reported as minimum-(average)-maximum for length and width ( $\mu\text{m}$ ). The number of spicule measurements (n) is specified for each spicule type. The specimen name is a unique ID (cruise, trawl set number, specimen collection number).

Specimen	Large styles	Small styles	Large Toxas	Small Toxas	Isochelae
PAA2014-007 Set 54 Col 85	546.5-(622.0)-698.5 × 11.5-(16.1)-21.2 n = 30	307.6-(354.8)-426.3 × 5.0-(7.0)-8.6 n = 30	297.5-(406.0)-541.8 × 5.5-(7.4)-9.2 n = 12	46.0-(163.0)-263.8 × 0.6-(1.9)-4.0 n = 17	10.7-(16.1)-18.5 n = 30
PAA2010-009 Set 86 Col 272	568.5-(626.5)-684.7 × 15.9-(17.9)-20.5 n = 10	281.9-(362.5)-414.4 × 6.6-(7.6)-8.8 n = 10	355.0-(445.0)-551.9 × 4.7-(6.6)-8.6 n = 10	73.0-(172.2)-280.1 × 0.6-(2.0)-3.7 n = 5	15.1-(16.0)-17.5 n = 10
PAA2012-007 Set 2 Col 1	544.5-(615.2)-704.1 × 13.5-(16.4)-18.8 n = 10	307.2-(334.8)-367.5 × 5.4-(6.3)-7.4 n = 10	295.8-(386.8)-540.5 × 4.4-(6.9)-9.8 n = 10	20.3-(96.2)-186.1 × 0.9-(1.5)-2.7 n = 10	15.8-(17.0)-19.1 n = 10
PAA2012-007 Set 65 Col 50	565.2-(687.5)-833.3 × 13.3-(15.5)-17.6 n = 10	408.6-(433.6)-462.7 × 6.3-(7.5)-9.2 n = 10	359.6-(429.6)-483.4 × 4.0-(6.5)-8.7 n = 10	110.4 × 0.8 n = 1	11.7-(15.1)-18.0 n = 10
PAA2011-007 Set 168 Col 584	627.0-(676.2)-752.8 × 14.1-(19.7)-23.0 n = 10	355.1-(398.8)-429.8 × 7.7-(9.8)-13.2 n = 10	210.1-(324.4)-380.8 × 5.5-(7.1)-10.1 n = 5	76.4-(160.4)-256.4 × 1.3-(2.4)-3.9 n = 10	13.0-(15.3)-16.8 n = 10



***Artemisina arcigera* (Schmidt, 1870)**

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**Physical description**

Characterized by a cushion shape with an oblong contour, our reference specimen of *Artemisina arcigera* (PAA2011-007 Set 72 Col 167) is dark ochre yellow in colour and measures approximately 2 to 3 cm long (Figure 5). The surface is very smooth, almost skin-like, with oscules with only slightly raised contours. The specimen is firm, compact, visually non-porous, but it could be minimally compressed. In total, 13 additional specimens were collected during the multispecies trawl surveys and five of them are used as supporting specimens for this species description.

**Habitat information**

Baffin Bay and east of Hudson Strait and Ungava Bay, at 161-517 m depth (Figure 6).

**Spicules (Table 2, Figure 7)**

**Megascleres:** Two kinds of subtylostyles are present. The longest and slimmest measure 452 to 627  $\mu\text{m}$  long and 7 to 12  $\mu\text{m}$  wide. The rounded tip of these long subtylostyles varies in shape and therefore the spicules could look like styles in certain cases (Figure 7B). Shorter and thicker, the subtylostyles of the second kind have a length range of 269 to 438  $\mu\text{m}$  and have a pronounced fusiform shape (Figure 7D). The narrowest section just past the spherical tip (neck) is well defined and the thickest part, being 9 to 16  $\mu\text{m}$  thick, is located in the middle of the spicule.

**Microscleres:** Palmate isochelae are particularly tiny: 6 to 14  $\mu\text{m}$  long. Toxas are quite variable in size, going from 41 to 371  $\mu\text{m}$  (measured tip to tip in a straight line). All the large toxas have heavily spined tips, whereas the smallest ones are usually smooth. However, medium-sized toxas occurred with and without spines and the number of spines seems to vary as a function of the size of the toxas. This is why, contrary to *Artemisina lundbecki*, the separation of toxas in different kinds or size categories was impossible here. The continuum observed in the size and the spinosity of the toxas for *Artemisina arcigera* is represented in Figure 7E. The average value for the angle formed by the two arms is 125 degrees ( $n = 30$  toxas, for the reference specimen), but the collected measurements vary between 89 and 165 degrees.

**Distinguishing characteristics**

To properly identify *Artemisina arcigera*, the spicule complement should be analyzed, because its external morphology could be very similar to some other species from the genus *Suberites*. Toxas are not occurring exclusively in Microcionidae, but their presence could be a useful criteria to quickly differentiate Microcionidae sponges from several other families of the Poecilosclerida order. Within our eastern Arctic collections, *Artemisina arcigera* is the only species with this

spicule component composed of two kinds of smooth subtylostyles, toxas with spiny and smooth ends and extremely small palmate isochelae.

### **Taxonomic remarks**

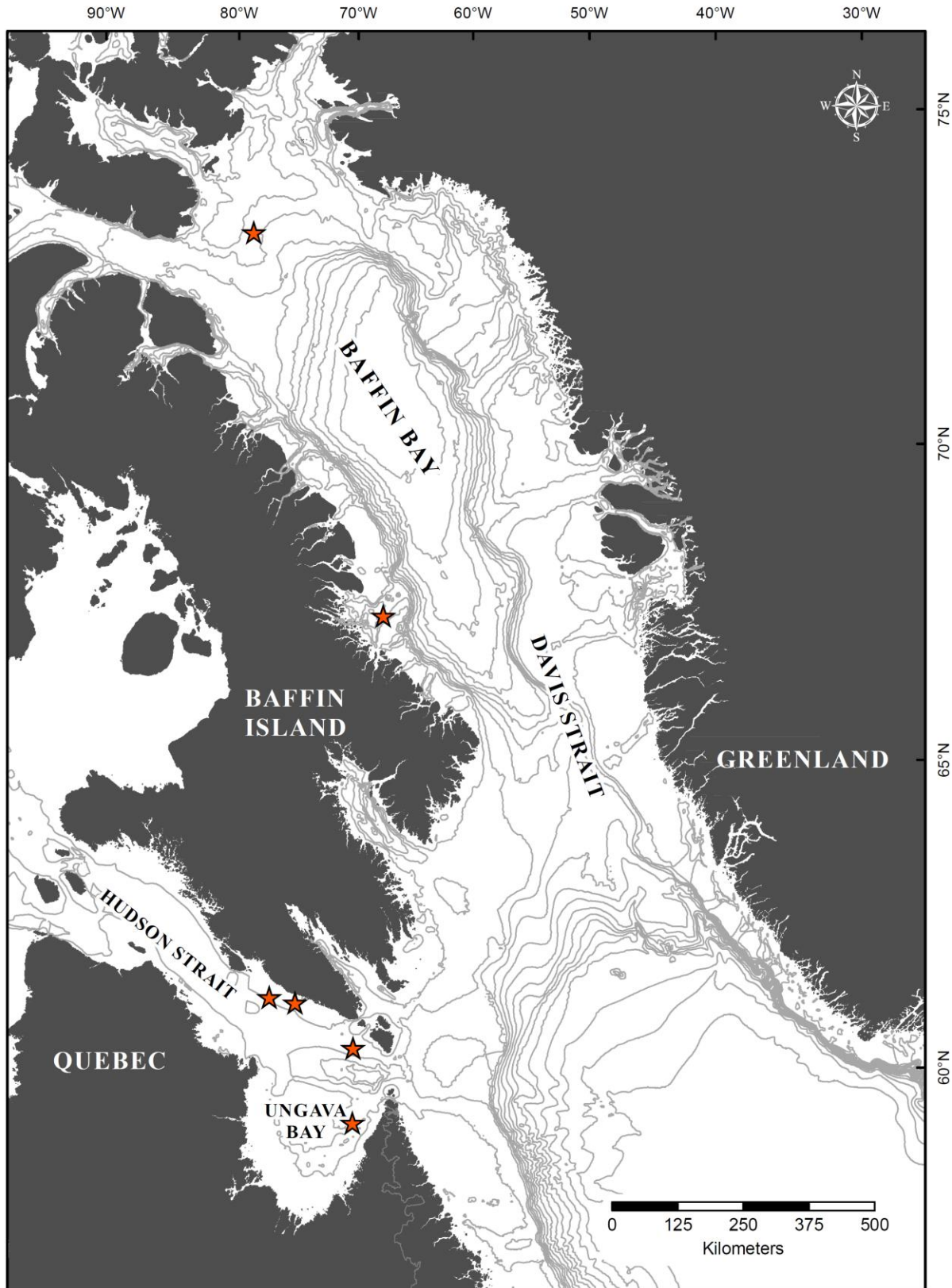
In 1870, Schmidt first described *Artemisina arcigera*, which he originally named *Suberites arciger*, as a spherical shaped sponge, brown in colour, with a spongy and smooth surface. He described the toxas with spiny ends, but he did not mention the tiny isochelae. He also described and illustrated a weird short and stout spicule with two rounded extremities. In 1882 and 1885, Vosmaer published two descriptions of this species under different names, *Esperia lanx* (Vosmaer, 1882) and *Artemisina suberitoides* (Vosmaer, 1885). For *Esperia lanx*, Vosmaer (1882) worked on an incomplete specimen and counted five different kinds of spicules, probably present due to contamination. Although, among that mix of spicules, he differentiated two kinds of subtylostyles: “ (...) slender and stout ones, often with an indication of head or fusiform shaft”. For *Artemisina suberitoides*, Vosmaer (1885) described a similar external morphology to the one described by Schmidt (1870) and he also mentioned the presence of pores not visible to the naked eye and a few thin papillae. Contrarily to Schmidt (1870), Vosmaer observed numerous “little anchors” but no peculiar rounded spicules. In this description of *Artemisina suberitoides* (Vosmaer, 1885), the subtylostyles were all regrouped in the same category, exhibiting high variability in shapes and sizes. In 1905, Lundbeck confirmed that *Suberites arciger* and *Artemisina suberitoides* were synonyms and renamed this species *Artemisina arcigera*. The isochelae being exceedingly minute, it would not be surprising that Schmidt (1870) overlooked them, as hypothesized by Fristedt (1887) and Lundbeck (1905). Regarding Schmidt’s peculiar rounded spicules, Lundbeck (1905) explained them as “monstruosities of the kind that is upon the whole not rarely found in sponges”. The spicule complement presented by Lundbeck (1905) includes the two different kinds of subtylostyles (290 to 400  $\mu\text{m}$  and 450 to 650  $\mu\text{m}$ ), toxas (70 to 320  $\mu\text{m}$ ), and the minute isochelae (7 to 13  $\mu\text{m}$ ). More than 50 years later, Koltun (1959) gave very similar spicule descriptions along with measurements almost exactly in the same ranges.

Concerning the external morphology and consistency, our specimens match the descriptions of the previously cited authors. We did not observed the thin papillae that Vosmaer (1885) drew, which may be a misrepresentation of the oscules with raised contours. Lundbeck (1905) described the oscules as “circular or somewhat irregular openings surrounded by a more or less projecting, spout-shaped margin formed by the skin”, which seems to correspond to our observations. The classification of subtylostyles for *Artemisina arcigera* is non-uniform in the literature. However, the more recent descriptions (Lundbeck, 1905; Koltun, 1959) mention the same two kinds of subtylostyles that we found with almost identical measurement ranges. Lundbeck (1905) noted that these two subtylostyles are not sharply separated from each other, which could explain why previous texts did not divide them. After compiling our measurements, we realized that only 14  $\mu\text{m}$  were separating the two measurement ranges. We observed the same toxas with spiny ends which were described and illustrated by authors in the past (Schmidt, 1870; Vosmaer 1882;

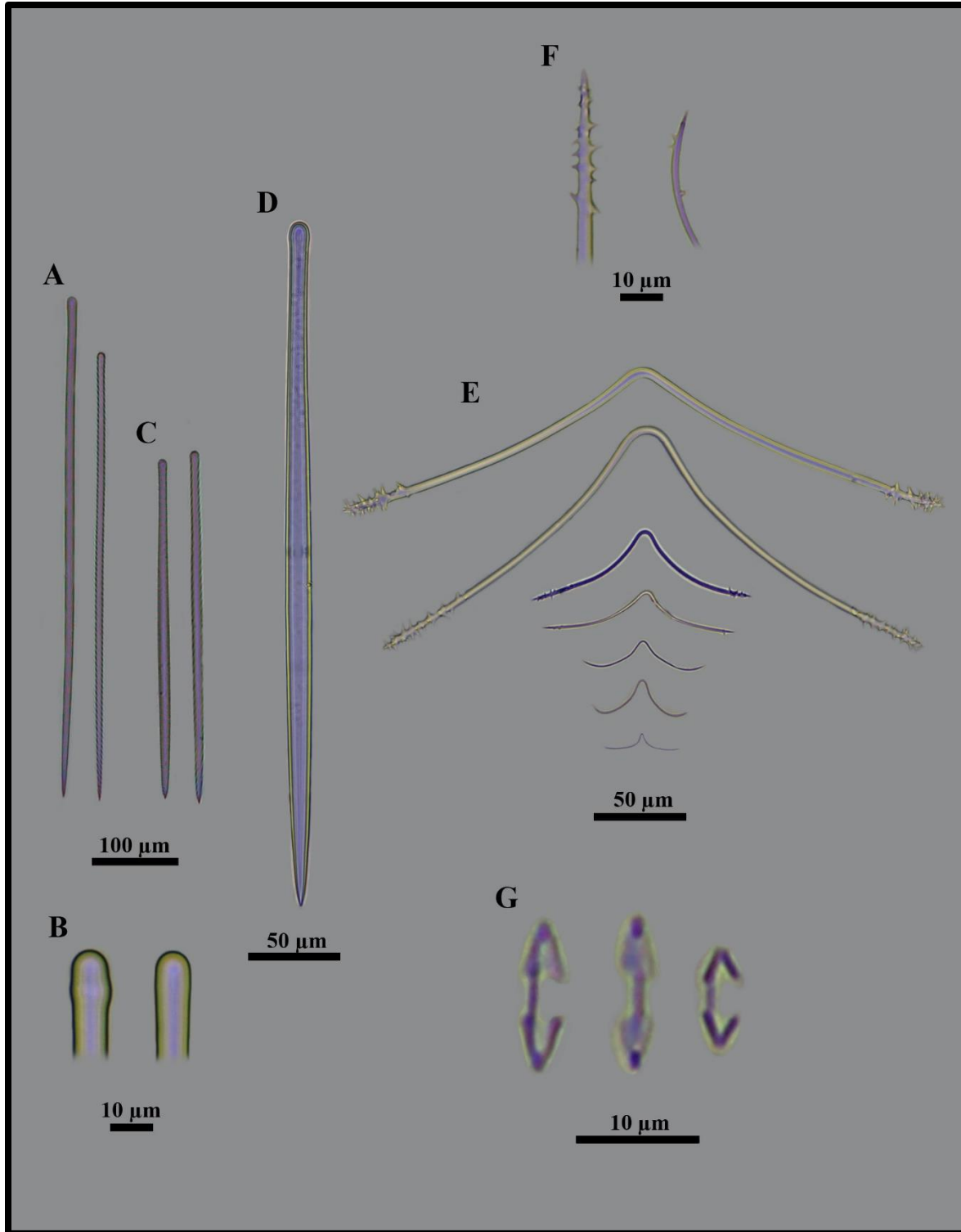
Vosmaer, 1885; Lundbeck, 1905). These measured 41 to 371  $\mu\text{m}$  (measured tip to tip in a straight line), which is similar to the range of 70 to 320  $\mu\text{m}$  found by Lundbeck (1905). However, comparisons between previous descriptions are not always straightforward as different techniques could be used for measuring toxas and moreover, these methods are not even specified in some cases. For example, Ridley and Dendy (1887) measured a single arm and then multiplied by two, while the gap between the two extremities is what we used to report the length of toxas.



**Figure 5.** *Artemisia arcigera* specimen PAA2011-007 Set 72 Col 167 showing opposite surfaces.



**Figure 6.** *Artemisia arcigera* collection locations.



**Figure 7.** *Artemisina arcigera* spicules from PAA2011-007 Set 72 Col 167. Long subtylostyles (A), Long subtylostyle heads (B), Short subtylostyles (C, D), Toxas with both spined and smooth extremities observed in a continuum (E), Spined toxa tips (F) and Isochelae (G).

**Table 2.** Spicule measurements from specimens of *Artemisina arcigera* all reported as minimum-(average)-maximum for length and width ( $\mu\text{m}$ ). The number of spicule measurements (n) is specified for each spicule type. The specimen name is a unique ID (cruise, trawl set number, specimen collection number).

<b>Specimen</b>	<b>Long subtylostyles</b>	<b>Short subtylostyles</b>	<b>Toxas</b>	<b>Isochelae</b>
PAA2011-007 Set 72 Col 167	451.6-(542.6)-605.6 × 7.2-(9.3)-11.8 n = 30	269.2-(341.8)-438.3 × 9.7-(12.4)-14.3 n = 30	53.2-(149.3)-321.6 × 0.8-(2.2)-5.3 n = 52	7.0-(9.9)-14.4 n = 30
PAA2011-007 Set 61 Col 150	464.2-(524.5)-563.0 × 9.2-(10.7)-11.9 n = 10	272.1-(313.5)-399.0 × 9.2-(11.2)-12.8 n = 10	40.9-(212.5)-371.3 × 0.5-(2.9)-5.3 n = 13	5.8-(9.8)-13.2 n = 10
PAA2012-007 Set 60 Col 47	526.7-(564.1)-608.6 × 8.0-(8.5)-9.4 n = 10	283.9-(337.9)-392.0 × 8.6-(10.3)-11.5 n = 10	46.0-(232.0)-370.4 × 1.1-(4.4)-7.5 n = 12	7.1-(9.0)-13.3 n = 10
PAA2014-007 Set 53 Col 83	511.9-(541.6)-600.4 × 8.6-(9.5)-10.6 n = 10	312.2-(372.3)-418.0 × 11.5-(13.4)-15.5 n = 10	135.8-(227.2)-278.0 × 1.8-(4.3)-5.7 n = 10	12.3-(12.9)-14.3 n = 10
PAA2013-008 Set 133 Col 276	485.4-(523.8)-562.8 × 9.7-(10.5)-11.8 n = 10	303.5-(349.6)-393.8 × 9.7-(12.2)-13.8 n = 10	104.2-(223.2)-294.6 × 1.7-(4.1)-6.0 n = 10	7.8-(10.5)-14.0 n = 10
PAA2011-007 Set 99 Col 207	544.3-(588.7)-627.4 × 8.0-(8.7)-9.7 n = 10	295.4-(340.3)-409.2 × 10.5-(12.7)-13.9 n = 10	71.9-(215.7)-332.4 × 1.1-(3.7)-6.8 n = 11	7.7-(10.0)-11.8 n = 10

## *Clathria*

ITIS TSN 203914 (species)

### *Clathria (Clathria) barleei* (Bowerbank, 1866)

WORMS AphiaID 167498

#### **Physical description**

Our reference specimen of *Clathria (Clathria) barleei* (PAA2011-007 Set 5 Col 17) is 20 cm long by 20 cm wide and 1 to 2 cm thick (Figure 8). On one side of its body but on all its length, this irregularly fan-shaped sponge is divided in two foliations that are expanding in the same plane. It seems like the sponge was sliced lengthwise down the side without cutting all the way. Even if we are not sure about how complete our specimen is, we suspect that the sponge was attached to the substrate by a small pedicel. The colour (after having been frozen) is a yellowish beige. The surface is even, minutely hispid and reticulated. It is so porous that we could see through it. Four additional specimens were collected during the multispecies trawl surveys and are used as supporting specimens for this species description.

#### **Habitat information**

Davis Strait and north-east of Labrador Sea, at 451-672 m depth (Figure 9).

#### **Spicules (Table 3, Figure 10)**

Megascleres: Smooth styles (Figure 10A) and subtylostyles with microspined heads (Figure 10B and C) are present. Styles are 299 to 501  $\mu\text{m}$  long and 9 to 19  $\mu\text{m}$  wide. A few of them have rounded-off ends (more strongyle like), but these are considered rare and are probably developmental forms. Subtylostyles are very slender, being 3 to 9  $\mu\text{m}$  wide, and their length ranges between 192 and 455  $\mu\text{m}$ . Very rare, short acanthostyles (Figure 10E), measuring 85 to 175  $\mu\text{m}$ , are present but not always found. For two out of five specimens, no acanthostyles were found.

Microscleres: Very consistent in terms of dimensions, palmate isochelae are 16 to 23  $\mu\text{m}$  long. All toxas are completely smooth and range from 217 to 716  $\mu\text{m}$  (measured tip to tip in a straight line). The average value for the angle formed by the two arms is 167 degrees ( $n = 7$  toxas, for the reference specimen). The two arms are therefore almost on the same axis for these toxas, which gives them a characteristic flat morphology (Figure 10D).

#### **Distinguishing characteristics**

*Clathria (Clathria) barleei* has a unique external morphology, but since the external membrane is often detached on the specimens collected in the trawl, the identification could become more difficult. Looking at the spicule complement, all toxas from this species are completely smooth and their shape (very wide angle between arms and abrupt flexion) makes them appear very different from the other toxas of our Microcionidae Arctic species (*Artemisina lundbecki* and



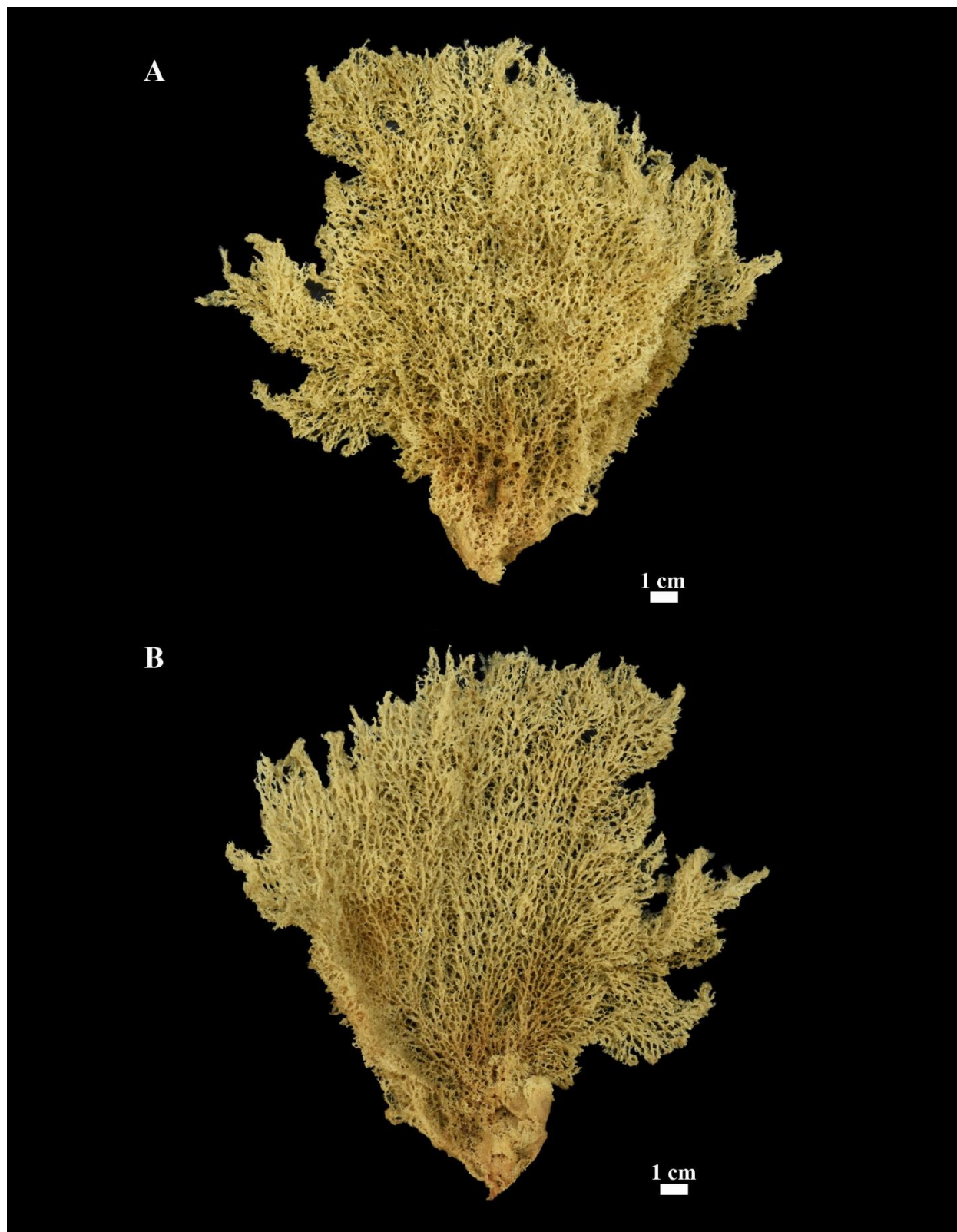
*Artemisina arcigera*). The presence of acanthostyles could also help to differentiate *Clathria* (*Clathria*) *barleei* from the *Artemisina* species. However, since these spicules are very rare, their absence from the prepared slides could be misleading. A combination of macroscopic and microscopic features should be considered to properly identify this species.

### **Taxonomic remarks**

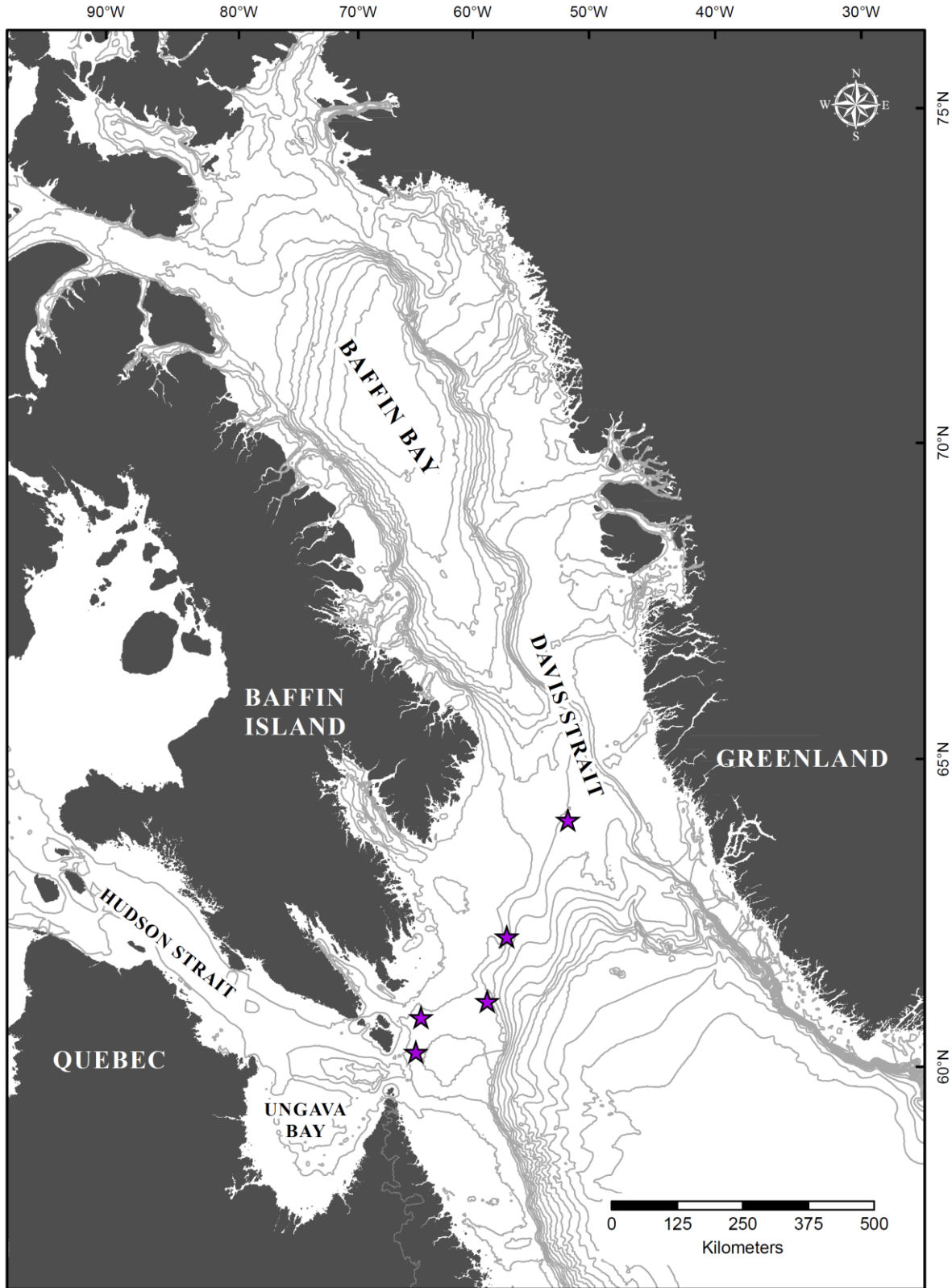
First described in 1866 by Bowerbank, *Isodictya barleei* is portrayed as an irregular fan-shaped sponge divided in two or three fleshy foliations of a pale buff or yellow colour. These are all attached to the same base, which could be slightly pedicelled (damaged specimen). Describing the external membrane, Bowerbank (1866) wrote: “The groups of oscula generally consist of a central one with from five to eight others around it, usually disposed in radiating lines. The groups are about equidistant from each other, and they give to the surface on which they are disposed a singular and very characteristic stellar appearance.” Concerning the spicules, the description of *Isodictya barleei* is brief and incomplete, with no mention of isochelae, toxas or acanthostyles. In 1869, Norman documented another specimen of *Clathria* (*Clathria*) *barleei* under the name *Isodictya laciniosa*. His description of the external morphology is similar to Bowerbank (1866)’s description. However, he mentioned that the oscula and pores are inconspicuous and that the sponge is translucent in every part, as a result of the open structure of this dry specimen. The stellar appearance was not described here, which could be explained by the drying process that probably changed the aspect of the dermal membrane and made the oscula and pores more difficult to observe. Styles, subtylostyles, isochelae and acanthostyles are included in this text. Acanthostyles are described as “attenuato-acuate, incipiently spinous, minute” spicules. In his text from 1874, Bowerbank still differentiated the following four species: *Halichondria mutula*, *Halichondria foliata*, *Isodictya laciniosa* and *Isodictya barleei*. Specimens examined were all sessile branching or fan-shaped sponges with ramifications expanding in the same place and a surface openly reticulated with a thin and pellucid dermal membrane, but the variability in their spicule complements led to several species names that were later synonymized under *Clathria* (*Clathria*) *barleei*. Adding to this variability, Van Soest and Stone (1986) specified that it is normal for Microcionidae sponges to loose microscleres and/or acanthostyles. Orueta (1901) similarly described the external morphology of this species, but also measured and illustrated the complete spicule complement, including the styles (317 µm), subtylostyles (255 µm), acanthostyles (106 µm), isochelae (17 µm) and the toxas (455 µm) of *Clathria* (*Clathria*) *barleei*, which was then identified as *Rhaphidophlus filifer* var. *cantabrica*. More recent descriptions from Van Soest and Stone (1986) and Ackers et al. (1992) documented *Clathria* (*Clathria*) *barleei* and provided spicule measurement ranges: styles (350-580 µm), subtylostyles (260-380 µm), acanthostyles (90 µm, no range given), isochelae (18-21 µm) and toxas (260-500 µm).

The variability in spicule complement could be challenging to identify this species. However all spicule types observed and measurements are in concordance with previously published descriptions. The measurement ranges presented in our report include the length values given by

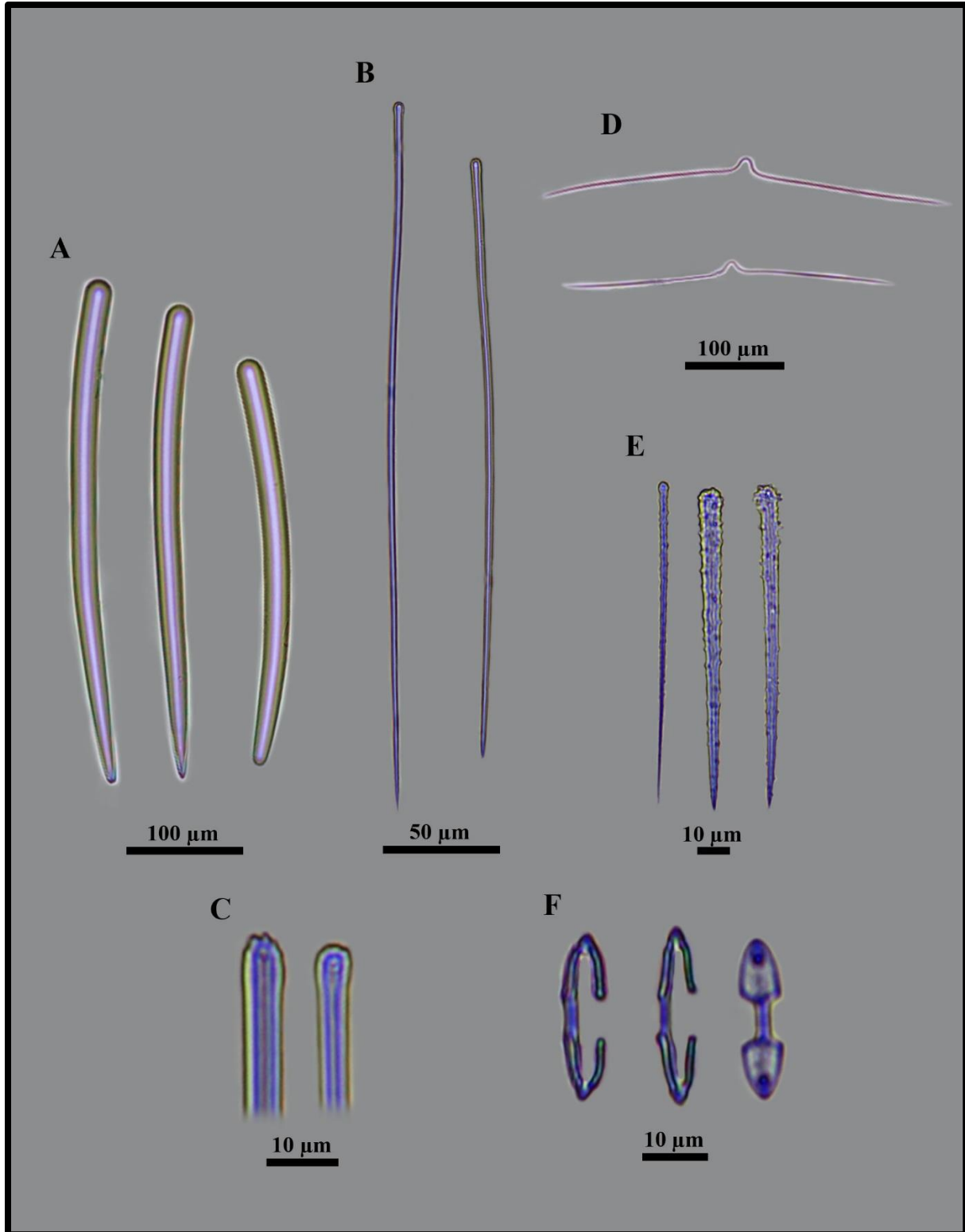
Orueta (1901) for the five different kinds of spicules, and also match measurement ranges given in the most recent publications (Van Soest and Stone, 1986; Ackers et al., 1992). The external morphology that we described is similar to the specimens described by Bowerbank (1866, 1874), but since we were missing the external membrane, the descriptions from Norman (1869) seemed more similar to what we observed.



**Figure 8.** *Clathria (Clathria) barleei* specimen PAA2011-007 Set 5 Col 17 showing opposite surfaces.



**Figure 9.** *Clathria (Clathria) barleei* collection locations.



**Figure 10.** *Clathria (Clathria) barleei* spicules from PAA2011-007 Set 5 Col 17. Styles (A), Subtylostyles (B), Microspined heads of subtylostyles (C), Texas (D), Acanthostyles (E) and Isochelae (F).

**Table 3.** Spicule measurements from specimens of *Clathria (Clathria) barleei* all reported as minimum-(average)-maximum for length and width ( $\mu\text{m}$ ). The number of spicule measurements (n) is specified for each spicule type. The specimen name is a unique ID (cruise, trawl set number, specimen collection number).

Specimen	Styles	Subtylostyles	Toxas	Acanthostyles	Isochelae
PAA2011-007 Set 5 Col 17	356.5-(428.1)-501.0 × 12.9-(16.2)-19.0 n = 30	255.3-(309.7)-455.3 × 3.4-(5.3)-9.2 n = 30	217.4-(314.5)-517.0 × 1.2-(1.9)-2.8 n = 7	100.3-(134.2)-175.3 × 2.4-(6.2)-9.8 n = 7	15.9-(19.0)-22.5 n = 30
PAA2011-007 Set 124 Col 245	350.7-(399.7)-439.4 × 12.6-(16.0)-19.3 n = 10	200.8-(277.3)-328.9 × 3.1-(4.6)-6.0 n = 10	276.9-(384.0)-517.2 × 1.8-(2.3)-2.9 n = 10	84.6-(93.7)-109.7 × 4.4-(5.5)-6.4 n = 10	16.3-(19.2)-22.4 n = 10
PAA2011-007 Set 114 Col 224	339.4-(416.7)-485.1 × 12.1-(14.6)-18.9 n = 10	271.2-(301.9)-329.3 × 3.8-(5.4)-6.6 n = 10	377.5-(535.4)-716.1 × 2.5-(3.3)-4.4 n = 10	Not found	18.0-(19.9)-21.9 n = 10
PAA2011-007 Set 38 Col 123	299.2-(403.2)-485.6 × 9.0-(12.6)-17.2 n = 10	191.5-(256.3)-324.5 × 2.8-(5.1)-7.4 n = 10	268.0-(394.3)-561.9 × 1.4-(2.6)-3.8 n = 10	102.3-(107.7)-113.1 × 5.3-(5.7)-6.1 n = 2	18.4-(19.8)-22.0 n = 10
PAA2013-008 Set 42 Col 151	370.5-(406.1)-450.6 × 12.7-(15.6)-19.0 n = 10	247.1-(286.0)-337.0 × 3.3-(6.6)-8.2 n = 10	272.2-(448.5)-547.4 × 2.1-(2.9)-3.8 n = 10	Not found	17.8-(20.1)-22.3 n = 10

## Descriptions of Family Acarnidae

### *Iophon*

*Iophon piceum* (Vosmaer, 1882)

ITIS TSN 48061 (genus)

WORMS AphiaID 132972

#### Physical description

Our reference specimen of *Iophon piceum* (PAA2011-007 Set 134 Col 319) is approximately 9 cm long by 9 cm wide (Figure 11). The specimen was probably damaged during the collection process, but the wide distal part and the much narrower base lead us to believe that this sponge is caliculate (cup shaped). The colour (after having been frozen) is a yellowish brown, which seems to be darker closer to the base and paler towards the distal extremities. However, the specimens that were preserved in ethanol are of a darker brown colour, almost black on certain parts. The sponge is rough to the touch and the surface is not particularly even as we could observe few ridges going from the base to the extremities. In total, 21 additional specimens were collected during the multispecies trawl surveys and four of them are used as supporting specimens for this species description.

#### Habitat information

Davis Strait at 474-842 m depth (Figure 12).

#### Spicules (Table 4, Figure 13)

Megascleres: The megascleral complement includes acanthostyles and tylotes. Acanthostyles are 290-387  $\mu\text{m}$  long and 11-23  $\mu\text{m}$  wide. They are slightly curved and spiny on their entire surface, but the density of spines could vary along the length (Figure 13A). In most cases, both extremities are more densely spined than the rest of the spicule. Tylotes are 234-306  $\mu\text{m}$  long and 6-14  $\mu\text{m}$  wide. They have microspined heads, but the shaft is thoroughly smooth and slightly curved as well (Figure 13B). Several polytylotic tylotes were observed for some specimens (Figure 13C, from specimen PAA2011-007 Set 152 Col 408).

Microscleres: Length of spurred anisochelae is highly variable, ranging between 15 and 38  $\mu\text{m}$ . Specifically for the reference specimen, numerous measurements were done to determine if the anisochelae belong to two distinct size classes. The majority of the anisochelae measure between 15 and 21  $\mu\text{m}$  (Figure 13G), but much larger anisochelae are also present (approximately 31-38  $\mu\text{m}$ ) (Figure 13H). However, several narrow gaps are detectable along the distribution of our length measurements, which prevent us from drawing clear conclusions. Moreover, the patterns observed were variable between specimens, with gaps in measurements not consistently in the same places for all specimens. Also, the biggest anisochelae found for PAA2014-007 Set 74 Col 129 is no more

than 30  $\mu\text{m}$  long and the specimen PAA2011-007 Set 152 Col 408 has no anisochelae at all. Based on all these observations and the lack of clear pattern, we decided to keep all anisochelae under one size class for our description. Bipocilli are tightly coiled and small (Figure 13E), ranging between 8 and 14  $\mu\text{m}$  with an average length of 11  $\mu\text{m}$ . They are asymmetric (although they could look symmetric under a specific angle, Figure 13F), with one extremity wider than the opposite one. The junction of that wider end with the shaft is typically associated with an indentation in the rim. Fine teeth are easily observed on the rims of bipocilli when spicules are observed on a temporary microscope slide (no mounting media), although it is not the case on our permanent slides with araldite.

### **Distinguishing characteristics**

The presence of bipocilli is a characteristic that belongs to the genus *Iophon* (Hooper, 2002b). The cup-shaped or leaf-shaped growth form as well as the dark colour when it is preserved in ethanol are two characteristics that could be very helpful to visually identify the species *Iophon piceum*. Nevertheless, the spicule complement should be examined and measured in order to confirm identification. The presence of the small and curled bipocilli coupled with the large and thick acanthostyles are distinguishing characteristics of *I. piceum*.

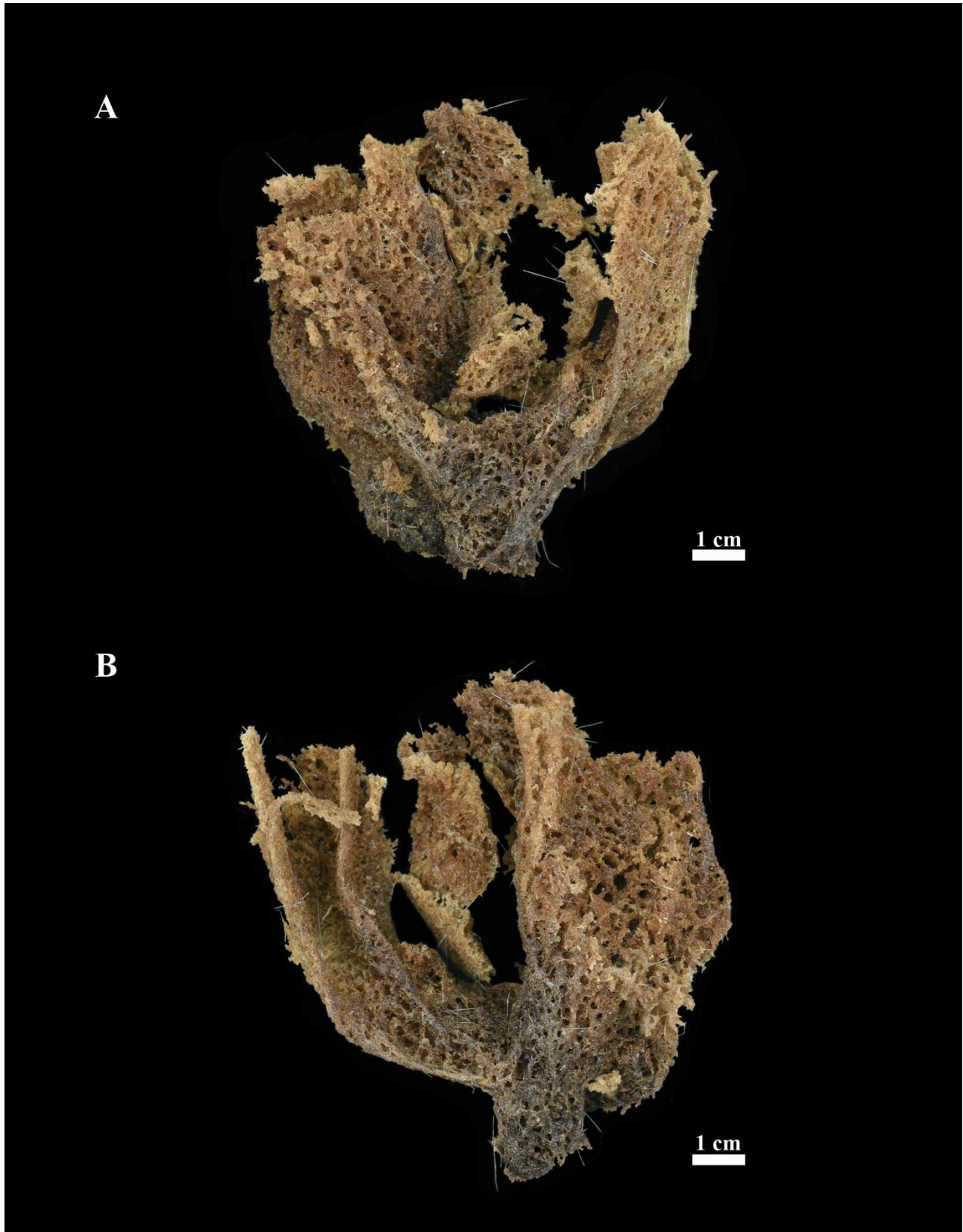
### **Taxonomic remarks**

The original description of this species was written by Vosmaer (1882) under the former species name *Alebion piceum*. The author described and illustrated the sponge as a “cup-shaped great mass of a pitchy colour (in spirit)”. He found the four different spicule types and he gave few details including the average dimensions. Lundbeck (1905) published a detailed redescription efficiently demonstrating the actual variability existing between specimens of this species. Leaf-shaped, irregularly lobate or cup-shaped, the *Iophon piceum* described by Lundbeck (1905) has a surface characterized by undulating or sinuous ridges that separate grooves of varying depth. This is exactly what we observed on our less damaged specimens. In fact, most of our specimens are broken due to their brittle and fragile consistency, also noticed by Lundbeck (1905). The same author described acanthostyles (260-450 x 10-20  $\mu\text{m}$ , from Lundbeck, 1905) that present a curve closer to the head and variable spinulation patterns. The author specified that the spines are often gathered near the acute tip and/or closer to the head, which is also what we observed. Vosmaer (1882) and Lundbeck (1905) both mentioned the variable thickness in the middle of the tylotes (238-298 x 5-11  $\mu\text{m}$ , from Lundbeck, 1905). Lundbeck (1905) also noted how both heads of the tylote are often shaped differently, with one more rounded and swollen than the other. The spurred anisochelae (16-36  $\mu\text{m}$ , from Lundbeck, 1905) and the rounded bipocilli (8-14  $\mu\text{m}$ , from Lundbeck, 1905) with their slight indentation that Lundbeck (1905) detailed in his remarks about the genus are found in our specimens. The absence of anisochelae in the three different spicule preparations (from different parts of the sponge) that we did for our specimen PAA2011-007 Set

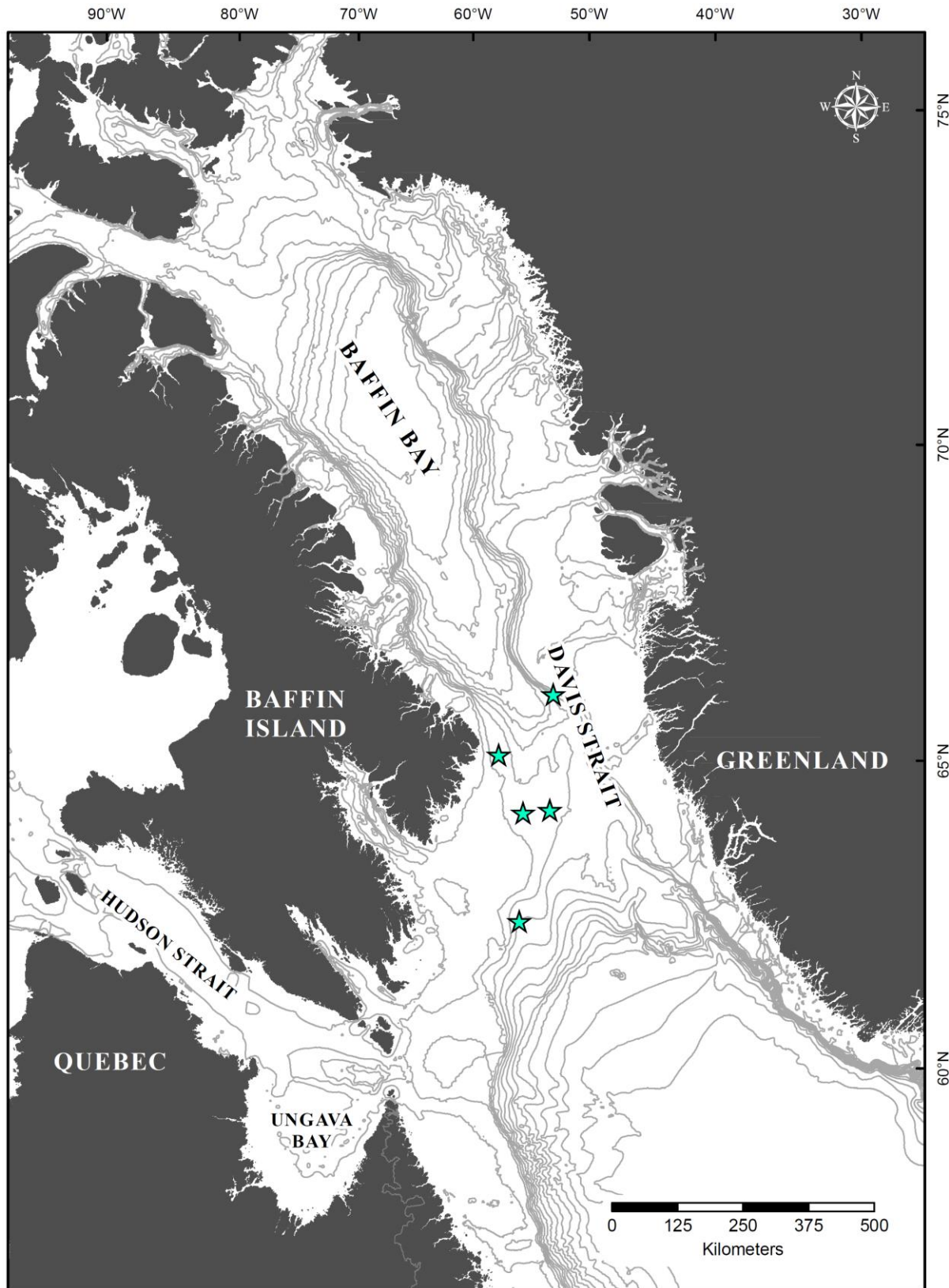


152 Col 408 is definitely surprising and currently unexplained. However, since all other spicules fit with the descriptions of *Iophon piceum*, we are confident that our identification is correct.

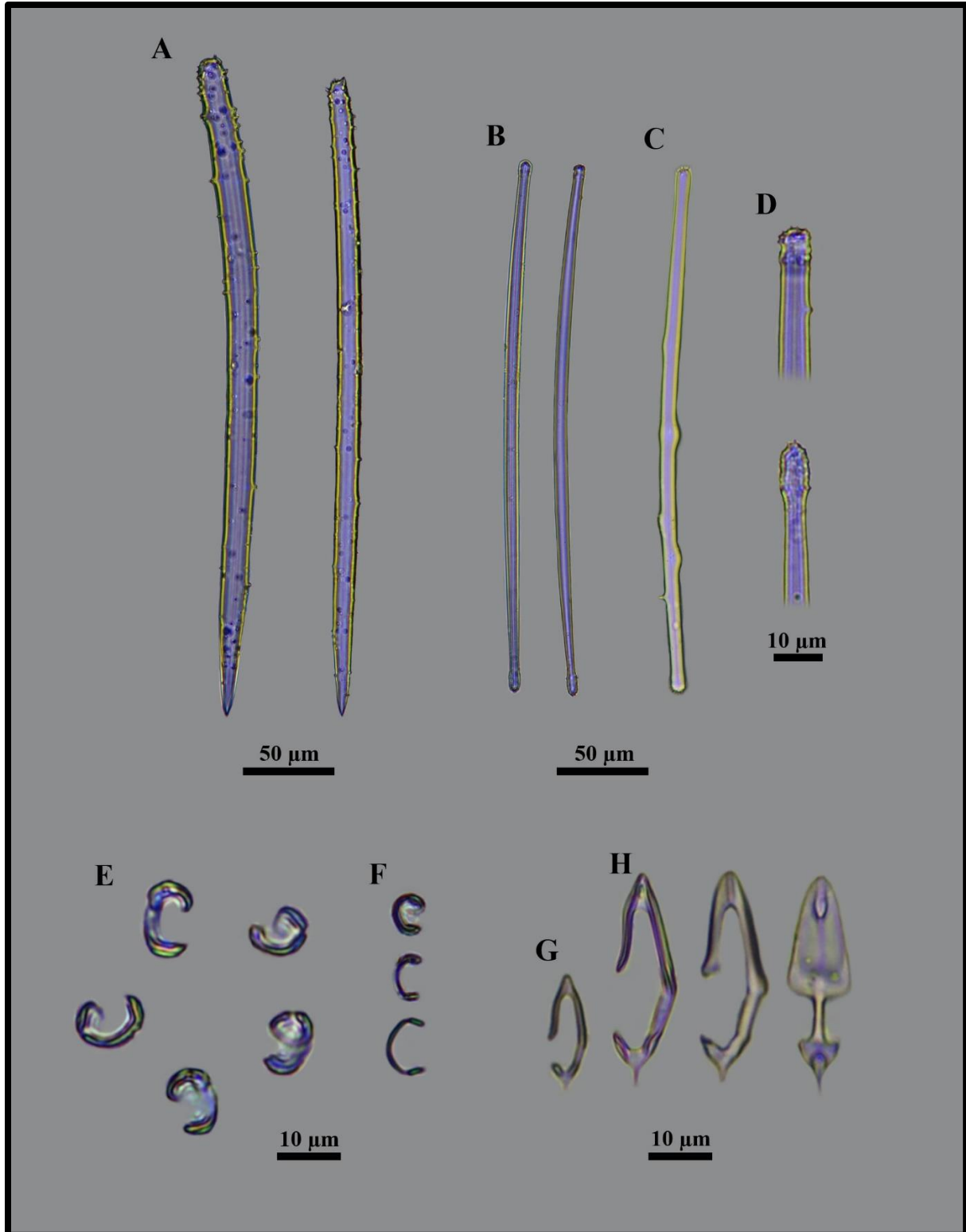
A recent article about Canadian Arctic sponges includes a description of an *Iophon piceum* specimen collected in Frobisher Bay (Dinn et al., 2019). Similarly to our reference specimen (Figure 11), the authors described fragments of what they suspect to be a cup-shaped individual of 10-20 cm in diameter. Their specimen and ours conform perfectly with the descriptions given by Vosmaer (1882) and Lundbeck (1905). However, like Dinn et al. (2019), we noticed the same two details. First, we obtained slightly higher widths than Lundbeck (1905) for megascleres, reaching a maximum of 23  $\mu\text{m}$  instead of 20  $\mu\text{m}$  for acanthostyles and 14  $\mu\text{m}$  instead of 10  $\mu\text{m}$  for tyloles. Second, Lundbeck (1905) found that acanthostyles vary from 260 to 450  $\mu\text{m}$ , whereas our length range was more limited (290-387  $\mu\text{m}$ ). However, Lundbeck (1905) did mention how these values were the extreme limits of the range when several individuals were considered and he observed that it did not vary much within the same specimen. Therefore, our narrow range of length values for acanthostyles could be due to a reduced variability between our specimens, all from the same geographic area (Davis Strait) and depth range. Although Dinn et al. (2019) provided a complete comparison between all currently accepted *Iophon* species reported in the area, a revision of this genus is much needed in order to properly represent the variability within and between the *Iophon* species of the area.



**Figure 11.** *Iophon piceum* specimen PAA2011-007 Set 134 Col 319 showing opposite surfaces.



**Figure 12.** *Iophon piceum* collection locations.



**Figure 13.** *Iophon piceum* spicules from specimen PAA2011-007 Set 134 Col 319 (except C from specimen PAA2011-007 Set 152 Col 408). Acanthostyles (A), Tyloles (B), Polytylotic tylole (C), Tylole heads (D), Bipocilli (E, F), Spurred anisochelae (G, H).

**Table 4.** Spicule measurements from specimens of *Iophon piceum* all reported as minimum-(average)-maximum for length and width ( $\mu\text{m}$ ). The number of spicule measurements (n) is specified for each spicule type. The specimen name is a unique ID (cruise, trawl set number, specimen collection number).

Specimen	Acanthostyles	Tylotes	Anisochelae <sup>1</sup>	Bipocilli
PAA2011-007 Set 134 Col 319	313.1-(347.4)-372.2 × 11.2-(14.2)-17.4 n = 30	258.4-(288.3)-305.2 × 5.5-(8.8)-11.9 n = 30	15.3-37.5 n = 48	10.0-(11.3)-14.1 n = 30
PAA2014-007 Set 74 Col 129	330.6-(348.6)-370.8 × 13.8-(18.4)-18.4 n = 10	244.7-(261.7)-284.8 × 7.4-(11.1)-14.0 n = 10	15.4-29.8 n = 11	9.4-(10.4)-12.2 n = 10
PAA2011-007 Set 155 Col 454	290.3-(346.8)-380.6 × 14.6-(18.1)-22.6 n = 10	252.5-(281.1)-297.2 × 10.1-(11.4)-12.9 n = 10	16.7-33.5 n = 19	9.6-(10.4)-11.0 n = 10
PAA2011-007 Set 152 Col 408	342.7-(366.4)-386.6 × 13.2-(15.6)-17.7 n = 10	259.0-(288.9)-306.0 × 7.9-(8.5)-9.4 n = 10	Not found	8.1-(9.3)-11.8 n = 10
PAA2010-009 Set 147 Col 194	313.9-(336.9)-360.2 × 11.2-(15.9)-18.2 n = 10	234.1-(277.8)-296.7 × 9.1-(10.2)-11.8 n = 10	16.4-33.8 n = 20	9.7-(10.9)-12.5 n = 10

<sup>1</sup> Average values for the length of anisochelae are not displayed because they were biased by our specific search for bigger anisochelae that are more rare.

### Physical description

Our *Iophon koltuni* specimen is limited to one fragment of 6 cm long by 5 cm wide (Figure 14). Along the contours of this specimen, the tissue was torn at some places and, therefore, the growth form is unknown. The surface is porous and seems relatively uniform on one side (Figure 14B), while the other side is more embossed and furrowed but less porous and relatively soft (Figure 14A). The colour (post-freezing) is dark brown.

### Habitat information

Ungava Bay, at 266 m depth (Figure 15).

### Spicules (Table 5, Figure 16)

Megascleres: The acanthostyles are 249-312  $\mu\text{m}$  long and 8-13  $\mu\text{m}$  wide, which makes them much shorter and thinner than those from our *Iophon piceum* specimens (Table 4). Spines seem to be uniformly dispersed along these spicules. However the number of spines could vary (Figure 16A), with few, larger spines often observed on the head of acanthostyles. Tyloles are 249-296  $\mu\text{m}$  long by 8-11  $\mu\text{m}$  wide and have only slightly spined heads (Figure 16B, 16C), although this feature is easily seen through a compound microscope (60X). Some megascleres are slightly curved.

Microscleres: Ranging between 17 and 33  $\mu\text{m}$ , spurred palmate anisochelae are not distinctly split in two size classes according to our findings ( $n = 50$  anisochelae randomly picked and measured). The average length of anisochelae for our specimen is 24  $\mu\text{m}$  long. Bipocilli have long teeth along the rims and are between 13 and 18  $\mu\text{m}$  long. The shaft is elongated and arcuate and a bend is present at mid-length. On average, the thickness at the bend is approximately 2  $\mu\text{m}$ .

### Distinguishing characteristics

The presence of bipocilli is a characteristic that belongs to the *Iophon* genus (Hooper, 2002b). *Iophon koltuni* is different from most *Iophon* species found in the area based on the large bipocilli with elongated teeth. However, the full spicule complement should be examined and measured in order to identify this species. Larger spines on acanthostyle heads seem to also be distinctive to *Iophon koltuni*, although this characteristic was also associated with *Iophon dubium* (Lundbeck, 1905) and therefore might not be a truly unique feature of the recently described species *Iophon koltuni* (Morozov et al., 2019).

### Taxonomic remarks

*Iophon koltuni* is a new species that was described by Morozov et al. in 2019. Their specimens were collected in the Laptev and the Barents seas in shallow waters (92-141 meters). Morozov et al. (2019) described a massive leaf-shaped sponge fragment with an uneven and porous surface and a dark brown colour. They presented the full spicule complement that includes acanthostyles, tylotes with microspined heads, anisochelae and large bipocilli with elongated teeth, including all measurements and SEM images. According to Morozov et al. (2019), the *Iophon (piceus) dubius* (unaccepted) described by Koltun (1959) is a synonym of *Iophon koltuni*, not to be confused with the accepted species *Iophon dubium* described by Hansen (1885) and Lundbeck (1905) which presents smaller bipocilli (Lundbeck, 1905) than *Iophon koltuni*.

A few months later, Dinn et al. (2019) published a paper about the sponge fauna of Frobisher Bay, describing a rich sponge garden of *Iophon koltuni* at 96 m depth. The *in situ* photographs clearly show several specimens with a finger-like growth form. It is noted that the pale yellow colour of the living specimens was in the process of turning dark brown/grey colour following exposure to air. Dinn et al. (2019) described the spicules in detail, pushing the description of *Iophon koltuni* by Morozov et al. (2019) much further. All features described, including the larger spines on acanthostyle' heads and the "large bipocilli with reduced, single, equal-sized alae and elongated teeth", appear to fit with our specimen. Considering the measurements made by Dinn et al. (2019) and Morozov et al. (2019) for *Iophon koltuni*, we conclude that our spicules correspond to the ranges published. However, the tylotes and bipocilli from our specimen are closer to the higher ends of the dimension ranges.

Even if our specimen fits well with the existing descriptions, the exact geometry of our bipocilli is not clearly defined by our images from the compound microscope (60X). We noticed slight variations in the shape of bipocilli, but this could be due to the observation angle or the presence of developmental forms. As shown through SEM images by Dinn et al. (2019), bipocilli of *Iophon koltuni* could have a slightly variable aspect. Morozov et al. (2019) also used SEM images to compare bipocilli of different *Iophon* species. In the future, SEM images would be ideal to properly depict the bipocilli of *Iophon* species. It would strengthen our ability and our confidence in making accurate taxonomic identification.

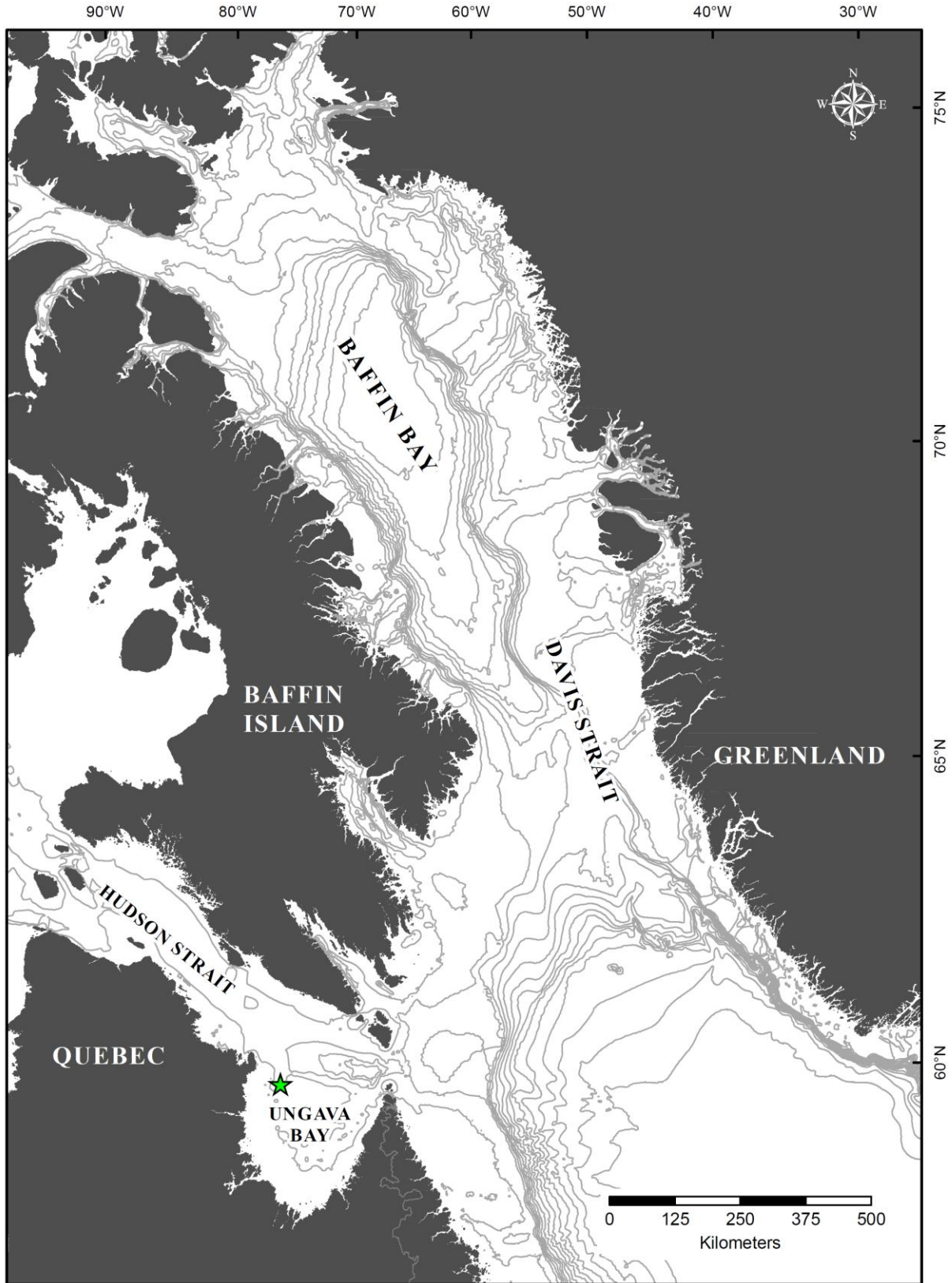
In a recent study, Murillo et al. (2018) described the sponge communities of eastern Canadian Arctic using the same specimens collected in the multispecies trawl surveys. At that time, all of the *Iophon* specimens were identified as *Iophon cf. piceum*. Therefore, following the conclusions of the present report which is based on a more detailed examination of all *Iophon* specimens from our Arctic collections and the new publications from Morozov et al. (2019) and Dinn et al. (2019), it should be noted that the *Iophon cf. piceum* specimens included in the analyses of Murillo et al. (2018) should be considered as *Iophon piceum*. The unique specimen of *Iophon koltuni* from our

Arctic collections was not used in the analysis performed by Murillo et al. (2018), due to an incomplete dataset for that trawl set.

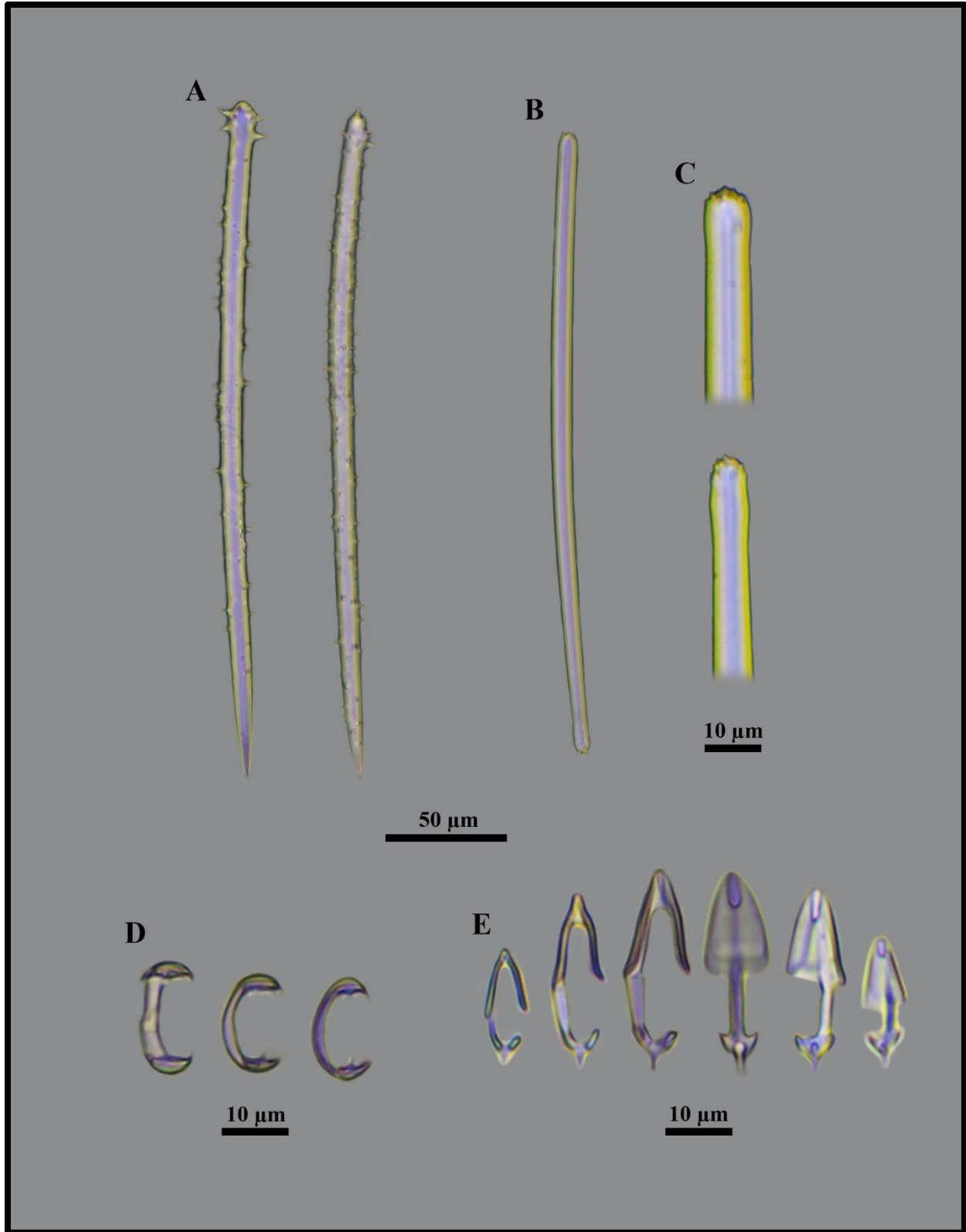




**Figure 14.** *Iophon koltuni* specimen PAA2013-008 Set 92 Col 224 showing opposite surfaces.



**Figure 15.** *Iophon koltuni* collection location.



**Figure 16.** *Iophon koltuni* spicules from PAA2013-008 Set 92 Col 224. Acanthostyles (A), Tylote (B), Tylote heads (C), Bipocilli (D), Spurred anisochelae (E).

**Table 5.** Spicule measurements from the specimen of *Iophon koltuni* all reported as minimum-(average)-maximum for length and width ( $\mu\text{m}$ ). The number of spicule measurements (n) is specified for each spicule type. The specimen name is a unique ID (cruise, trawl set number, specimen collection number).

<b>Specimen</b>	<b>Acanthostyles</b>	<b>Tylotes</b>	<b>Anisochelae</b>	<b>Bipocilli</b>
PAA2013-008 Set 92 Col 224	248.8-(285.5)-311.8 × 8.3-(10.3)-12.8 n = 30	249.1-(272.0)-296.4 × 7.5-(9.1)-10.7 n = 30	16.6-(23.5)-33.2 × 5.1-(7.9)-11.5 n = 50	12.6-(14.7)-17.6 n = 30

## Descriptions of Family Esperiopsidae

### *Semisuberites*

#### *Semisuberites cf. cribrosa* (Miklucho-Maclay, 1870)

ITIS TSN 659440 (genus)

WORMS AphiaID 168379

#### Physical description

Our two only specimens of *Semisuberites cf. cribrosa* (PAA2011-007 Set 80 Col 180) are brown-beige in colour with fouling of the surface visible near the base (Figure 17). The smaller specimen is 4 cm long and the larger is 7 cm long. They have rounded basal stalks less than 0.5 cm in diameter and 1.5 to 2 cm in length. For both specimens, as the stalk ends the sponge body expands, flaring outward and giving the whole sponge a characteristic trumpet-like shape. The surface is smooth and shiny out of water yet hispid from brushes of projecting spicules. The interior surface exposed near the apex is more porous with scattered small pores (less than 1 mm in diameter). The inset of the apex shows the partially exposed sponge interior where the edge of the funnel is folded over (Figure 17).

#### Habitat information

Ungava Bay, at 129 m depth (Figure 18).

#### Spicules (Figure 19, Table 6)

Megascleres: Smooth styles can be subdivided into two size categories (I, II). Styles I are 462-625  $\mu\text{m}$  with a width of 5-12  $\mu\text{m}$  at the midpoint and a width of 6-11  $\mu\text{m}$  just inside the basal end. Styles II are smaller, 176-337  $\mu\text{m}$  long, and more fusiform with the midpoint 6-10  $\mu\text{m}$  wide and the basal end narrower at 5-8  $\mu\text{m}$ . Very thin hair-like and slightly acanthose styles are also present but they are rare and frequently broken. These fine acanthostyles are 2-3  $\mu\text{m}$  wide both at the midpoint and at the basal end. Length measurements (180-476  $\mu\text{m}$ ) likely underestimate the full length since the unbroken acanthostyles were rare.

Microscleres: Absent.

#### Distinguishing characteristics

This species is distinguished from the different *Esperiopsis* species by the absence of microscleres and by having exclusively styles (smooth styles and acanthostyles) for megascleres. Styles II are fusiform in shape, tapering toward the ends, like the styles of *Esperiopsis villosa*. Other sponges from our Arctic collections with exclusively styles are *Phakellia bowerbanki* and *Hymeniacidon* sp. *Semisuberites cf. cribrosa* is distinguished from the *Hymeniacidon* sp. in our collection by

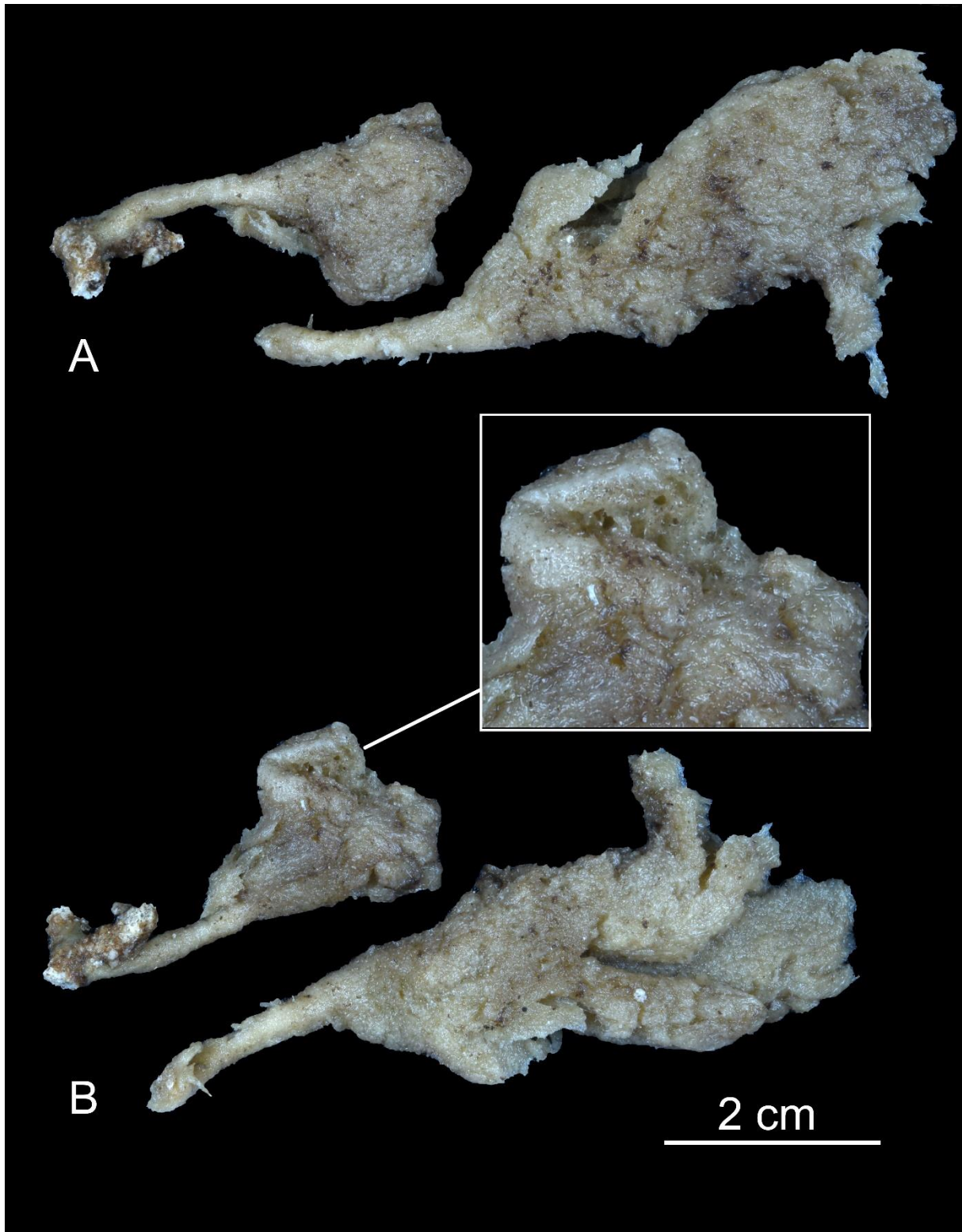
lacking tylote-like swellings on the styles. In *Hymeniacion*, these swellings are often irregular and may project sideways from the style base. *P. bowerbanki* differs from *Semisuberites* cf. *cribrosa* by lacking the hair-like acanthostyles and by having a single size class of styles ~200-300  $\mu\text{m}$ . Morphologically, *P. bowerbanki* and *Axinella arctica* are also trumpet-like in shape but the relatively smooth surface of *S.* cf. *cribrosa* is distinct from the honeycomb-like surface of both *A. arctica* and *P. bowerbanki*.

### **Taxonomic Remarks**

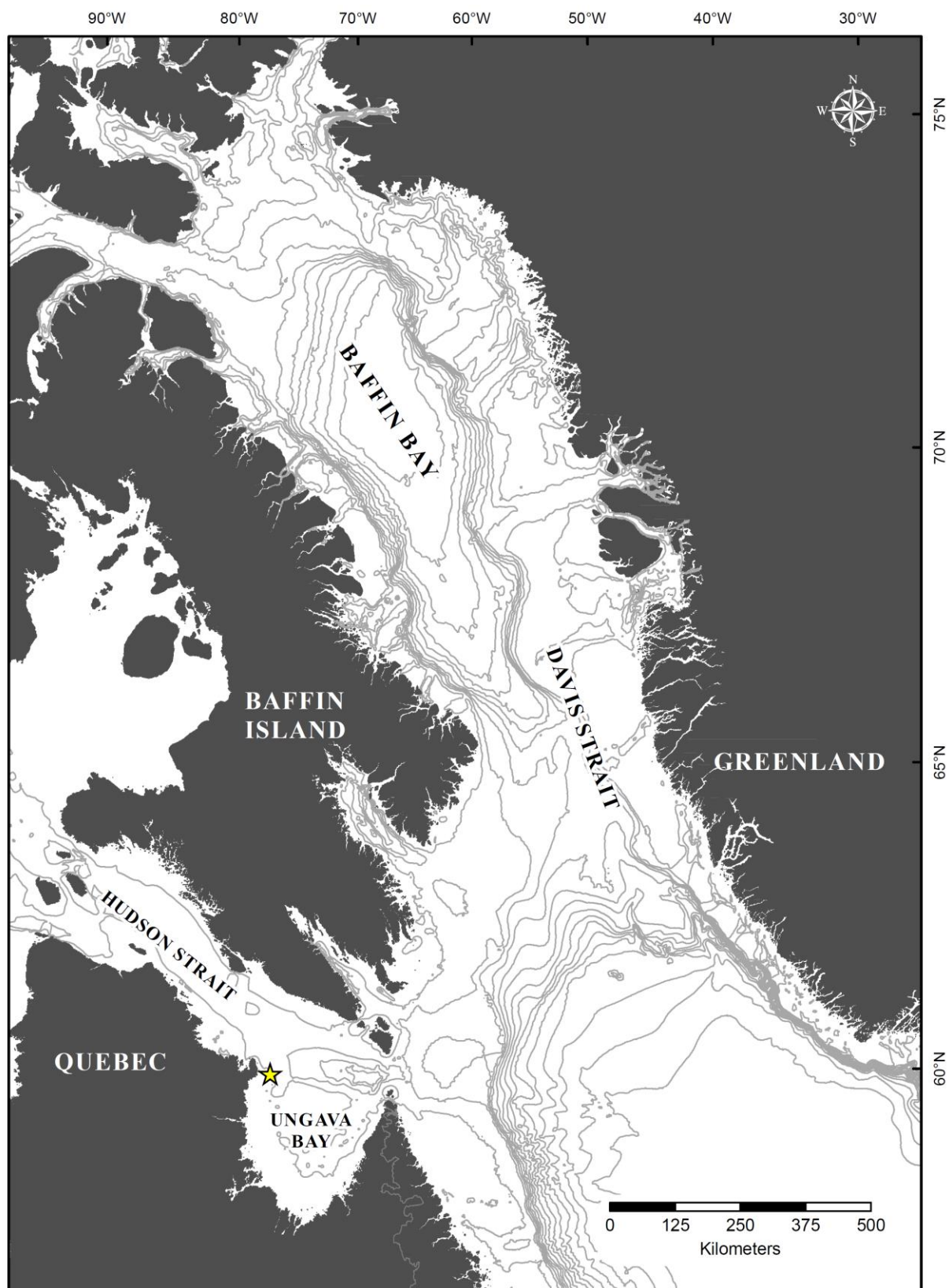
The sponge was first described as *Veluspa polymorpha* var. *cribrosa* by Miklucho-Maclay (1870) – a stemmed sponge which grows in colonies of multiple individuals with stems expanding into flattened plate or funnel-shaped bodies. Details on spicules are missing. Later, Carter (1877) described the same species as *Semisuberites arctica*, n. sp. Like our specimens, the described sponges had round stems giving rise to funnel-shaped bodies. Carter (1877) described a smooth exterior with microscopic pores, and larger canals and pores on the inside of the funnel. Smooth styles were described in two forms: styles up to 1/48<sup>th</sup> inch by 1/30000<sup>th</sup> inch (529 by 8  $\mu\text{m}$ ), gradually tapering to a point, like our styles I, and a second style type with slight terminal inflations (tylote like swellings), like our styles II (Figure 19C and D). Carter (1877) does not distinguish two size classes of styles and did not document the fine acanthostyles observed in our specimen. Many sponge specimens now believed to be *Semisuberites cribrosa* have been described under different names. Van Soest and Hajdu (2002) compiled figures and descriptions of these specimens. Overall, *Semisuberites cribrosa*, the sole accepted species for the genus, is described as a stalked sponge with a funnel-shaped body that has two classes of styles measuring around 200-300  $\mu\text{m}$  and 400-500  $\mu\text{m}$  long, arranged in a loose reticulation with polyspicular tracts.

The thin acanthostyles described in our specimen have not been previously described – although as mentioned, they are very fine and often broken so may have been overlooked in other specimens. We are designating our specimens *Semisuberites* cf. *cribrosa* given the discrepancy between our specimens and those previously described without mention of fine acanthostyles. Given the difference in surface texture (observable in our SEM images but faint in Figure 19F) compared to the styles I and II, we believe that the acanthostyles are a distinct spicule type and therefore are not developing styles.



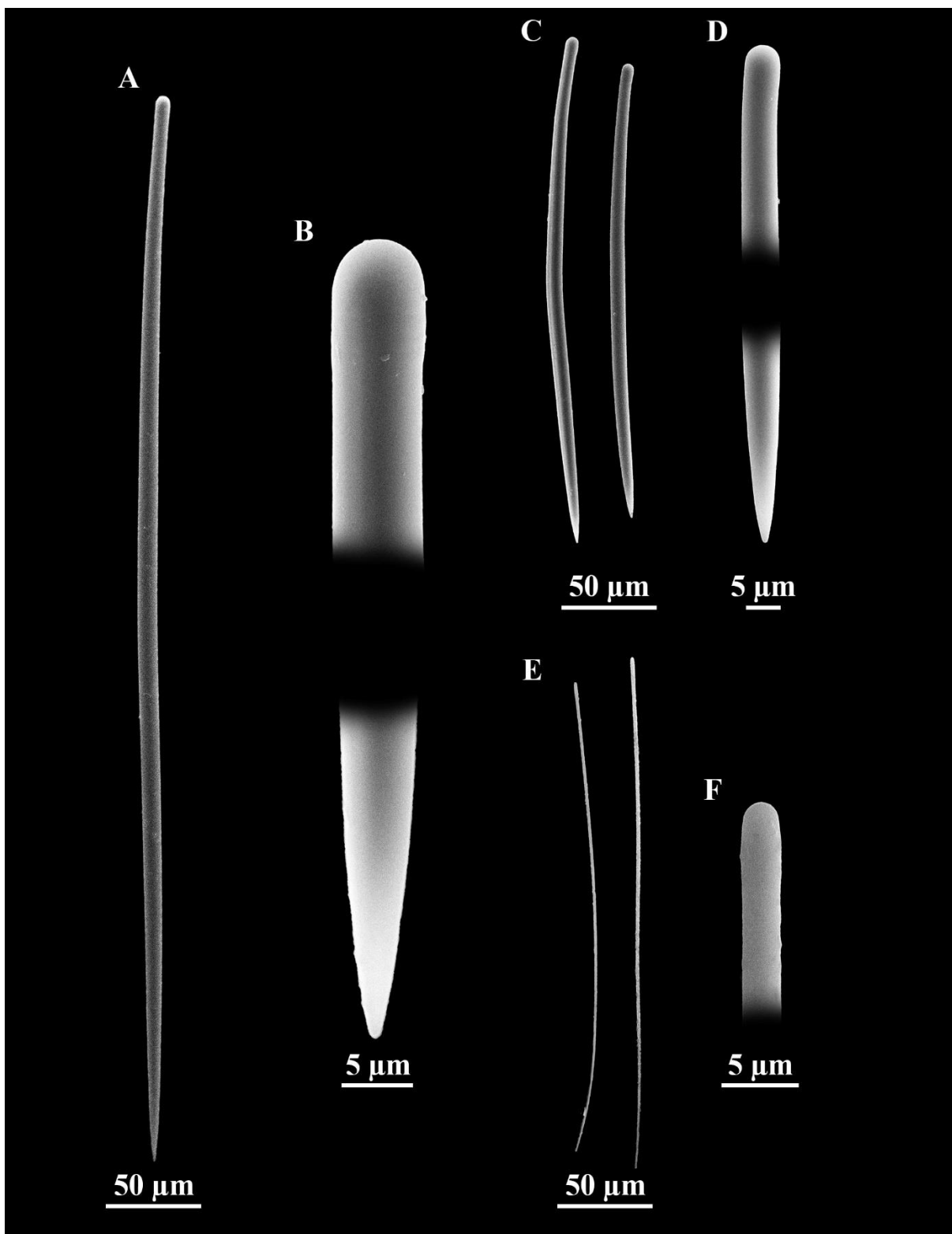


**Figure 17.** *Semisuberites* cf. *cribrosa* specimens PAA2011-007 Set 80 Col 180 showing opposite surfaces. The inset of the apex shows the partially exposed sponge interior where the edge of the funnel is folded over.



**Figure 18.** *Semisuberites cf. cribrosa* collection location.





**Figure 19.** *Semisuberites cf. cribrosa* spicules from specimens PAA2011-007 Set 80 Col 180. Style I full spicule (A) and end detail (B), Styles II full spicules (C) and end detail (D), Thin acanthostyles full spicules (E) and end detail (F).

**Table 6.** Spicule measurements from a specimen of *Semisuberites cf. cribrosa* all reported as minimum-(average)-maximum for length and width ( $\mu\text{m}$ ). Width was measured at the midpoint (mid) and also at the basal end (base) of the spicules. The number of spicule measurements (n) is specified for each spicule type. The specimen name is a unique ID (cruise, trawl set number, specimen collection number). Note that the acanthostyles were typically broken and therefore the given range is an underestimate of the true length.

<b>Specimen</b>	<b>Styles I</b>	<b>Styles II</b>	<b>Thin Acanthostyles</b>
PAA2011-007 Set 80 Col 180	461.8-(524.2)-625.0 × 5.3-(9.8)-11.7 (mid) × 5.5-(8.0)-11.2 (base) n = 30	176.3-(260.1)-336.6 × 6.1-(7.8)-9.7 (mid) × 5.0-(6.4)-7.8 (base) n = 30	180.2-(279.0)-476.2 × 1.8-(2.6)-3.3 (mid) × 1.9-(2.4)-3.0 (base) n = 10

*Esperiopsis*

ITIS TSN 48240

*Esperiopsis villosa* (Carter, 1874)

WORMS AphiaID 133272

**Physical description**

Our reference specimen for *Esperiopsis villosa* (PAA2014-007 Set 150 Col 394) is approximately 11 cm long by 9 cm wide (Figure 20). The sponge is beige to brown or grey in colour. It is massive and lobate, with a fibrous consistency including well defined, dense spicule tracts that branch, then rejoin and finally end at the surface in tufts of projecting spicules, giving the sponge a shaggy appearance. In some specimens, the membranous surface tissue is partially intact with visible oscules. In total, six additional specimens were collected during the multispecies trawl surveys and three of them are used as supporting specimens for this species description.

**Habitat Information**

Davis Strait and south of Baffin Bay at 516-782 m depth (Figure 21).

**Spicules (Table 7, Figure 22)**

Megascleres: Smooth and straight mycalostyles (Figure 22A) are present in a single size class ranging from 546 to 787  $\mu\text{m}$  in length and 14 to 24  $\mu\text{m}$  in width at the midpoint. Styles taper toward the ends where the width just inside the base is 10-18  $\mu\text{m}$ . The basal ends may be subtylote with a slight terminal swelling. Additionally, thinner shorter styles with a uniform width are present in a few specimens but may be contaminants. These thinner and smaller styles are excluded from Table 7 and Figure 22. In specimen PAA2014-007 Set 150 Col 394, these styles are 305-373  $\mu\text{m}$  long and 3-5  $\mu\text{m}$  wide at the midpoint ( $n = 10$ ).

Microscleres: Sigmas (Figure 22B) span a large size range: 52-204  $\mu\text{m}$  long and 3-16  $\mu\text{m}$  wide (width of the shaft). Sigmas under 100  $\mu\text{m}$  are more abundant. Very thin sigmas are present in some specimens and are possibly developmental forms. Palmate isochelae occur in three distinct shapes that roughly correspond to three size categories. Isochelae I (Figure 22C) are 65-119  $\mu\text{m}$  long with a shaft 3-13  $\mu\text{m}$  wide. The distinct morphology of isochelae I may be a distinguishing characteristic. The shaft is straight and gives rise to a single long, narrow, spatula-shaped alae on each end. Uniquely, the alae are fringed by fine teeth that project diagonally away from the end of each ala, giving the isochelae a serrated appearance. Similarly, the edges of the shaft are serrated, starting along the thin edges that emerge from the sides of shaft, away from the midpoint. These serrated edges are visible at high magnification (400X or higher) in both light and electron microscopy. To confirm that a given chela belongs to this category, it is necessary to confirm the presence of serrated edges, particularly given that these isochelae overlap in size with isochelae II (Figure 22D and E). We also observed very thin forms with more hook-like alae without serration.

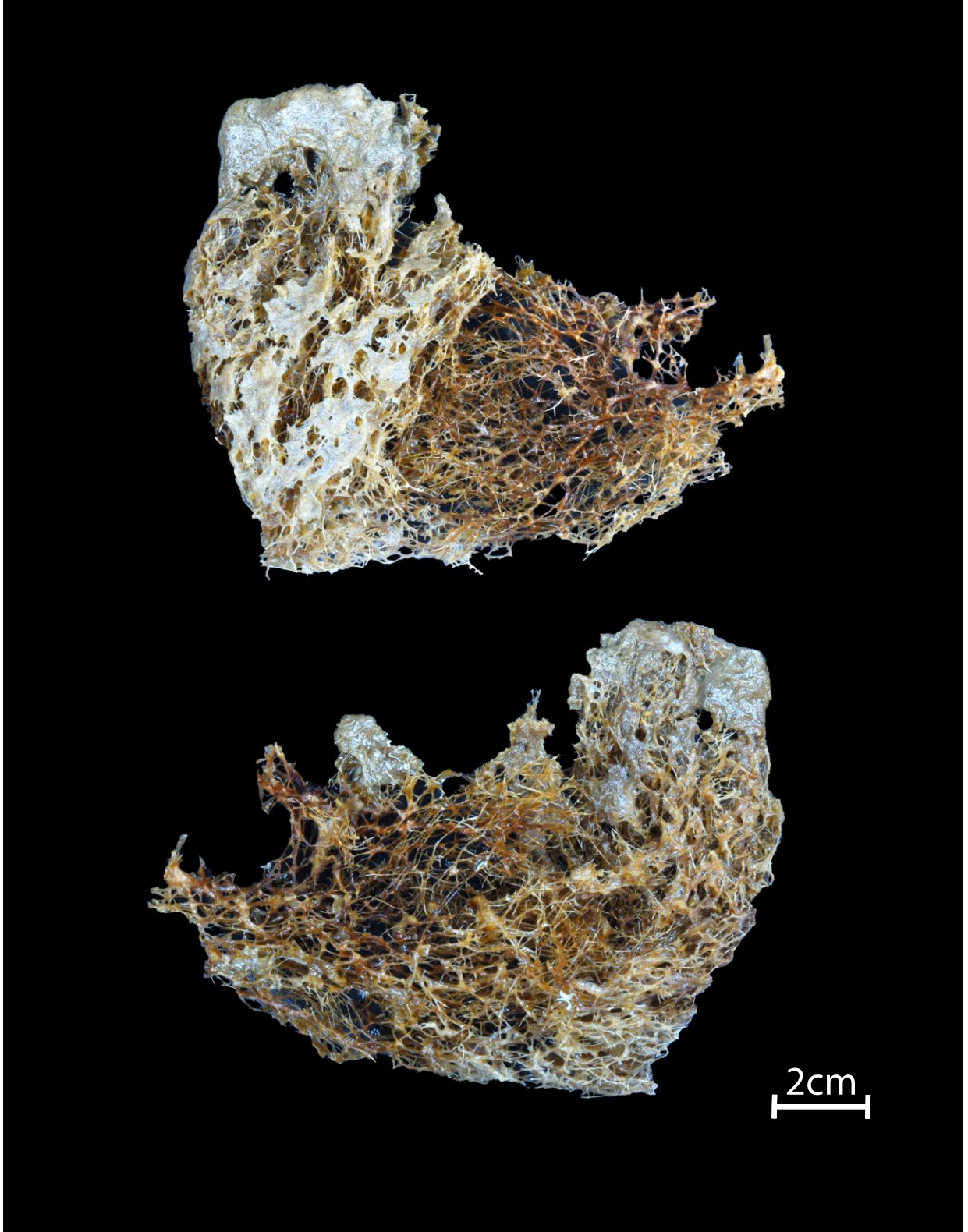
Given the matching size range and similar overall shape, these may be developmental forms of isochelae I. Isochelae II (Figure 22D and E) also have a straight shaft, but the alae are shorter, more robust and triangular in shape, with smooth edges. Isochelae II are 29-91  $\mu\text{m}$  long with a shaft width of 1-7  $\mu\text{m}$ . Note that in our reference specimen PAA2014-007 Set 150 Col 394 the average size for isochelae II is smaller. This reflects a larger number of small isochelae II in the prepared slides for this specimen. The smallest isochelae of *E. villosa* are the isochelae III (Figure 22F) with a length of 16-35  $\mu\text{m}$ . They have a curved shaft, giving the isochelae an arched profile.

### **Distinguishing characteristics**

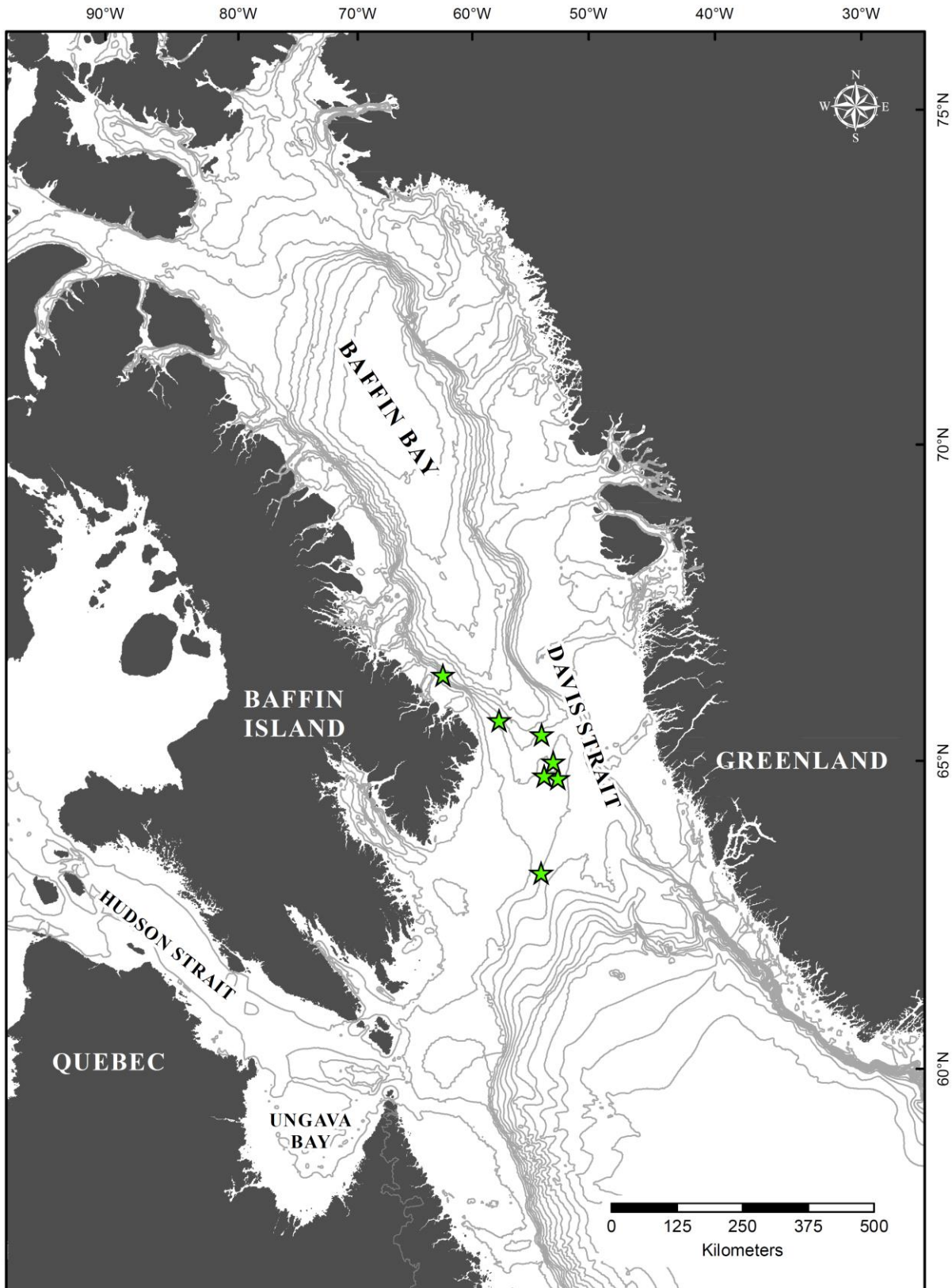
This species may be recognizable by its dense spicule tracts which branch, rejoin and project from the membranous surface. However, some sponges in the family Mycalidae, including *Mycale lingua*, have a similar appearance. The analysis of the spicule complement is required to identify this species. *Esperiopsis villosa* has fusiform styles (546-787  $\mu\text{m}$ ), sigmas in a broad size range (52-204  $\mu\text{m}$ ) and three types of morphologically distinct isochelae previously described, including a larger fringed isochelae type (isochelae I) which is quite distinct according to our knowledge.

### **Taxonomic remarks**

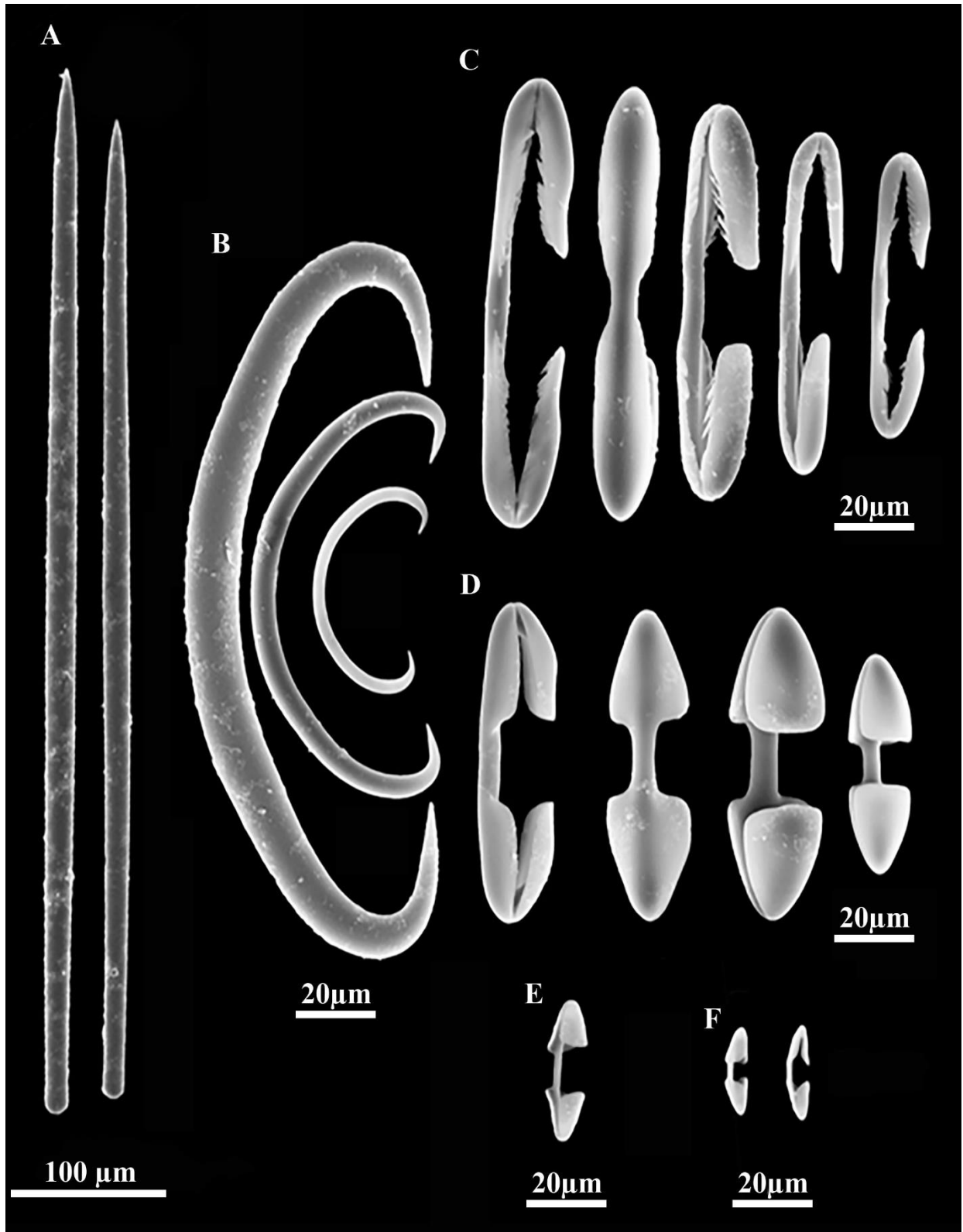
This species was originally described as *Esperia villosa* by Carter (1874). Lundbeck (1905) redescribed the same specimen as *Esperiopsis villosa*. Our description is consistent with Lundbeck's but we add details of spicule morphology including the presence of fine, tooth-like fringes along the shafts and alae of the isochelae I. Lundbeck (1905) described the species as a massive lobate sponge with a partial dermal membrane, a villous surface, irregularly scattered oscules and a fibrous consistency, much like the appearance of our specimens. Matching the fusiform styles that we observed, Lundbeck (1905) described smooth styles with constricted necks and slightly thicker centers. He also noted skinny smooth styles, skinny sigmas and tiny isochelae as developmental forms. The following measurements were reported by Lundbeck (1905) and overlap in size with our *Esperiopsis villosa*: Styles 560-670  $\times$  10-20  $\mu\text{m}$ , sigmas 50-193  $\mu\text{m}$ , long and narrow isochelae with recurved alae 83-113  $\mu\text{m}$ , short and wide isochelae 50-83  $\mu\text{m}$ , smaller isochelae 23-28  $\mu\text{m}$ . He noted the exceptionally large sigmas, listing them as a distinguishing characteristic for the species. Our measurements were very similar but with larger size ranges. Lundbeck (1905) also notes that, although the smallest isochelae (our isochelae III) have curved shafts and the medium class (our isochelae II) have straight shafts, there are additionally small isochelae with straight shafts. Lundbeck (1905) interpreted these small straight-shafted isochelae as transitional forms. We assume these transitional isochelae described by Lundbeck (1905), match our isochelae II in the lower end of the size range (Figure 22E). Smaller isochelae II are difficult to distinguish from isochelae III, and the distinction between the two in this report may be artificial.



**Figure 20.** *Esperiopsis villosa* specimen PAA2014-007 Set 150 Col 394 showing opposite surfaces.



**Figure 21.** *Esperiopsis villosa* collection locations.



**Figure 22.** *Esperioipsis villosa* spicules from specimen PAA2014-007 Set 150 Col 394. Styles I (A), Sigmas (B), Isochelae I (C), Isochelae II (D, E), Isochelae III (F).

**Table 7.** Spicule measurements from specimens of *Esperiopsis villosa* all reported as minimum-(average)-maximum for length and width ( $\mu\text{m}$ ). For the styles, width was measured at the midpoint (mid) and also at the basal end (base) of the spicules. The number of spicule measurements (n) is specified for each spicule type. The specimen name is a unique ID (cruise, trawl set number, specimen collection number).

<b>Specimen</b>	<b>Styles</b>	<b>Sigmas</b>	<b>Isochelae I</b>	<b>Isochelae II</b>	<b>Isochelae III</b>
PAA2014-007 Set 150 Col 394	562.2-(696.5)-771.4 × 16.4-(20.7)-23.7 (mid) × 13.0-16.0-18.3 (base) n = 30	55.7-(125.1)-203.7 × 3.6-(8.5)-14.6 n = 40	66.8-(102.9)-119.1 × 3.3-(5.25)-7.0 n = 30	29.2-(48.9)-90.8 × 1.4-(3.1)-6.1 n = 30	19.8-(24.1)-35.4 × 1.0-(1.5)-2.4 n = 30
PAA2014-007 Set 63 Col 97	563.0-(697.1)-786.5 × 15.0-(18.5)-21.4 (mid) × 11.2-(14.4)-18.2 (base) n = 30	58.4-(102.8)-190.5 × 4.3-(7.7)-15.9 n = 42	89.7-(102.1)-114.3 × 5.8-(7.2)-12.8 n = 18	43.8-(63.8)-88.7 × 3.2-(5.1)-7.3 n = 10	23.5-(28.0)-32.0 × 1.6-(2.0)-2.6 n = 10
PAA2011-007 Set 168 Col 509	545.8-(620.3)-709.3 × 15.0-(18.6)-22.3 (mid) × 12.5-(14.8)-18.2 (base) n = 30	51.5-(93.6)-187.2 × 3.4-(6.5)-14.8 n = 67	65.0-(88.9)-104.5 × 3.6-(5.4)-7.2 n = 38	46.9-(64.7)-89.1 × 2.7-(4.9)-7.2 n = 22	15.5-(26.5)-33.5 × 1.6-(2.0)-2.6 n = 23
PAA2011-007 Set 163 Col 484	575.8-(636.5)-676.8 × 14.4-(18.2)-21.7 (mid) × 10.0-(14.1)-16.7 (base) n = 10	57.8-(79.0)-193.4 × 3.8-(6.0)-15.4 n = 30	73.0-(93.4)-110.8 × 3.7-(4.8)-5.7 n = 11	39.1-(55.9)-74.6 × 2.8-(4.3)-6.7 n = 13	21.4-(23.9)-27.8 × 1.6-(1.8)-1.9 n = 10



### Physical description

The only specimen of *Esperiopsis* sp. 1 (PAA2010-009 Set 115 Col 556) in our collection consists of two small fragments that are brown in colour and resemble spicule clumps (Figure 23). The fragments were picked from a bag with several other sponges from a single trawl set.

### Habitat information

Davis Strait at 782 m depth (Figure 24).

### Spicules (Figure 25, Table 8)

Megascleres: For this specimen, the straight pencil-like styles are 381-416  $\mu\text{m}$  long by 5-12  $\mu\text{m}$  wide at the midpoint. Styles may have a slight swelling at the basal end, but are otherwise uniform in width until abruptly tapering to a fine drawn-out point. Thinner, gradually tapering styles are also present, but rare.

Microscleres: Three types of sigmas are present. Sigmas I are large, ranging from 162-254  $\mu\text{m}$  in length and 6-16  $\mu\text{m}$  in width. Interestingly, some of these sigmas were very sparsely acanthose with one or more small spines observed on many. Sigmas II are horseshoe-shaped with recurved ends. Their shaft at the midpoint was 2-7  $\mu\text{m}$  wide. The length of sigmas II was measured in two ways: the distance between the centre of the sigma shaft and the most distal location on a single arm of the sigma (41-111  $\mu\text{m}$ ) and the longest distance from the outside of one arm to the outside of the other arm (51-117  $\mu\text{m}$ ). Sigmas III were rare and 14-20  $\mu\text{m}$  long with a width of  $\sim 1$   $\mu\text{m}$  or smaller. Three size classes of palmate isochelae are present. Isochelae I (81-101  $\mu\text{m}$  long by 5-13  $\mu\text{m}$  wide) and isochelae II (55-75  $\mu\text{m}$  long by 3-8  $\mu\text{m}$  wide) were similar in shape to the isochelae II of *Esperiopsis villosa*, with a straight shaft giving rise to alae with smooth margins and rounded triangular alae. Isochelae III of *Esperiopsis* sp. 1 appear similar to the isochelae III in *Esperiopsis villosa*. This third size class of isochelae is the smallest, measuring 22-31  $\mu\text{m}$  long by 1-3  $\mu\text{m}$  wide with an arched appearance in profile. Trichodragmas are abundant in the two fragments that we inspected and individual raphides within were  $< 20$   $\mu\text{m}$  long.

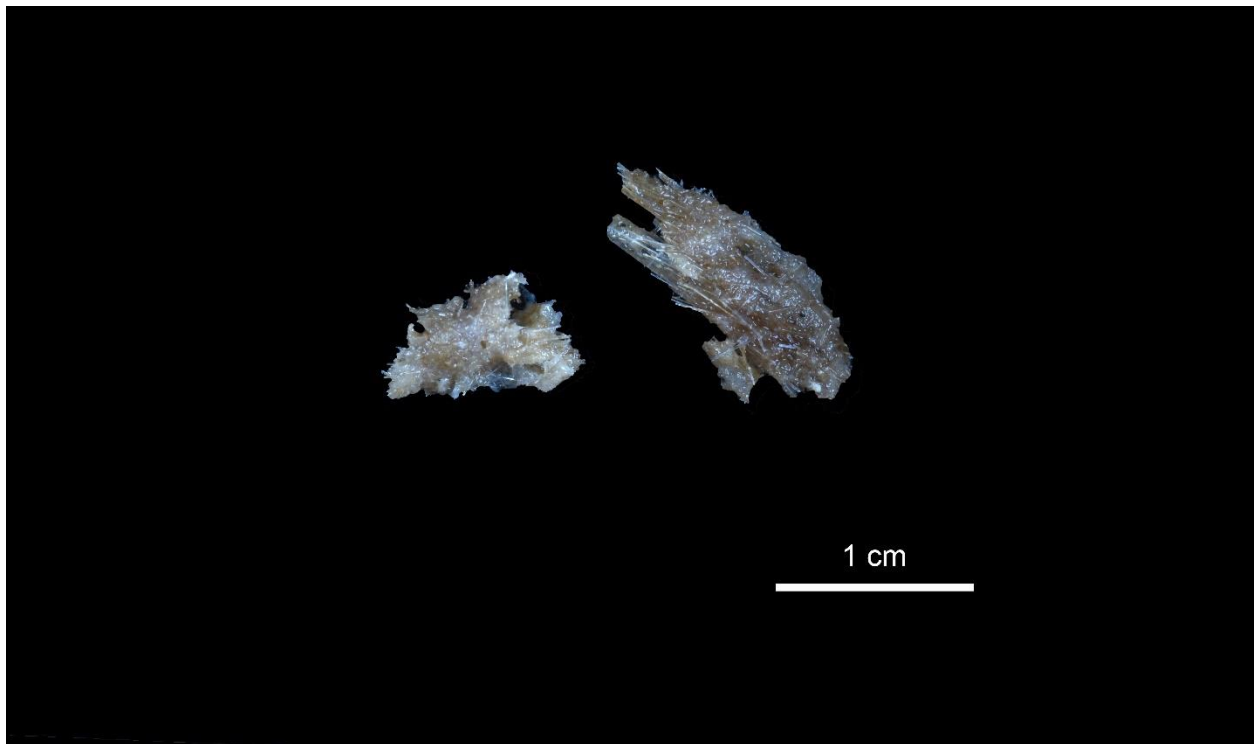
### Distinguishing characteristics

Morphologically, the two fragments were indistinct with an appearance similar to spicule clumps. However, the spicule complement was fairly consistent throughout, implying that it is not a random collection of spicules. This sponge is distinguished by styles with sharply tapering ends and drawn out points, three types of sigmas including the distinct horseshoe-shaped sigmas II with recurved ends, and three size classes of palmate isochelae. Trichodragmas were present as well.

Comparison with other samples of the same sponge species will be necessary to determine which, if any, spicule types are contaminants.

### Taxonomic remarks

While the styles in this specimen lack the fusiform shape of *E. villosa* and *S. cf. cribrosa*, the combination of styles, sigmas and multiple size classes of palmate isochelae is consistent with *Esperiopsis*. Like *Esperiopsis* sp. 1, *E. variussigma* is described as having no distinguishable surface details, and also has 330-485  $\mu\text{m}$  long styles with slightly swollen ends that are fairly constant along their length but sharply pointed. Furthermore, the compressed sigmas described by Hoshino (1981) match our horseshoe-shaped sigmas II, and like *Esperiopsis* sp. 1, multiple sizes of isochelae are reported for *E. variussigma*. However, in *E. variussigma*, size classes corresponding to our sigmas III and isochelae III are not found. Further comparison of *Esperiopsis* sp. 1 with published *Esperiopsis* species is underway and needed to determine if *Esperiopsis* sp. 1 is a unique species. Comparison with additional specimens is also needed to determine if any of the spicules reported here are contaminants.



**Figure 23.** *Esperiopsis* sp. 1 specimen PAA2010-009 Set 115 Col 556.

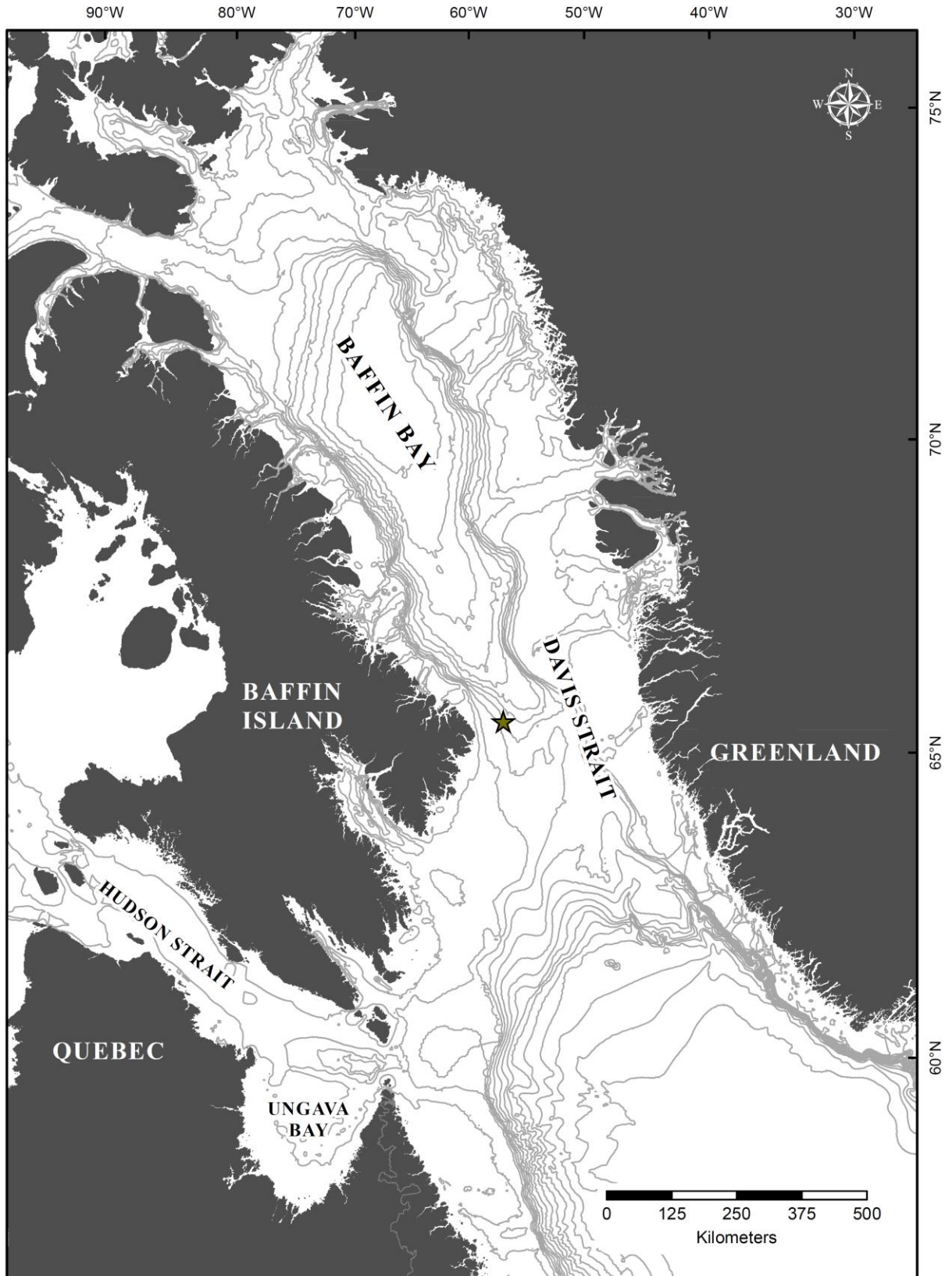
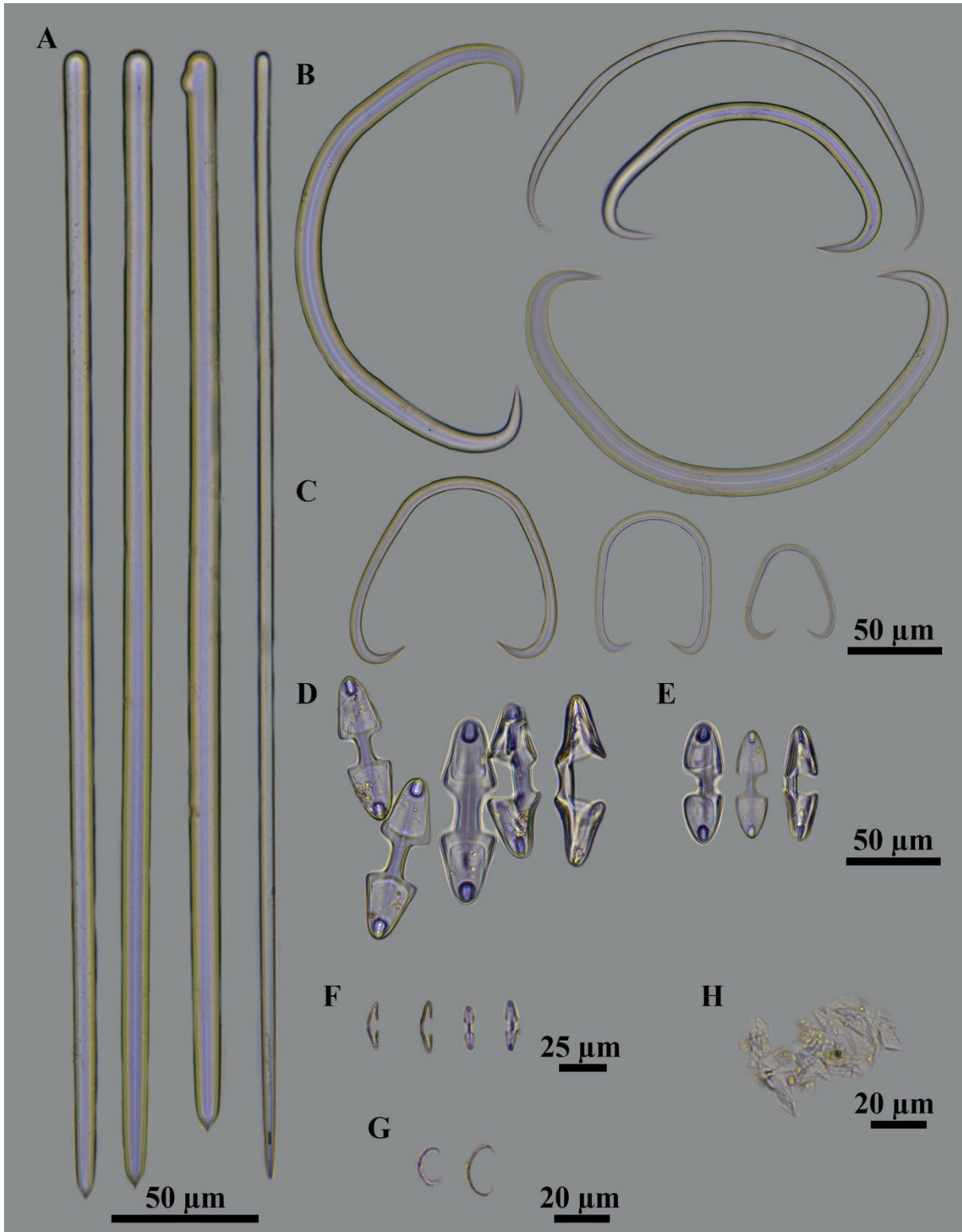


Figure 24. *Esperiopsis* sp. 1 collection location.



**Figure 25.** *Esperlopsis* sp. 1 spicules from specimen PAA2010-009 Set 115 Col 556. Styles (A), Sigmas I (B), Recurved Sigmas II (C), Isochelae I (D), Isochelae II (E), Isochelae III (F), Sigmas III (G), Trichodragmas (H)..

**Table 8.** Spicule measurements from a specimen of *Esperiopsis* sp. 1 all reported as minimum-(average)-maximum for length and width ( $\mu\text{m}$ ). For the styles, width was measured at the midpoint (mid) and also at the basal end (base) of the spicules. The length for sigmas II was measured in two ways: the distance between the centre of the sigma shaft and the most distal location on a single arm of the sigma (41 to 111  $\mu\text{m}$ ) and the longest distance from the outside of one arm to the outside of the other arm (51-117  $\mu\text{m}$ ). The number of spicule measurements (n) is specified for each spicule type. The specimen name is a unique ID (cruise, trawl set number, specimen collection number).

<b>Specimen</b>	<b>Styles</b>	<b>Sigmas I</b>	<b>Sigmas II</b>	<b>Sigmas III</b>
PAA2010-009 Set 115 Col 556	381.2-(352.3)-416.3 × 5.1-(9.2)-11.6 (mid) × 5.7-(10.6)-5.9 (base) n = 34	161.5-(220.0)-254.2 × 5.7-(13.3)-16.0 n = 30	50.9-(80.2)-117.0 40.9-(62.4)-111.0 × 1.8-(4.5)-6.8 n = 18 (rare)	13.8-(16.0)-20.2 n = 10 (rare)
<b>Specimen</b>	<b>Isochelae I</b>	<b>Isochelae II</b>	<b>Isochelae III</b>	
PAA2010-009 Set 115 Col 556	80.5-(91.2)-100.9 × 5.0-(8.5)-13.1 n = 30	55.4-(63.63)-74.5 × 2.8-(5.7)-7.6 n = 30	22.4-(25.9)-30.9 × 1.2-(2.0)-2.9 n = 30	

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## REFERENCES

- Ackers, R.G., Moss, D., Picton, B.E. 1992. Sponges of the British Isles ("Sponges V"). A Colour Guide and Working Document. Marine Conservation Society. 1-175.
- Baker, E., Odenthal, B., Tompkins, G., Walkusz, W., Siferd, T., Kenchington, E. 2018a. Sponges from the 2010-2014 Paamiut multispecies trawl surveys, eastern Arctic and Subarctic: Class Demospongiae, Subclass Heteroscleromorpha, Order Poecilosclerida, Families Crellidae and Myxillidae. *Can. Tech. Rep. Fish. Aquat. Sci.* 3253: iv + 52 p.
- Baker, E., Odenthal, B., Walkusz, W., Siferd, T., Ríos, P., Tompkins, G., Kenchington, E. 2018b. Sponges from the 2010-2014 Paamiut multispecies trawl surveys, eastern Arctic and Subarctic: Class Demospongiae, Subclass Heteroscleromorpha, Order Poecilosclerida, Families Dendoricellidae and Tedaniidae. *Can. Tech. Rep. Fish. Aquat. Sci.* 3282: v + 46 p.
- Beazley, L.I., Kenchington, E.L., Murillo, F.J., Sacau, M. 2013. Deep-sea sponge grounds enhance diversity and abundance of epibenthic megafauna in the Northwest Atlantic. *ICES J. Mar. Sci.* 70: 1471-1490.
- Beazley, L., Kenchington, E., Yashayaev, I., Murillo, F.J. 2015. Drivers of epibenthic megafaunal composition in the sponge grounds of the Sackville Spur, Northwest Atlantic. *Deep-Sea Res. PT. I* 98: 102-114.
- Boury-Esnault, N., Van Beveren, M. 1982. Les Démosponges du plateau continental de Kerguelen-Heard. *Comité national français des recherches antarctiques.* 52: 1-175.

- Bowerbank, J.S. 1866. A Monograph of the British Spongiadae, Volume 2. Ray Society, London. i-xx, 1-388.
- Bowerbank, J.S. 1874. A Monograph of the British Spongiadae, Volume 3. Ray Society, London. i-xvii, 1-367, pls I-XCII.
- Cárdenas, P., Perez, T., Boury-Esnault, N. 2012. Sponge systematics facing new challenges. *Adv. Mar. Biol.* 61: 79-209.
- Carter, H.J. 1874. Descriptions and figures of deep-sea sponges and their spicules from the Atlantic Ocean, dredged up on board H.M.S. 'Porcupine', chiefly in 1869; with figures and descriptions of some remarkable spicules from the Agulhas Shoal and Colon, Panama. *Ann. Mag. Nat. Hist.* (4) 14 (79): 207-221, 245-257, pls. XIII-XV.
- Carter, H.J. 1875. Notes introductory to the study and classification of the Spongida, Part II., Proposed classification of the Spongida. *Ann. Mag. Nat. Hist.* 4: 126-145.
- Carter, H.J. 1877. Arctic and Antarctic sponges &c. *Annals and Magazine of Natural History.* (4) 20(115): 38-42, pl. I.
- Dendy, A. 1922. Report on the Sigmatotetragonida collected by H.M.S. 'Sealark' in the Indian Ocean. *In Reports of the Percy Sladen Trust Expedition to the Indian Ocean in 1905, Volume 7. Transactions of the Linnean Society of London.* 18(1): 1-164, pls 1-18.
- Dinn, C., Edinger, E., Leys, S.P. 2019. Sponge (Porifera) fauna of Frobisher Bay, Baffin Island, Canada with the description of an *Iophon* rich sponge garden. *Zootaxa* 4576(2): 301-325.
- Fristedt, K. 1887. Sponges from the Atlantic and Arctic Oceans and the Behring Sea. *Vega-Expeditionens Vetenskap, Iakttagelser (Nordenskiöld).* 4: 401-471, pls 22-31.
- Gray, J.E. 1867. Notes on the arrangement of sponges, with the descriptions of some new genera. *P. Zool. Soc. Lond.* 1867(2): 492-558, pls XXVII-XXVIII.
- Hajdu, E., Desqueyroux-Faúndez, R., Willenz, P. 2006. *Clathria (Cornulotrocha) rosetafiordica* sp.nov. from a south-east Pacific fjord (Chilean Patagonia) (Microcionidae: Poecilosclerida: Demospongiae: Porifera). *J. Mar. Biol. Assoc. UK.* 86(5): 957-961. DOI: 10.1017/S0025315406013920.
- Hansen, G.A. 1885. Spongiadae. The Norwegian North-Atlantic Expedition 1876-1878. *Zoology* 13: 1-26, pls I-VII, 1 map.
- Hestetun, J.T., Vacelet, J., Boury-Esnault, N., Borchiellini, C., Kelly, M., Ríos, P., Cristobo, J., Rapp, H.T. 2016. The systematics of carnivorous sponges. *Molecular Phylogenetics and Evolution.* 94 Part A: 327-345.

- Hooper, J.N.A. 2002a. Family Microcionidae Carter, 1875. *In* Hooper, J.N.A., Van Soest, R.W.M. (eds.). *Systema Porifera: A guide to the classification of sponges*. Kluwer Academic/Plenum Publishers, New York, pp. 432-468.
- Hooper, J.N.A. 2002b. Family Acarnidae Dendy, 1922. *In* Hooper, J.N.A., Van Soest, R.W.M. (eds.). *Systema Porifera: A guide to the classification of sponges*. Kluwer Academic/Plenum Publishers, New York, pp. 412-431.
- Hooper, J.N.A., Van Soest, R.W.M. 2002. *Systema Porifera: A guide to the classification of sponges*. Kluwer Academic/Plenum Publishers, New York, 1-1101 p., 1103-1706 p. (2 volumes).
- Hoshino, T. 1981. Shallow-water demosponges of Western Japan, 1. *Journal of Science of the Hiroshima University (B)*. 29(1): 47-205.
- Kingsley, M.C.S., Kannevorff, P., and Carlsson, D.M. 2004. Buffered random sampling: a sequential inhibited spatial point process applied to sampling in a trawl survey for northern shrimp *Pandalus borealis* in West Greenland waters. *ICES J. Mar. Sci.* 61: 12-24.
- Koltun, V.M. 1959. Кремнегоровые губки северных и дальневосточных морей СССР (Siliceous horny sponges of the northern and fareastern seas of the U.S.S.R.). *In* Pavlovsky, E.N. (ed.). *Identifiers of the USSR fauna issued by the Zoological Institute of the Academy of Sciences of the USSR, Volume 67, Russian*. Moscow–Leningrad: Nauka, Academy of Sciences of the USSR, 263 p.
- Lundbeck, W. 1902. Porifera (Part I) Homorrhaphidae and Heterorrhaphidae. *In* The Danish Ingolf-Expedition, Bianco Luno, Copenhagen. 6(1): 1-108, pls I-XIX.
- Lundbeck, W. 1905. Porifera (Part II) Desmacidonidae (pars.). *In* The Danish Ingolf-Expedition, Bianco Luno, Copenhagen. 6(2): 1-219, pls I-XX.
- Lundbeck, W. 1909. The Porifera of East Greenland (Reprinted from *Meddelelser om Gronland Vol. XXIX*). Bianco Luno, Copenhagen. 29: 423-464.
- Lundbeck, W. 1910. Porifera (Part III) Desmacidonidae (pars.). *In* The Danish Ingolf-Expedition, Bianco Luno, Copenhagen. 6(3): 1-124, pls I-XI.
- Maldonado, M., Ribes, M., van Duyl, F.C. 2012. Nutrient fluxes through sponges: Biology, budgets, and ecological implications. *In* Beccero, M.A., Uriz, M.J., Maldonado, M., Turon, X. (eds.). *Advances in Marine Biology, Volume 62, Advances in sponge science: Physiology, chemical and microbial diversity, biotechnology*. Academic Press, Amsterdam, pp. 113-182.



- Maldonado, M., Aguilar, R., Bannister, R.J., Bell, J.J., Conway, K.W., Dayton, P.K., Díaz, C., Gutt, J., Kelly, M., Kenchington, E.L.R., Leys, S.P., Pomponi, S.A., Rapp, H.T., Rützler, K., Tendal, O.S., Vacelet, J., Young, C.M. 2017. Sponge grounds as key marine habitats: A synthetic review of types, structure, functional roles, and conservation concerns. *In* Rossi, S., Bramanti, L., Gori, A., Orejas, C. (eds.). *Marine animal forests, The ecology of benthic biodiversity hotspots*. Springer International Publishing, Cham, pp.143-183.
- Miklucho-Maclay, N.N. 1870. Über einige Schwämme des nördlichen Stillen Oceans und des Eismeeres, welche im Zoologischen Museum der Kaiserlichen Akademie der Wissenschaften in St. Petersburg aufgestellt sind. Ein Beitrag zur Morphologie und Verbreitung der Spongien. *Mémoires de l'Académie Impériale des Sciences de St. Petersburg*. 15(3): 1-24.
- Morozov, G., Sabirov, R., Zimina, O. 2019. Sponge fauna of the New Siberian Shoal: biodiversity and some features of formation. *J. Nat. Hist.* 1-32.
- Morrow, C., Cárdenas, P. 2015. Proposal for a revised classification of the Demospongiae (Porifera). *Front. Zool.* 12: 7. DOI: 10.1186/s12983-015-0099-8.
- Murillo, F.J., Kenchington, E., Tompkins, G., Beazley, L., Baker, E., Knudby, A., Walkusz, W. 2018. Sponge assemblages and predicted archetypes in the eastern Canadian Arctic. *Mar. Ecol. Prog. Ser.* 597: 115-135.
- NAFO, 2019. Conservation and Enforcement Measures. NAFO/FC Doc. 19/01, Serial No. N6901, 191 p.
- Norman, A.M. 1869. Last report on dredging among the Shetland Isles, Part 2, On the Crustacea, Tunicata, Polyzoa, Echinodermata, Actinozoa, Hydrozoa, and Porifera. *In* Report of the thirty-eighth meeting of the British Association for the Advancement of Science; held in Norwich in August 1868. pp. 247–336.
- Orueta, D. de, 1901. Descripción de algunas esponjas del Cantabrico. *Bol. Soc. Esp. Hist. nat.* 1: 331-335.
- Ridley, S.O., Dendy, A. 1886. Preliminary report on the Monaxonida collected by H.M.S. Challenger, Part I. *Ann. Mag. Nat. Hist.* 18: 325-351, 470-493.
- Ridley, S.O., Dendy, A. 1887. Report on the Monaxonida collected by H.M.S. 'Challenger' during the years 1873-1876, Report on the scientific results of the voyage of 'H.M.S. Challenger', 1873-1876. *Zoology* 20(59): i-xviii, 1-275, pls I-L1.
- Ríos, P., Cristobo, F.J., Urgorri, V. 2004. Poecilosclerida (Porifera, Demospongiae) collected by the Spanish Antarctic expedition BENTART-94. *Cah. Biol. Mar.* 45: 97-119.

- Ristau, D.A. 1978. Six new species of shallow-water marine demosponges from California. *Proc. Biol. Soc. Wash.* 91(3): 569-589.
- Van Soest, R.W.M., Stone, S.M. 1989. *Antho brattegardi* sp. n. (Porifera: Poecilosclerida), with remarks on and a key to the clathriids of Norwegian waters. *Sarsia*. 71(1): 41-48.
- Schmidt, O. 1870. Grundzüge einer Spongien-Fauna des atlantischen Gebietes. Wilhelm Engelmann, Leipzig. iii-iv, 1-88, pls I-VI.
- Tompkins, G., Baker, E., Anstey, L., Walkusz, W., Siferd, T., Kenchington, E. 2017. Sponges from the 2010–2014 Paamiut multispecies trawl surveys, eastern Arctic and Subarctic: Class Demospongiae, Subclass Heteroscleromorpha, Order Poecilosclerida, Family Coelosphaeridae, Genera *Forcepia* and *Lissodendoryx*. *Can. Tech. Rep. Fish. Aquat. Sci.* 3224: v + 129 p.
- Topsent, E. 1907. Poecilosclérides nouvelles recueillies par le Français dans l'Antarctique. *Bulletin du Muséum national d'histoire naturelle, Paris.* 13: 69-76.
- Topsent, E. 1904. Spongiaires des Açores. Résultats des campagnes scientifiques accomplies par le Prince Albert I, Monaco. 25: 1-280, pls 1-18.
- Topsent, E. 1913. Spongiaires provenant des campagnes scientifiques de la 'Princesse Alice' dans les Mers du Nord (1898-1899 – 1906-1907). Résultats des campagnes scientifiques accomplies par le Prince Albert I, Monaco 45: 1-67.
- Van Soest, R.W.M. Marine Species Identification Portal, Sponges of the NE Atlantic. Accessed at [http://species-identification.org/species.php?species\\_group=sponges&menuentry=groepen&id=2&tab=beschrijving](http://species-identification.org/species.php?species_group=sponges&menuentry=groepen&id=2&tab=beschrijving).
- Van Soest, R.W.M., Beglinger, E.J., de Voogd, N.J. 2013. Microcionid sponges from Northwest Africa and the Macaronesian Islands (Porifera, Demospongiae, Poecilosclerida). *Zool. Med. Leiden.* 87(4): 275-404.
- Van Soest, R.W.M., Boury-Esnault, N., Hooper, J.N.A., Rützler, K., de Voogd, N.J., Alvarez, B., Hajdu, E., Pisera, A.B., Manconi, R., Schönberg, C., Klautau, M., Picton, B., Kelly, M., Vacelet, J., Dohrmann, M., Díaz, M.-C., Cárdenas, P., Carballo, J.L., Ríos, P., Downey, R. 2019. World Porifera Database. Accessed at <http://www.marinespecies.org/porifera> on 2019-07-11. DOI:10.14284/359.
- Van Soest, R.W.M., Hajdu, E. 2002. Family Esperiopsidae Hentschel, 1923. *In* Hooper, J.N.A., Van Soest, R.W.M. (eds.). *Systema Porifera: A guide to the classification of sponges.* Kluwer Academic/Plenum Publishers, New York, pp. 656-664.

Vosmaer, G.C.J. 1882. Report on the sponges dredged up in the Arctic Sea by the 'Willem Barents' in the years 1878 and 1879. *Niederländisches Archiv für Zoologie Supplement*. 1(3): 1-58, pls I-IV.

Vosmaer, G.C.J. 1885. The Sponges of the 'Willem Barents' Expedition 1880 and 1881. *Bijdragen tot de Dierkunde*. 12 (3): 1-47, pls I-V.