A Review: Halogenated Compounds from Marine Fungi

Cong Wang 1,2,* Huanyun Lu 1, Jianzhou Lan 1, KH Ahammad Zaman 2 and Shugeng Cao 2, *

1 Key Laboratory of Chemistry and Engineering of Forest Products, State Ethnic Affairs Commission, Guangxi Key Laboratory of Chemistry and Engineering of Forest Products, Guangxi Collaborative Innovation Center for Chemistry and Engineering of Forest Products, School of Chemistry and Chemical Engineering, Guangxi University for Nationalities, Nanning 530006, China; luhuanyun2020@163.com (H.L.); lanjianzhou1576@163.com (J.L.)
2 Department of Pharmaceutical Sciences, Daniel K. Inouye College of Pharmacy, University of Hawai’i, Hilo, HI 96720, USA; kzaman@hawaii.edu
* Correspondence: wangcong123206@163.com (C.W.); scao@hawaii.edu (S.C.)

Abstract: Marine fungi produce many halogenated metabolites with a variety of structures, from acyclic entities with a simple linear chain to multifaceted polycyclic molecules. Over the past few decades, their pharmaceutical and medical application have been explored and still the door is kept open due to the need of new drugs from relatively underexplored sources. Biological properties of halogenated compounds such as anticancer, antiviral, antibacterial, anti-inflammatory, antifungal, antifouling, and insecticidal activity have been investigated. This review describes the chemical structures and biological activities of 217 halogenated compounds derived mainly from Penicillium and Aspergillus marine fungal strains reported from 1994 to 2019.

Keywords: marine fungi; chemical structures; natural products; halogenated compounds

1. Introduction

Marine fungi are a treasure source of marine natural products. Marine-derived fungi are important providers of biologically prominent natural products due to their ability to produce secondary metabolites with novel structures and pharmacological activities. According to a paper on marine microbial natural products from 2010 to 2013 [1], natural products from marine fungi account for 63% of marine microorganisms. Due to the enormous amount of chloride and bromide ions available in seawater, many of these secondary metabolites are halogenated. Marine natural products cover a diverse assembly of molecules, including polyketides, peptides, terpenes, phenols, acetogenins, alkaloids, and volatile halogenated hydrocarbons [2]. The fungi isolated from the marine sources might also be found in the terrestrial region. However, marine derived fungi usually produce more halogenated compounds than their terrestrial counterparts due to the presence of high halogen concentrations in the Ocean. Halogenated natural products encompass many classes of compounds, ranging in complexity from halocarbons (mostly halomethanes and haloethanes) to higher molecular weight molecules, which often contain oxygen and/or nitrogen atoms in addition to halogens [3,4]. One of the major focal points of research undoubtedly has been the discovery and characterization of new halogenated compounds, along with a remarkable effort toward the assessment of their possible pharmacological activities and biomedical applications. Active compounds account for nearly 59.2% new halogenated natural products isolated from marine fungi. This paper provides an overview of the sources of marine-derived fungi, chemical structures, and biological activities of 217 halogenated compounds (Table S1) derived from marine fungi from 1994 to 2019.
2. Halogenated Compounds from *Penicillium* sp.

### 2.1. Sponges-Associated *Penicillium* sp.

Two azaphilone derivatives penicilazaphilones D (1) and E (2) were isolated from a sponge-derived fungal strain *Penicillium sclerotiorum* GDST-2013-0415 (Figure 1). Compound 2 was the first azaphilone with a tetrahydrofuran ring at C-3 [5]. A diphenyl ether methyl 3-chloro-2-(2,4-dimethoxy-6-methylphenox)-6-hydroxy-4-methoxybenzoate (3), bromophilones A (4) and B (5), were obtained from *Penicillium canescens* 4.14. 6a [6].

![Figure 1. Structures of compounds 1–38.](image)

### 2.2. Other Marine Animals-Associated *Penicillium* sp.

New meroterpenoids chodrimanins K and L (6 and 7) were isolated from *Penicillium* sp. SCS-KFD09 (marine worm *Sipunculus nudus*), and 6 exhibited anti-H1N1 activity with an IC$_{50}$ value of 74 µM [7]. A new meroterpenoid, named chodrimanin O (8), was isolated from a fermentation of *Penicillium* sp. SCS-KFD09 (marine worm *Sipunculus nudus*). Compound 8 showed protein tyrosine phosphatase 1B inhibitory activity with an IC$_{50}$ value of 71.6 µM [8].

### 2.3. Marine Algae-Associated *Penicillium* sp.

Diphenyl ethers 4,6,4',6'-tetrabromo-3,3'-di hydroxy-5,5'-dimethyldiphenyl ether (9) and 4,6,2',4',6'-pentabromo-3,3'-dihydroxy-5,5'-dimethyl diphenyl ether (10) were obtained by feeding a culture of *Penicillium chrysogenum* with CaBr$_2$. Compounds 9 and 10 showed 2,2-diphenyl-1-picrylhydrazyl (DPPH) activity with IC$_{50}$ values of 18 and 15 µM, respectively [9].

### 2.4. Mangroves-Associated *Penicillium* sp.

Two new epipolythiodioxopiperazine alkaloids penicisulfuranols A (11) and D (12) with a rare spiro-furan ring, which were isolated from the mangrove endophytic fungus *Penicillium janthinellum* HDN13-309, showed cytotoxicity against Hela and HL-60 with IC$_{50}$ values of 0.5 and 0.3, 0.1 and 1.2 µM, respectively [10]. In addition, 4-chloro-1-hydroxy-3-methoxy-6-methyl-8-methoxycarbonyl-xanthen-9-one (13) and 2'-acetoxyl-7-chlorocitreoroscin (14) were purified from the fungal strain *Penicillium citrinum* HL-5126, of which 14 showed activity against *Vibrio parahaemolyticus* with an MIC value of 10 µM [11].
2.5. Penicillium sp. from Marine Sediments

New gentisyl alcohol derivatives dimeric terrestrols B (15), D (16), F and G (17 and 18), and a monomer (19) were obtained from Penicillium terrestrum and were cytotoxic to HL-60, MOLT-4, A-549, and BEL-7402 with IC_{50} values in the range of 5.3 to 64.7 µM [12]. Compounds 15 and 16 exhibited tscavenging activity in a DPPH assay with IC_{50} values ranging from 4.1 to 5.2 µM. A study of the marine sediment derived fungus Penicillium terrestrum resulted in the identification of chlortanspiroines A (20), B (21), terrestrols K (22), and L (23). Compound 20 displayed inhibitory activity against HL-60 and A549 with IC_{50} values of 9.2 and 39.7 µM, respectively [13]. Compound 21 displayed inhibitory activity against HL-60 with an IC_{50} value of 10.5 µM, and A549 with IC_{50} values of 9.2 and 39.7 µM, respectively [14].

Compound 22 displayed inhibitory activity against HL-60 and A549 with IC_{50} values of 9.2 and 39.7 µM, respectively [14]. Compound 23 displayed inhibitory activity against HL-60 with an IC_{50} value of 12.7 µM at 5 µg/disc, and three chlorinated eremophilane-type sesquiterpenes (24–26) were purified from Penicillium sp. PR19N-1 isolated from the deep-sea sediment collected from Prydz Bay [14]. Compound 24 displayed inhibitory activity against HL-60 and A549 with IC_{50} values of 11.8 ± 0.2 and 12.2 ± 0.1 µM, respectively. Tanzawaic acid P (28) was isolated from a marine-derived fungal strain Penicillium sp. CF07370, and it was active against HeLa cell line with an IC_{50} value of 5.9 ± 0.8 µM after 72 h [15]. Emodacidamides C (29), F (30), and G (31) were obtained from a marine-derived fungal strain Penicillium sp. SCSIO sof101. Compound 29 inhibited interleukin-2 secretion with an IC_{50} value of 4.1 µM [16]. Penicilones C (32) and D (33) were purified from Penicillium janthinellum HK1-6, which were active against meticillin-resistant S. aureus (MRSA, ATCC 43300, ATCC 35667) with MIC values ranging from 3.13 to 12.5 µg/mL [17]. Penicillium janthinellum HK1-6 produced two azaphilones penicilones G (34) and H (35), which were active against MRSA (ATCC 43300, ATCC 35667, ATCC 25923, ATCC 29213) and E. faecalis (ATCC 51299, ATCC 35667) with MIC values in the range of 3.13–50 µg/mL [18].

2.6. Penicillium sp. from Other Marine Sources

Ligerin (36) was separated from Penicillium canescens MMS351, which showed cytotoxicity against the POS1 cell with an IC_{50} value of 117 nM [19]. Ligerin was synthesized from fumagillin, and it showed good activity against SaOS2 [20]. The culture of Penicillium copitica TPU1270 (marine foam, Iriomote Island, Okinawa Prefecture, Japan) yielded penicililimide (37) [21]. A new azaphilone penicilazaphilone C (38), which was isolated from the fungus Penicillium sclerotiorum M-22, showed cytotoxicity against B-16 and SGC-7901 with IC_{50} values of 0.065 and 0.720 mM, respectively. Compound 38 also exhibited strong antibacterial activity against Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli, and Klebsiella pneumoniae with MIC values ranging from 0.037 to 0.150 mM [22].

3. Halogenated Compounds from Aspergillus sp.

3.1. Sponges-Associated Aspergillus sp.

Two new polyketides chlorocarolides A (39) and B (40) were from Aspergillus cf. ochraceus 941,026 [23] (Figure 2). Aspergillus ostianus TUF 01F313 yielded 8-chloro-9-hydroxy-8,9-deoxyasperlactone (41), 9-chloro-8-hydroxy-8,9-deoxyasperlactone (42), and 9-chloro-8-hydroxy-8,9-deoxyaspyrone (43), of which compounds 42 and 43 inhibited the growth of Ruegeria atlantica at 25 µg/disc with an inhibition zone diameter of 10.1 and 10.5 mm, respectively [24]. Compound 41 was active against Regenia atlantica with an inhibition diameter of 12.7 mm at 5 µg/disc, and it was also active against S. aureus with an inhibition diameter of 10.2 mm at 25 µg/disc. Aspergillusidones B (44), C (45), and aspergillusether A (46) were separated from Aspergillus ungius CRI282-03 [25]. Compounds 44 and 45 inhibited aromatase with IC_{50} values of 4.1 and 0.7 µM, respectively. Compound 44 showed scavenging activity in a DPPH assay with an IC_{50} value less than 15.6 µM. Aspergillus sp. OUCMDZ-1583 (an unidentified marine sponge XD10410, Xisha Islands, China) produced a new metabolite, aspergone O (47), which inhibited α-glucosidase with an IC_{50} value of 1.54 mM [26]. Ochrasperforloid (48) from Aspergillus flocculosus 16D-1 (the sponge Phakellia fusca, Yongxing Island, China) showed inhibitory activity to-
wards THP-1 and NO production in LPS-activated RAW264.7, with IC$_{50}$ values of 2.02 and 1.11 µM, respectively [27].
3.2. Other Marine Animals-Associated Aspergillus sp.

Notoamide N (49) and notoamide P (50) were isolated from the cultures of Aspergillus sp. MF297-2 [28,29]. A mycotoxin ochratoxin A n-butyl ester (51) was isolated from a marine-derived fungal strain Aspergillus sp. SCSGAF0093 from Melitodes squamata collected from the South China Sea. The bio-toxicity of compound 51 was determined by the brine shrimp lethality bioassay with a median lethal concentration (LC₅₀) value of 4.14 μM [30]. Two new indole-diterpene alkaloids asperindoles A (52) and C (53) were isolated from the fermentation broth of Aspergillus sp. KMM 4676, of which compound 52 showed cytotoxicity toward PC-3 cells, LNCaP cells, and 22Rv1 cells, with IC₅₀ values of 69.4, 47.8, and 4.86 μM, respectively [31].

3.3. Marine Algae-Associated Aspergillus sp.

Aspergillus sydowii produced sydowins A (54) and B (55) [32]. A polyoxygenated decalin derivative dehydroxychlorofusarielin B (56) was isolated from the culture of Aspergillus sp. MFB024, which exhibited antibacterial activities against S. aureus, MRSA, and multidrug-resistant S. aureus with an equal MIC of 62.5 μg/mL [33]. (R)-(−)-5-bromomellein (57), produced by Aspergillus ochraceus, exhibited radical scavenging activity against DPPH with an IC₅₀ value of 24 μM [34]. Aspergillus nidulans EN-330 afforded a chlorinated indole-diterpenoid 19-hydroxypenitrem A (58), which inhibited cytotoxic activity against brine shrimp with a LD₅₀ value of 3.2 μM and showed antibacterial activities [35]. Aspergillus alliaceus afforded allianthrones A–C (59–61), among which 59 displayed cytotoxic activity against the HCT-116 and SK-Mel-5 with IC₅₀ values of 9.0 and 11.0 μM, respectively [36].
3.4. *Aspergillus* sp. from Marine Sediments

A study on the *Aspergillus* sp. SC510 F063 derived from the marine sediment sample resulted in the discovery of chlorinated anthraquinones (1′S)-7-chloroaverantin (62), (1′S)-5-O-methyl-7-chloroaverantin (63), (1′S)-1′-O-methyl-7-chloroaverantin (64), (1′S)-6,1′-O,0-dimethyl-7-chloroaverantin (65), (1′S)-7-chloroaverantin-1′-butyl ether (66), 7-chloroaverenythrin (67), 6-O-methyl-7-chloroaverenythrin (68), brominated anthraquinones (1′S)-6,1′-O,0-dimethyl-7-bromoaverantin (69), and (1′S)-6-O-methyl-7-bromoaverantin (70) [37], of which compounds 63, 64, and 70 exhibited cytotoxic activities against SF-268 with MIC values of 7.11 ± 0.14, 34.06 ± 2.98, and 24.69 ± 0.72 µM, respectively. Compounds 63, 64, and 70 also showed cytotoxic activities against NCI-H460 with MIC values of 7.42 ± 0.14, 37.19 ± 1.95, and 18.91 ± 1.43 µM, respectively. Compounds 63, 64, and 70 further demonstrated cytotoxic activities against MCF-7 with MIC values of 6.64 ± 0.36 to 49.53 ± 0.72 µM, respectively. The deep-sea-derived fungal strain *A. westerdijkiae* DFFSCS013 afforded a new prenylated indole alkaloid 5-chlorosclerotiamide (71), which showed cytotoxicity against K562 with an MIC value of 44 µM [38].

3.5. *Aspergillus* sp. from Other Marine Sources

5′-Hydroxychloroflavonin (72) was purified from *Aspergillus* sp. AF119 [39]. A new depsidone 7-chlorofolipastatin (73) was isolated from *Aspergillus ungui* NKH-007 collected in the Suruga Bay, which inhibited SOAT1 and SOAT2 isozymes [40].

4. Halogenated Compounds from Other Marine Fungi

4.1. Other Sponges-Associated Fungi

Cultivation of an unidentified fungal strain afforded three new chlorinated sesquiterpenes chlorilins A–C (74–76). Compound 74 inhibited human tumor cell lines T-47D and SNB-75 with IC50 values of 0.7 and 0.5 µM, respectively [41]. Trichodenone B (77), and trichodenone C (78) isolated from *Trichoderma harzianum* OUPS-N115 exhibited antitumor activity against P388 with ED50 values of 1.21 and 1.45 µg/mL, respectively [42]. Trichodenones B and C were synthesized by Usami et al. [43]. Gymnastatins A–G (79–88) [44–46], I–K (86–88) [47], Q (89) and R (90) [48], and dankastatins A–C (91–93) [48,49] were isolated from the cultures of *Gymnascella dankaliensis*. Gymnastatin A (79) was synthesized by anodic oxidation of the corresponding phenols [50]. Gymnastatins F (84) and Q (85) were synthesized by the tandem Michael and aldol reaction [51] (Figure 3). These compounds (79–93) showed cytotoxicity against P388, among which compounds 86 and 87 exhibited cytotoxicity against 39 human cancer cell lines with the average of log GI50 at −5.77 and −5.71, respectively. Compound 86 exhibited strong cytotoxic effect against HBC-5, NCI-H522, OVCAR-3, and MKN1, while compound 87 strongly inhibited SF-539, HCT-116, NCI-H522, OVCAR-3, and OVCAR-8. Compound 89 showed cytotoxicity against 39 human cancer cell lines with mean log GI50 values at −4.81, which also demonstrated cytotoxicity against BSY-1 and MKN7 with mean log GI50 values at −5.47 and −5.17, respectively. Compound 93 showed cytotoxicity against the P388 cell line with an ED50 value of 57 ng/mL. In a 2008 report, chlorohydroaspyrones A and B (94 and 95) obtained from *Exophiala* sp. showed antibacterial activity against *S. aureus* and multidrug-resistant *S. aureus* with an equal MIC value of 62.5 and 125 µg/mL [52]. Both compounds 94 and 95 demonstrated antimicrobial activity against MRSA with MIC values of 125 and 62.5 µg/mL, respectively. A culture of *Acremonium* sp. J05B-1-F-3 produced compounds 96–98 [53]. 5-Chloroacremines A and H (99 and 100), acremine O (101) were obtained from *Acremonium persicum* [54]. New chloroazaphilone derivatives helicusin E (102), isochromophiline X (103), and isochromophiline XI (104) were isolated from *Bartalina robillardoides* LF550. Compound 104 displayed antibacterial activity against *Bacillus subtilis*, *Staphylococcus lentus*, and *Trichophyton rubrum* with IC50 values of 55.6, 78.4, and 41.5 µM, respectively. Compounds 103 and 104 showed inhibitory activity against PDE4 with IC50 values of 11.7 and 8.30 µM [55], respectively. Minioluteumide A (105) was isolated from *Talaromyces minioluteus*, which showed weak cytotoxic activity [56]. Stachyogrisphenone B (106) was...
isolated from Stachybotry sp. HH1 ZDS1F1-2, which showed weak cytotoxic activity against intestinal virus EV71 with an IC₅₀ value of 30.1 μM and inhibited cyclooxygenase with an IC₅₀ value of 8.9 μM [57]. One new isocoumarin derivative 107 was separated from Phoma sp. 135 [58], which was isolated from the sponge Ectyplasia perox collected in Dominica, Lauro Club Reef.

Figure 3. Structures of compounds 85–113.

4.2. Other Marine Animals-Associated Fungi

A marine-derived fungus LL-37H248 produced spiroxins A (108) and E (109). Compound 108 showed growth inhibition against 25 cancer cell lines with a mean IC₅₀ value of 0.09 μg/mL [59]. The total synthesis of spiroxin A has been achieved in two competing cascade processes [60]. Cochliomycin C (110) was obtained from Cochliobolus lunatus, which was isolated from the gorgonian coral D. gemmacea [61]. Cochliomycin C (110) was synthesized from sugar D-lyxose [62]. Chondrosterin H (111) was purified from Chondrotereum sp. nov. SF002. The fungal strain SF002 was isolated from the coral Sarcophyton tortuosum [63]. A new chlorinated benzophenone derivative named (±)-pestalachloride D (112) was obtained from Pestalotiopsis sp. ZJ-2009-7-6 [64], which showed inhibitory activity against Escherichia coli, Vibrio anguillarum, and V. parahaemolyticus with MIC values of 5, 10, and 20 μM, respectively. (±)-Pestalachloride D was synthesized by way of a biomimetic Knoevenagel/Hetero-Diels–Alder Cascade reaction [65]. One new depside guisinol (113), which was active against S. aureus (5 mg/mL DMSO, 15 μL added), was identified from the metabolites of Emericella unguis M87-2 isolated from the cannonball jellyfish Stomolopus meliagris [66]. The chemical investigation of Acremonium striatisporum KMM 4401 from the sea cucumber Eupentacta fraudatrix [67] yielded two compounds, virescensides Z₅ and Z₇ (114 and 115) (Figure 4). Pericosines A (116), D (117), and E (118) [68] were obtained from Periconia byssaides OUPS-N133, which was isolated from the sea hare Aplysia kurodai. Pericosine A (116) was synthesized from diverse aromatic cis-dihydropyridol precursors by the chemoenzymatic synthesis [69]. Compound 118 was synthesized by Mizuki et al. in 2014 [70]. Chaetomium globosum OUPS-T106B-6 isolated from the flathead grey mullet Mugil cephalus (Japan) yielded chaetomugilins C (119) [71,72], D-F (120–122) [73], G (123), H (124) [74], and I–O (125–131) [75], seco-chaetomugilins A (132) and D (133) [76], 11-epi-chaetomugilin A (134), 4’-epi-chaetomugilin A (135) [77],
chaeto-mugilins P–R (136–138), 11-epi-chaetomugilin I (139) [78], chaetomugilin S (140), of which 119–122 were cytotoxic against P388 and HL-60 cell lines with IC$_{50}$ values of 3.3–15.7 and 1.3–13.2 µM [71,72], respectively. Compounds 123–128, 130–131, and 134 showed growth inhibition against many cancer cell lines. (−)-Spiromalbramide (141), (+)-isomalbrancheamide B (142), (+)-malbrancheamide C (143), and isomalbrancheamide B (144) were produced by Malbranchea graminicola 086937A [79]. Two new brominated resorcylic acid lactones, 5-bromozeaenol (145) and 3,5-dibromozeaenol (146) [80] were produced by Cochliobolus lunatus TA26-46 induced by inhibitors of histone deacetylase. C. lunatus TA26-46 was isolated from the Zoanthid Palythoa haddoni. Trichodermaid B (147) was obtained from Trichoderma virens CNL910, which displayed cytotoxicity against HCT-116 with IC$_{50}$ values of 0.32 µg/mL [81]. Compound 147 also showed inhibitory activity against C. albicans, vancomycin-resistant E. faecium, and MRSA with an equal MIC value of 15 µg/mL. The synthesis of 147 was reported by Lu and Zakarian in 2008 [82]. An unprecedented polyketide carbon skeleton roussoellatide (148) was obtained from the marine-derived fungus Rousoella sp. DLM33 [83]. Two benzofuran derivatives, 6-chloro-2-(2-hydroxypropan-2-yl)-2,3-dihydro-5-hydroxybenzofuran and 7-chloro-2-(2-hydroxypropan-2-yl)-2,3-dihydro-5-hydroxybenzofuran (149 and 150) were separated from Pseudallescheria boydii, which was isolated from the crown-of-thorns starfish Acanthaster planci (Hainan Sanya National Coral Reef Reserve, Hainan) [84].

Figure 4. Structures of compounds 114–151.

4.3. Other marine Algae-Associated Fungi

A new benzophenone pestalone (151) was isolated from a coculture broth of Pestalotia sp. CNL-365 and bacterium strain CNJ-328A. Compound 151 exhibited inhibitory activity against MRSA and vancomycin-resistant Enterococcus faecium with MIC values of 37 and 78 ng/mL, respectively. Compound 151 was cytotoxic against the NCI 60 human cancer cell lines with a mean GI$_{50}$ value of 6.0 µM [85]. Compound 151 was synthesized with orcinol as the starting material [86]. Two new alkenoates, methyl 2,4-dibromo-5-oxo-2-decenolate (152) and methyl 2,4-dibromo-5-oxo-3-decenolate (153) were discovered from an unidentified fungus from the seaweed Gracilaria verrucosa [87] (Figure 5). The chemical investigation of a culture of Beauveria felina yielded [β-MePro] destruxin E (154) [88]. A study of Botrytis sp. led to the identification of bromomyrothene B (155) [89]. Acremonisol A (156) was obtained from Acremonium sp. [90]. Chaetoanthone C (157) was
Molecules 2021, 26, 458

4.4. Other Mangroves-Associated Fungi

A new griseofulvin derivative 7-chloro-2',5,6-trimethoxy-6'-methylspiro(benzofuran-2(3H),1'-2 cyclohexene)3,4'-dione (165) was produced by Sporothrix sp. 4335 [97]. Emericophenolics A (166) and B (167) were produced by Emericella sp. HK-ZJ and were found to show antiviral activity with IC50 values of 42.1 and 62.0 μg/mL, respectively [98]. Pestalotethers A-C (168–170) and pestalachromones A-C (171–173) were purified from Pestalotiopsis sp. PSU-MA69, which was isolated from a branch of a mangrove plant Rhizophora apiculata [99]. Pestalotiopene C (174), a polyketide derivative, was obtained from Acremonium strictum, collected from the mangrove tree Rhizophora apiculata Blume [100].
**Paradictyoarthrinium diffractum** BCC 8704 produced a new hydroanthraquinone, paradictyoarthrin A (175), which showed cytotoxicity against KB, MCF-7, NCI-H187, and Vero with IC₅₀ values of 26, 24, 23, and 31 µg/mL, respectively [101]. The marine mangrove *A. ilicifolius* provided *Lasiodiplodia theobromae* ZJ-HQ1, which produced chloroureppusomers A (176) and B (177). Compounds 176 and 177 showed antimicrobial activity against *S. aureus* and *B. subtilis* with MIC values of 6.2, 50, 3.2, and 25 µg/mL, respectively. Compounds 176 and 177 also showed cytotoxicity against A549, HepG2, HeLa, MCF-7, and HEK293T with IC₅₀ values ranging from 5.9 to 27 µM [102]. Rhizovarins A and B (178 and 179) were separated from a fermentation of *Mucor irregularis* QEN-189 isolated from *Rhizophora stylosa* (Hainan Island) and were cytotoxic against A-549 with IC₅₀ values of 11.5 and 9.6 µM, respectively. Both compounds 178 and 179 were also cytotoxic to HL-60 cells with IC₅₀ values of 6.3 and 5.0 µM, respectively [103]. Sesquiterpenoid derivatives, rhinomilisins A–C (180–182) and I (183) were isolated from *Phinocladiella similis*, of which 180 showed cytotoxicity against L5178Y with an IC₅₀ value of 5.0 µM [104].

4.5. Other Marine Plants-Associated Fungi

Polyporapryanne D (184) with a 2-phenylpyranon-4-one derivative skeleton was isolated from an extract of *Polyporales* sp. PSU-ES44 [105].

4.6. Other Marine Sediments-Associated Fungi

Chlorogentisylquinone (185) was purified from a marine-derived fungus FOM-8108, which showed nSMase activity with an IC₅₀ value of 1.2 µM [106]. Spiromastixones B-O (186–199) were isolated from *Spiromastix* sp. MCCCSA00308, which exhibited antibacterial activity against *Staphylococcus aureus* ATCC 29213, *Bacillus thuringiensis* SCSIO BT01, and *Bacillus subtilis* SCSIO BT01 with MIC values in the range of 0.125–8.0 µg/mL. Compounds 190–194 exhibited antibiotic activity against MRSA and *S. epidermidis* (MRSE) with the same inhibitory activity as levofloxacin. Compound 194 displayed inhibitory activity against VREF and VRE with an equal IC₅₀ value of 4 µM [107]. Emerixanthone A (200) was isolated from *Emericella* sp. SCSIO 05240, which exhibited weak antibacterial activity against *Klebsiella pneumonia* (ATCC 13883), *Escherichia coli* (ATCC 29922), *Staphylococcus aureus* (ATCC 29213), *Aeromonas hydrophila* (ATCC 7966), *Acinetobacter baumannii* (ATCC 19606), and *Enterococcus faecalis* (ATCC 29212) [108]. Cladosporol G (201) was purified from a fermentation of *Cladosporium cladosporioides* HDN14-342, which was isolated from a sediment sample (Indian Ocean). Compound 201 was cytotoxic against HeLa cells with an IC₅₀ value of 3.9 µM [109]. Pestalotiopsis neglecta yielded pestalones B–H (202–208), which were cytotoxic against PANC-1, A549, HCT116, MCFM, DU145, and HepG2 tumor cell lines with IC₅₀ values in the range of 4.8–37 µM [110]. *Chaetomium globosum* HDN151398 yielded azaphilone alkaloids N-glutarylchaetoviridins A–C (209–211). Compound 211 exhibited cytotoxicity against HO8910 and MGC-803 with IC₅₀ values of 6.6 and 9.7 µM, respectively [111].

4.7. Other Marine Source-Associated Fungi

A culture of *F. heterosporum* CNC-477 produced neomangicols A and B (212 and 213). Compound 212 was cytotoxic against MCF-7 and CACO-2 cells with IC₅₀ values of 4.9 and 5.7 µM, respectively, and compound 213 showed antibacterial activity against *B. subtilis* at 50 µg/disc with an inhibition zone diameter of 10 mm [112]. Chaephilone C (214) and chaetoviridines A–C (215–217) were isolated from *Chaetomium* sp. NA-S01-R1. These compounds (214–217) showed antimicrobial activity and cytotoxicity [113].

5. Conclusions

According to our summary of halogenated compounds identified from 1994 to 2019 (Figure 6, Table 1), the research on halogenated compounds from marine fungi was traced back to 1994 when chloriolins A–C (74–76) were discovered from an unidentified fungus isolated from the Indo-Pacific sponge *Jaspias aff. johnstoni* (Table 2) [41]. Since 2008, more new halogenated compounds than ever from marine fungi were isolated annually except before
2016. By the end of 2019, 217 new halogenated compounds from marine fungi have been reported. We have done our best to include as many new halogenated compounds isolated from marine fungi as possible, but the list may still not be complete.

![Figure 6. Numbers of new halogenated compounds reported annually from 1994–2019.](image)

### Table 1. The initial research on antimicrobial active compounds from fungi.

| First Producing Strain | Environment Source | Compound | Time |
|-------------------------|--------------------|----------|------|
| *Aspergillus cf. ochraceus* 941026 | Jaspis of Coriacea, Indian-Pacific Ocean | Chlorocarolides A–B (39 and 40) | 1996 |
| Unidentified fungus | Indo-Pacific sponge *Jaspis aff. johnstoni* | Chloriolins A–C (74–76) | 1994 |

### Table 2. Halogenated compounds isolated from marine fungi (1994–2019).

| Compound | Producing Strain | Environment Source | Bioactivity | Ref. |
|----------|------------------|--------------------|-------------|------|
| 1–2      | *Penicillium sclerotiorum* GDST-2013-0415 | Unidentified sponge GDST-2013-04, the coral reef at a depth of 10 m in the sea area of Shantou, Guangdong, China | - | [5] |
| 3–5      | *Penicillium canescens* 4.14. 6a. | The inner tissues of the marine sponge *Agelas oroides*, the coast of *Sigacik* Izmir, Turkey | - | [6] |
| 6–8      | *Penicillium* sp. SCS-KFD09 | A marine worm, *Sipunculus nudus* (HK10404), Haikou Bay, China | 6: Anti-<sub>H<sub>2</sub>N<sub>2</sub> activity; 8: Protein tyrosine phosphatase 1B inhibitory activity | [7,8] |
| 9–10     | *Penicillium chrysogenum* | *Hypnea complex*, South Gyeongsang, Korea | DPPH activity | [9] |
| 11–12    | *Penicillium janthinellum* HDN13-309 | *Sonneratia caseolaris*, Hainan, China | cytotoxicity | [10] |
| 13–14    | *Penicillium citrinum* HL-5126 | *Bruguiera sexangular var. rhynchoptera*, the South China Sea | 14: Antibacterial activity | [11] |
| 15–19    | *Penicillium Terrestre* | Sediment, Jiaozhou Bay, China | cytotoxicity; 15: DPPH activity | [12] |
| 20–23    | *Penicillium Terrestre* | Sediment, Jiaozhou Bay, China | 20–21: Cytotoxicity | [13] |
| 24–27    | *Penicillium* sp. PR19N-1 | Sediment (~1000 m), Prydz Bay, Antarctica | 24: Cytotoxicity | [14] |
| Compound | Producing Strain | Environment Source | Bioactivity | Ref. |
|----------|------------------|--------------------|-------------|------|
| 28       | *Penicillium* CF07370 | Sediment (~100 m), Bahia de Los Angeles (Gulf of California, Mexico) | cytotoxicity | [15] |
| 29–31    | *Penicillium* sp. SCSIO sof101 | Sediment (2448 m), the South China Sea (112°12′ E, 18°0.541’ N) | cytotoxicity | [16] |
| 32–35    | *Penicillium janthinellum* HK1-6 | The mangrove rhizosphere soil, Dongzhaihaigang mangrove natural reserve, Hainan Island | antibacterial activity | [17,18] |
| 36       | *Penicillium canescens* MMS351 | Seawater, French Atlantic coast | cytotoxicity | [19,20] |
| 37       | *Penicillium copticola* TPU1270 | Marine foam, Irismote Island, Okinawa Prefecture, Japan | - | [21] |
| 38       | *Penicillium sclerotiorum* M-22 | The rotten leaf sample, on the west coast of Haikou, Hainan, China | cytotoxicity, antibacterial activity | [22] |
| 39–40    | *Aspergillus* cf. ochraceus 941026 | Jaspis of Coriacea, Indian-Pacific Ocean | - | [23] |
| 41–43    | *A. ostianus* TUF 01F313 | Unidentified sponge, Pohnpei, Micronesia | antibacterial activity | [24] |
| 44–46    | *Aspergillus unguis* CRI282-03 | Unidentified sponge CRI282, Thailand | Aromatase inhibitor, DPPH | [25] |
| 47       | *Aspergillus* sp. OUCMDZ-1583 | An unidentified marine sponge XD10410, Xisha Islands, China | α-glucosidase inhibitor, inhibitory activity towards THP-1 and NO production in LPS-activated RAW264.7 | [26] |
| 48       | *Aspergillus floculosus* 16D-1 | The sponge Phakellia fusca, Yongxing Island, China | - | [27] |
| 49–50    | *Aspergillus* sp. MF297-2 | *Mytilus edulis*, Japan | - | [28,29] |
| 51       | *Aspergillus* sp. SCSGAFO093 | Melitodes squamata collected from the South China Sea | - | [30] |
| 52–53    | *Aspergillus* sp. KMM 4676 | Unidentified colonial ascidian, Shikotan Island, Pacific Ocean | Cytotoxicity | [31] |
| 54–55    | *Aspergillus sydowii* | *Acanthophora spicifera*, Bay of Bengal, India | - | [32] |
| 56       | *Aspergillus* sp. MFB024 | *Sargassum horneri*, Korea | antibacterial activity | [33] |
| 57       | *Aspergillus ochraceus* | Marine red alga *Chondria crassicalis*, Yokki Island, Kyeongnam, Korea | DPPH activity | [34] |
| 58       | *Aspergillus nidulans* EN-330 | Marine red alga *P. scopulorum* var. *villum*, Yantai, China | cytotoxicity, antibacterial activity | [35] |
| 59–61    | *Aspergillus alliaceus* | Marine alga by Biovictica GmbH | cytotoxicity | [36] |
| 62–70    | *Aspergillus* sp. SCSIO F063 | A marine sediment sample, the South China Sea | Cytotoxicity, 63, 64, 70: Cytotoxicity | [37] |
| 71       | *A. westerdijkiae* DFFSCS013 | A marine sediment sample, the South China Sea | cytotoxicity | [38] |
| 72       | *Aspergillus* sp. AF119 | Sediment, Xiamen beach, China | - | [39] |
| 73       | *Aspergillus ungui* NKH-007 | Soil (331 m), Suruga Bay, Japan (138°18.1207’ E, 34°22.4813’ N) | inhibitor of sterol O-acyltransferase | [40] |
| 74–76    | unidentified fungus | Indo-Pacific sponge *Jaspis aff. johnstoni* | Cytotoxicity | [41] |
| 77–78    | *Trichoderma harzianum* OUPS-N115 | Halichondria okadai, Japan | cytotoxicity | [42,43] |
| 79–93    | *Gymnascella dankalensis* | Halichondria japonica, Japan | cytotoxicity | [44–51] |
| 94–95    | *Exophiala* sp. | *Halichondria panicea*, Bogil Island, Jeonnam Province, Korea | antibacterial activity | [52] |
| 96–98    | *Acremonium* sp. J05B-1-F-3 | Sponge *Stelletta* sp. (J05B-1), the coast of Jeju Island, Korea | - | [53] |
| 99–101   | *Acremonium persicinum* | Sponge *Anomoiaenthalia rubrawere*, the gneering reef offshore from Mooloolaba | - | [54] |
Table 2. Cont.

| Compound | Producing Strain | Environment Source | Bioactivity | Ref. |
|----------|------------------|--------------------|-------------|------|
| 102–104  | Bartalinia robillardoides LF550 | Marine sponge *Tethya aurantium*, the Limsky kanal (Canal di Lemme or Limsky channel, Croatia) | 104: Antibacterial activity | [55] |
| 105      | *Talaromyces miniolutes* | Unidentified marine sponge, Pilae Unidentified marine sponge, Pilae | 103–104: Inhibitory activity towards PDE4 | cytotoxicity | [56] |
| 106      | *Stachybotry* sp. HH1 | Bay, Phi Phi Island, Krabi Province, Thailand | - | anti-virus activity | [57] |
| 107      | *Phoma* sp. 135 | Sponge *Ectyplasia perox*, Dominica Orange coral, Dixon Bay, Vancouver | - | - | [58] |
| 108–109  | fungus LL-37H248 | Island, Canada | 108: Cytotoxicity | [59,60] |
| 110      | *Cochliobolus lunatus* | Gorgonian *Dichotella gemmaea*, the South China Sea | - | - | [61,62] |
| 111      | *Chondrostereum* sp. nov. SF002 | *Sarcophytontortuosum*, Sanya, Hainan | antibacterial activity | [63] |
| 112      | *Pestalothopsis* sp. ZJ-2009-7-6 | *Sarcophytontortuosum*, Yongxing Island | antibacterial activity | [64,65] |
| 113      | *Emericella unguis* M87-2 | *Stomolopus meliagris*, Paria Bay, Venezuela | antibacterial activity | [66] |
| 114–115  | *Acrocnium striatissporum* KMM 4401 | *Euptacta fraudatrix*, Japan | - | - | [67] |
| 116–118  | *Periconia byssoides* OUPS-N133 | Sea hare *Aplysia kurodai*, Japan | - | - | [68–70] |
| 119–140  | *Chaetomiun globosum* OUPS-T106B-6 | Marine fish *Mugil cephalus*, Japan | 119–128, 130–131, 133: Cytotoxicity | - | [71–78] |
| 141–144  | *Malbranchea graminicola* (O86937A | Unidentified invertebrate, Kona, Hawaii | - | - | [79] |
| 145–146  | *Cochliobolus lunatus* TA26-46 | *Palythoa haddoni*, Weizhou Island | - | - | [80] |
| 147      | *Trichoderma virens* CNL910 | *Didennum mole*, Papua New Guinea | cytotoxicity, antimicrobial activity | [81,82] |
| 148      | *Rousselloa* sp. DLM33 | the ascidian *Didennum ligulum*, the north coast of São Paulo state, Brazil | - | - | [83] |
| 149–150  | *Pseudallescheria boydii* | *Acanthaster planci*, Hainan Sanya National Coral Reef Reserve, Hainan | - | - | [84] |
| 151      | *Pestalothopsis* sp. CNL-365 | *Rosenvingea* sp. Bahamas | cytotoxicity, antimicrobial activity | [85,86] |
| 152–153  | unidentified fungus | *Gracillaria verrucose*, Korea | - | - | [87] |
| 154      | *Beauveria flexa* | *Caulerpa* sp., *São Paulo* | - | - | [88] |
| 155      | *Enteromorpha compressa*, *Busan, Korea* | *Botrygis* sp. | - | - | [89] |
| 156      | *Acremonium* sp. | *Plocamium* sp., Heligoland | - | - | [90] |
| 157      | *Chaetomium* sp. | The algal species (taxonomy not determined), Kamari on the island Santorini, Greece | antiprotozoal activities | [91] |
| 158      | *Curvularia* sp. 768 | *Acanthophora spicifera*, The Territory of Guam | - | - | [92] |
| 159–160  | *Fusarium tricinctum* | *Sargassum ringgoldium*, Yeosu, Korea | antibacterial activity | [93] |
| 161–162  | *Phoma herbarum* Trichoderma sp. (cf. *T. brevicompactum*) TPU1999 | *Gloiopeitis tenax*, Korea | DPPH activity | [94] |
| 163      | *Trichoderma asperellum* cf44-2 | A red alga, Palau | - | - | [95] |
| 164      | *Trichoderma asperellum* cf44-2 | Marine brown alga *Sargassum* sp., Zoushan Islands | antibacterial activity | [96] |
| 165      | *Sporothrix* sp. 4335 | The bark of an estuarine mangrove, the South China Sea | - | - | [97] |
| 166–167  | *Emericella* sp. HK-ZJ | *A. corniculata*, Haikou, China | antiviral activity | [98] |
| 168–173  | *Pestalothopsis* sp. PSU-MA69 | *R. apiculate*, Thailand | - | - | [99] |
| 174      | *Acrocnium strictum* | The mangrove tree *Rhizophora apiculate* Blume | - | - | [100] |
Table 2. Cont.

| Compound     | Producing Strain                  | Environment Source                                                                 | Bioactivity                     | Ref.   |
|--------------|-----------------------------------|------------------------------------------------------------------------------------|---------------------------------|--------|
| 175          | Paradictyoarthrinium diffractum   | A mangrove wood in Laem Son National Park, Ranong Province, Thailand               | cytotoxicity                    | [101]  |
| 176–177      | Lasiodiplodia theobromae ZJ-HQ1   | The marine mangrove A. ilicifolius, China                                        | cytotoxicity, antibacterial activity | [102]  |
| 178–179      | Mucor irregularis QEN-189         | Mangrove plant Rhizophora stylosa, Hainan Island, China                           | cytotoxicity                    | [103]  |
| 180–183      | Rhinocladiella similis            | Acrostichum aureum (Pteridaceae), Douala, Cameroon                               |                                 | [104]  |
| 184          | Polyporales sp. PSU-ES44          | Marine sand, Katase Enoshima Beach, Kanagawa, Japan                               |                                 | [105]  |
| 185          | marine-derived fungus FOM-8108    | Deep-sea sediment (2869 m), the South Atlantic Ocean (GPS 13.7501 W, 15.1668 S)  | nSMase activity                 | [106]  |
| 186–199      | Spironastix sp. MCCCG3A00308      | South Atlantic Ocean (GPS 13.7501 W, 15.1668 S)                                  | antibacterial activity          | [107]  |
| 200          | Emericella sp. SCSIO 05240        | A sediment sample (3258 m), the South China Sea                                 | antibacterial activity          | [108]  |
| 201          | Cladosporium cladosporioides HDN14-342 | Sediment sample, Indian Ocean                                                 | cytotoxicity                    | [109]  |
| 202–208      | Pestalotiopsis neglecta           | Marine sediment (–10 m), Gageo, Korea                                            | 205–208: Cytotoxicity           | [110]  |
| 209–211      | Chaetomium globosum HDN151398     | The sediment sample, South China Sea                                             | 211: Cytotoxicity               | [111]  |
| 212–213      | F. heterosporum CNC-477           | A driftwood sample, Sweetings Cay, Bahamas                                       | 212: Cytotoxicity; 213: Antibacterial activity, antimicrobial activity, cytotoxicity | [112]  |
| 214–217      | Chaetomium sp. NA-S01-R1          | A seawater sample, the West Pacific Ocean                                       |                                 |        |

Most of the papers that reported new halogenated compounds in this period of time (1994–2019) were published in *J. Nat. Prod.* (32), *J. Antibiot.* (13), Marine Drugs (11), and *Tetrahedron Letters* (8) (Figure 7). The main journals that reported new halogenated compounds from marine fungi were *J. Nat. Prod.* (38.7%), *J. Antibiot.* (8.8%), *Tetrahedron* (8.3%), *Mar. Drugs* (10.6%), *Tetrahedron Lett.* (6.0%), and *J. Org. Chem.* (4.1%) (Figure 8). *J. Nat. Prod.* is the most preeminent journal that published more articles and more new halogenated compounds than any other journal.
Fungi isolated from sponges, sediments, algae, and mangroves produced most of the new halogenated compounds (22.6, 27.6, 11.1, and 10.6%, respectively) (Figure 9). Marine animals hosted diverse fungal species and strains that produced more than 50% of the new halogenated compounds from 1994 to 2019, indicating that they are an excellent source for the discovery of new halogenated compounds.

The numbers of halogenated compounds from marine Penicillium sp., Aspergillus sp., and the other fungi were 38, 35, and 144, respectively (Figure 10). It seems that halogenation in the marine environment is not specifically favorable to any fungal species or strains. Therefore, it would be interesting to investigate whether halogenations in marine fungi are enzymatic or nonenzymatic. The numbers of cytotoxic and antimicrobial halogenated compounds from marine fungi account for 32.6 and 18.9%, respectively (Figure 11). In addition, 39.2% of the halogenated compounds were tested as inactive in the reported assays, but it is worthy to evaluate these compounds in other biological settings.

These new marine natural products from marine fungi have different structure skeletons including polyketides, nitrogen-containing compounds, sterols, and terpenoids (Figure 12). Polyketides account for the majority (169, 78%) of the new halogenated compounds (217) isolated from marine fungi (Figure 12). The number of chlorinated compounds is 191, which is far more than that of brominated compounds simply due to the fact
that chloride/chlorine is dominant in the Ocean when compared with bromide/bromine (Figure 13).

![Figure 10](image1.png)

**Figure 10.** Numbers of new halogenated compounds from different marine fungi (1994–2019).

![Figure 11](image2.png)

**Figure 11.** Activity of new halogenated compounds from marine fungi (1994–2019).

![Figure 12](image3.png)

**Figure 12.** Structural classes of new halogenated compounds (1994–2019).
One of the challenges of discovering promising biologically active secondary metabolites from marine fungi is to mimic the culture environment as the marine. The surrounding environment such as oxygen, pressure, light, and salinity etc. significantly influence the growth of the marine fungi, as well as their ability to produce secondary metabolites. Although it is a challenge, investigating marine fungi for their halogenated secondary metabolites is worth it since more than 60% halogenated compounds isolated from marine fungi have some kind of significant biological activities. It is also worthy to assess halogenated compounds in a broader range of assays.

**Supplementary Materials:** The Supplementary Materials are available online.

**Author Contributions:** S.C. and C.W. conceived and designed the format of the paper; C.W. edited the article and analyzed the data; H.L. and J.L. drew the structures of the compounds; K.A.Z. reviewed the manuscript; S.C. revised the manuscript. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was supported by the Guangxi Natural Science Foundation under grant number 2019GXNSFBA185002, a specific research project of Guangxi for research bases and talents (AD18126005, AD18281066). Seed grants from the University of Hawaii at Hilo (UHH), start-up funding from the University of Hawaii Cancer Center (UHCC) and Daniel K. Inouye College of Pharmacy (DKICP), and the Victoria S. and Bradley L. Geist Foundation (15ADV-74420, 17CON-86295, and 20CON-102163) to S.C. Funding for this work was also supported by the Hawaii IDeA Network for Biomedical Research Excellence III and IV (INBRE-III and INBRE-IV) project: NIGMS grant number 5P20GM103466.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study are available in this article and supplementary material.

**Conflicts of Interest:** The authors declare no conflict of interest.

**Sample Availability:** Samples of the compounds are not available from the authors.

**References**

1. Zhao, C.; Zhu, T.; Zhu, W. New marine natural products of microbial origin from 2010 to 2013. *Chin. J. Org. Chem.* **2013**, *33*, 1195–1234. [CrossRef]
2. Butler, A.; Sandy, M. Mechanistic considerations of halogenating enzymes. *Nature* **2009**, *460*, 848–854. [CrossRef] [PubMed]
3. Ballschmiter, K. Review: Pattern and sources of naturally produced organohalogens in the marine environment: Biogenic formation of organohalogens. *Chemosphere* **2003**, *52*, 313–324. [CrossRef]
4. Gribble, G.-W. The diversity of naturally produced organohalogens. *Chemosphere* 2003, 52, 289–297. [CrossRef]

5. Wang, C.-Y.; Hao, J.-D.; Ning, X.-Y.; Wu, J.-S.; Zhao, D.-L.; Kong, C.-J.; Shao, C.-L.; Wang, C.-Y. Penicilazaphilones D and E: Two new azaphilones from a sponge-derived strain of the fungus *Penicillium sclerotiorum*. *RSC Adv.* 2018, 8, 4348–4353. [CrossRef]

6. Frank, M.; Hartmann, R.; Plenker, M.; Mándi, A.; Kurtán, T.; Özkaya, F.-C.; Müller, W.-E.; Kassack, M.-U.; Hamacher, A.; Lin, W.; et al. Brominated azaphilones from the sponge-associated fungus *Penicillium canescens* strain 4.14. 6a. *J. Nat. Prod.* 2019, 82, 2159–2166. [CrossRef]

7. Kong, F.-D.; Ma, Q.-Y.; Huang, S.-Z.; Wang, P.; Wang, J.-F.; Zhou, L.-M.; Yuan, J.-Z.; Dai, H.-F.; Zhao, Y.-X. Chrodrimanins K–N and related meroterpenoids from the fungus *Penicillium* sp. SCS-KFD09 isolated from a marine worm, *Sipunculus nudus*. *J. Nat. Prod.* 2017, 80, 1039–1047. [CrossRef]

8. Kong, F.-D.; Zhang, R.-S.; Ma, Q.-Y.; Xie, Q.-Y.; Wang, P.; Chen, P.-W.; Zhou, L.-M.; Dai, H.-F.; Luo, D.-Q.; Zhao, Y.-X. Chrodrimanins O–S from the fungus *Penicillium* sp. SCS-KFD09 isolated from a marine worm, *Sipunculus nudus*. *Fitoterapia* 2017, 122, 1–6. [PubMed]

9. Yang, G.; Yun, K.; Nenkep, V.-N.; Choi, H.-D.; Kang, J.-S.; Son, B.-W. Induced production of halogenated diphenyl ethers from the marine-derived fungus *Penicillium chrysogenum*. *Bioresour. Technol.* 2011, 102, 6338–6342. [CrossRef] [PubMed]

10. Zhu, M.; Zhang, X.; Feng, H.; Dai, J.; Li, J.; Che, Q.; Gu, Q.; Zhu, T.; Li, D. Penicisulfuranols A–F, alkaloids from the mangrove endophytic fungus *Penicillium janthinellum* HDN13-309. *J. Nat. Prod.* 2017, 80, 71–75. [CrossRef]

11. He, K.-Y.; Zhang, C.; Duan, Y.-R.; Huang, G.-L.; Yang, C.-Y.; Lu, X.-R.; Zheng, C.-J.; Chen, G.-Y. New chlorinated xanthone and anthraquinone produced by a mangrove-derived fungus *Penicillium citrinum* HL-5126. *J. Antibiot.* 2017, 70, 823–827. [CrossRef] [PubMed]

12. Chen, L.; Fang, Y.; Zhu, T.; Gu, Q.; Zhu, W. Gentiols alcohol derivatives from the marine-derived fungus *Penicillium Terrestre*. *J. Nat. Prod.* 2008, 71, 66–70. [CrossRef] [PubMed]

13. Li, D.; Chen, L.; Zhu, T.; Kurtán, T.; Mándi, A.; Zhao, Z.; Li, J.; Gu, Q. Chloctanspirones A and B, novel chlorinated polyketides with an unprecedented skeleton, from marine sediment derived fungus *Penicillium Terrestre*. *Tetrahedron* 2011, 67, 7913–7918. [CrossRef]

14. Wu, G.; Lin, A.; Gu, Q.; Zhu, T. Li, D. Four new chloro-eremophilane sesquiterpenes from an Antarctic deep-sea derived fungus, *Penicillium sp.* PR19N-1. *Mar. Drugs* 2013, 11, 1399–1408. [CrossRef]

15. Cardoso-Martinez, F.; José, M.; Diaz-Marrero, A.-R.; Darias, J.; Cerella, C.; Diederich, M.; Cueto, M. Tanazawaic acids isolated from a marine-derived fungus of the genus *Penicillium* with cytotoxic activities. *Org. Biomol. Chem.* 2015, 13, 7248–7256. [CrossRef]

16. Luo, M.; Cui, Z.; Huang, H.; Song, X.; Sun, A.; Dang, Y.; Lu, L.; Ju, J. Amino acid conjugated anthraquinones from the marine-derived fungus *Penicillium janthinellum* SCSIO sof101. *J. Nat. Prod.* 2017, 80, 1668–1673. [CrossRef]

17. Chen, M.; Shen, N.-X.; Chen, Z.-Q.; Zhang, F.-M.; Chen, Y. Penicilones A–D, anti-MRSA azaphilones from the marine-derived fungus *Penicillium janthinellum* HK1-6. *J. Nat. Prod.* 2017, 80, 1081–1086. [CrossRef]

18. Chen, M.; Zheng, Y.-Y.; Chen, Z.-Q.; Shen, N.-X.; Shen, L.; Zhang, F.-M.; Zhou, X.-J.; Wang, C.-Y. NaBr-induced production of brominated azaphilones and related tricyclic polyketides by the marine-derived fungus *Penicillium janthinellum* HK1-6. *J. Nat. Prod.* 2019, 82, 368–374. [CrossRef]

19. Vansteelandt, M.; Blanche, E.; Egorov, M.; Petit, F.; Toupet, L.; Bondon, A.; Monteau, F.; Le Bizec, B.; Thomas, O.-P.; Pouchus, Y.-F. Ligerin, an antiproliferative chlorinated sesquiterpenoid from a marine-derived *Penicillium* strain. *J. Nat. Prod.* 2013, 76, 297–303. [CrossRef]

20. Blanche, E.; Vansteelandt, M.; Le Bot, R.; Egorov, M.; Guittion, Y.; Pouchus, Y.-F.; Grovel, O. Synthesis and antiproliferative activity of ligerin and new fumagillin analogs against osteosarcoma. *Eur. J. Med. Chem.* 2014, 79, 244–250. [CrossRef]

21. Bu, Y.-Y.; Yamazaki, H.; Ukai, K.; Namikoshi, M. *Penicillium* himaginiforme, an actinomycete from *Aspergillus* sp. HK1-6. *J. Antibiot.* 2016, 68, 537–539. [CrossRef] [PubMed]

22. Zhou, S.-L.; Wang, M.; Zhao, H.-G.; Huang, Y.-H.; Lin, Y.-Y.; Tan, G.-H.; Chen, S.-L. Penicilazaphilone C, a new antineoplastic and antibacterial azaphilone from the marine fungus *Penicillium sclerotiorum*. *Arch. Pharm.* 2016, 39, 1621–1627. [CrossRef] [PubMed]

23. Abrell, L.-M.; Borgeson, B.; Crews, P. Chloro polyketides from the cultured fungus (*Aspergillus*) separated from a marine sponge. *Tetrahedron Lett.* 1996, 37, 2321–2324. [CrossRef]

24. Namikoshi, M.; Negishi, R.; Nagai, H.; Dmitrenok, A.; Kobayashi, H. Three new chlorine containing antibiotics from a marine-derived fungus *Aspergillus ostiarius* collected in Pohnpei. *J. Antibiot.* 2003, 56, 755–761. [CrossRef] [PubMed]

25. Sureram, S.; Wiyakrutta, S.; Ngamrojanavanich, N.; Mahidol, C.; Ruchirawat, S.; Kittakoop, P. Depsidones, Aromatase inhibitors and radical scavenging agents from the marine-derived fungus *Penicillium janthinellum* CRI282-03. *Planta Med.* 2015, 81, 537–541. [CrossRef]

26. Kong, F.; Zhao, C.; Hao, J.; Wang, C.; Wang, W.; Huang, X.; Zhu, W. New α-glucosidase inhibitors from a marine sponge-derived fungus, *Aspergillus* sp. OUCMDZ-1583. *RSC Adv.* 2015, 5, 68852–68863. [CrossRef]

27. Gu, B.-B.; Jiao, F.-R.; Wu, W.; Liu, L.; Jiao, W.-H.; Sun, F.; Wang, S.-P.; Yang, F.; Lin, H.-W. Ochrsaperforlloicoid, an ochratoxin-ergosteroid heterodimer with inhibition of IL-6 and NO production from *Aspergillus flaccidus* 16D-1. *RSC Adv.* 2019, 9, 7251–7256. [CrossRef]

28. Tsukamoto, S.; Kawabata, T.; Kato, H.; Greshock, T.-J.; Hirota, H.; Ohta, T.; Williams, R.-M. Isolation of antipodal (−)-versicolamide B and notoamides L–N from a marine-derived *Aspergillus* sp. *Org. Lett.* 2009, 11, 1297–1300. [CrossRef]
29. Tsukamoto, S.; Umaoka, H.; Yoshikawa, K.; Ikeda, T.; Hirot, H. Notoamioide A, a structurally unprecedented prenylated indole alkaloid, and notoamides P-R from a marine-derived fungus, Aspergillus sp. J. Nat. Prod. 2010, 73, 1438–1440. [CrossRef]

30. Xu, X.; He, F.; Zhang, X.; Bao, J.; Qi, S. New mycotoxins from marine-derived fungus Aspergillus sp. SCSGAF0093. Food Chem. Toxicol. 2013, 53, 46–51. [CrossRef]

31. Ivanets, E.-V.; Yurchenko, A.-N.; Smetanina, O.-F.; Rasin, A.-B.; Zhuravleva, O.-I.; Pivkin, M.-V.; Popov, R.-S.; Von Amsberg, G.; Afifyatullov, S.-S.; Dyshlovoy, S.-A. Asperinidole A–D and a p-terphenyl derivative from the ascidian-derived fungus Aspergillus sp. KMM 4676. Mar. Drugs 2018, 16, 232. [PubMed]

32. Teuschel, F.; Lin, W.; Wray, V.; Edrada, R.; Padmakumar, K.; Proksch, P.; Ebel, R. Two new cyclopentanoids from the endophytic fungus Aspergillus sydowii associated with the marine alga Acanthophora spicifera. Nat. Prod. Commun. 2006, 1, 927–933. [CrossRef]

33. Nguyen, H.-P.; Zhang, D.; Lee, U.; Kang, J.-S.; Choi, H.-D.; Son, B.-W. Dehydroxychlorofusarilin B, an antibacterial polyoxygenated decalin derivative from the marine-derived fungus Aspergillus sp. J. Nat. Prod. 2007, 70, 1188–1190. [CrossRef] [PubMed]

34. Yun, K.; Feng, Z.; Choi, H.-D.; Kang, J.-S.; Son, B.-W. New production of (R)-(−)-5-bromomellein, a dihydroisocoumarin derivative from the marine-derived fungus Aspergillus ochraceus. Chem. Nat. Compd. 2013, 49, 24–26. [CrossRef]

35. Zhang, P.; Li, X.-M.; Li, X.; Wang, B.-G. New indole-diterpenoids from the algal-associated fungus Aspergillus nidulans. Phytochem. Lett. 2015, 12, 182–185. [CrossRef]

36. Mandelare, P.-E.; Adpressa, D.-A.; Kaweesa, E.-N.; Zakharov, L.-N.; Loesgen, S. Coulture of two developmental stages of a marine-derived Aspergillus alliaceus results in the production of the cytotoxic bimacranthone allianthione A. J. Nat. Prod. 2018, 81, 1014–1022. [CrossRef]

37. Huang, H.; Wang, F.; Luo, M.; Chen, Y.; Song, Y.; Zhang, W.; Zhang, S.; Ju, J. Halogenated anthraquinones from the marine-derived fungus Aspergillus sp. SCSSIO F063. J. Nat. Prod. 2012, 75, 1346–1352. [CrossRef] [PubMed]

38. Peng, J.; Zhang, X.-Y.; Tu, Z.-C.; Xu, X.-Y.; Qi, S.-H. Alkaloids from the deep-sea-derived fungus Aspergillus westerdijkiae DFFSCS013. J. Nat. Prod. 2013, 76, 983–987. [CrossRef]

39. Liu, S.; Lu, C.; Huang, J.; Shen, Y. Three new compounds from the marine fungal strain Aspergillus sp. AF119. Rec. Nat. Prod. 2012, 6, 334–338.

40. Uchida, R.; Nakajyo, K.; Kobayashi, K.; Ohshiro, T.; Terahara, T.; Imada, C.; Tomoda, H. 7-Chlorofolipastatin, an inhibitor of sterol O-acyltransferase, produced by marine-derived Aspergillus westerdijkiae sp. KMM 4676. [PubMed]

41. Ivanets, E.-V.; Yurchenko, A.-N.; Smetanina, O.-F.; Rasin, A.-B.; Zhuravleva, O.-I.; Pivkin, M.-V.; Popov, R.-S.; Von Amsberg, G.; Afifyatullov, S.-S.; Dyshlovoy, S.-A. Asperinidole A–D and a p-terphenyl derivative from the ascidian-derived fungus Aspergillus sp. KMM 4676. Mar. Drugs 2018, 16, 232. [PubMed]

42. Teuschel, F.; Lin, W.; Wray, V.; Edrada, R.; Padmakumar, K.; Proksch, P.; Ebel, R. Two new cyclopentanoids from the endophytic fungus Aspergillus sydowii associated with the marine alga Acanthophora spicifera. Nat. Prod. Commun. 2006, 1, 927–933. [CrossRef]

43. Nguyen, H.-P.; Zhang, D.; Lee, U.; Kang, J.-S.; Choi, H.-D.; Son, B.-W. Dehydroxychlorofusarilin B, an antibacterial polyoxygenated decalin derivative from the marine-derived fungus Aspergillus sp. J. Nat. Prod. 2007, 70, 1188–1190. [CrossRef] [PubMed]

44. Numata, A.; Amagata, T.; Minoura, K.; Ito, T. Gymnastatins, novel cytotoxic metabolites produced by a fungal strain from a sponge. J. Antibiot. 1998, 51, 33–40. [CrossRef] [PubMed]

45. Amagata, T.; Usami, Y.; Minoura, K.; Ito, T.; Numata, A. Cytotoxic substances produced by a fungal strain from a sponge: Physico-chemical properties and structures. J. Antibiot. 1998, 51, 33–40. [CrossRef] [PubMed]

46. Amagata, T.; Usami, Y.; Ikura, T.; Amagata, T.; Numata, A. First total syntheses and configuration assignments of cytotoxic trichodenones A–C. Tetrahedron: Asymmetry 2000, 11, 3711–3725. [CrossRef]

47. Numata, A.; Amagata, T.; Minoura, K.; Ito, T. Gymnastatins, novel cytotoxic metabolites produced by a fungal strain from a sponge. Tetrahedron Lett. 1997, 38, 5675–5678. [CrossRef]

48. Amagata, T.; Doi, M.; Ohta, T.; Minoura, K.; Ito, T.; Numata, A. Absolute stereostructures of novel cytotoxic metabolites, gymnastatins A-E, from a Gymnascella species separated from a Halichondria sponge. J. Chem. Soc. Perkin Trans. 1 1998, 21, 3585–3600. [CrossRef]

49. Numata, A.; Minoura, K.; Numata, A. Gymnastatins F-H, cytostatic metabolites from the sponge-derived fungus Gymnascella dankaliensis. J. Nat. Prod. 2006, 69, 1384–1388. [CrossRef]

50. Amagata, T.; Takigawa, K.; Minoura, K. Gymnastatins I-K, Cancer cell growth inhibitors from a sponge-derived Gymnascella dankaliensis. Heterocycles 2010, 81, 897–907. [CrossRef]

51. Amagata, T.; Tanaka, M.; Yamada, T.; Minoura, K.; Numata, A. Gymnastatins and dankastatins, growth inhibitory metabolites of a Gymnascella species from a Halichondria Sponge. J. Nat. Prod. 2008, 71, 340–345. [CrossRef]

52. Amagata, T.; Tanaka, M.; Yamada, T.; Chen, Y.-P.; Minoura, K.; Numata, A. Additional cytotoxic substances isolated from the sponge-derived Gymnascella dankaliensis. Tetrahedron Lett. 2013, 54, 5960–5962. [CrossRef]

53. Ogamino, T.; Ohnishi, S.; Ishikawa, Y.; Sugai, T.; Obata, R.; Nishiyama, S. Synthesis and biological assessment of hemiacetal spiro derivatives towards development of efficient chemotherapeutic agent. Sci. Technol. Adv. Mater. 2006, 7, 175. [CrossRef]

54. Murayama, K.; Tanabe, T.; Ishikawa, Y.; Nakamura, K.; Nishiyama, S. A synthetic study on gymnastatins F and Q: The tandem Michael and aldol reaction approach. Tetrahedron Lett. 2009, 50, 3191–3194. [CrossRef]

55. Zhang, D.; Yang, X.; Kang, J.-S.; Choi, H.-D.; Son, B.-W. Chlorohydroaspyrones A and B, antibacterial aspyrone derivatives from the marine-derived fungus Exophiala sp. J. Nat. Prod. 2008, 71, 1485–1460. [CrossRef] [PubMed]

56. Zhang, P.; Bao, B.; Dang, H.-T.; Hong, J.; Lee, H.-J.; Yoo, E.-S.; Bae, K.-S.; Jung, J.-H. Anti-inflammatory sesquiterpenoids from a sponge-derived fungus Acremonium sp. J. Nat. Prod. 2009, 72, 270–275. [CrossRef] [PubMed]

57. Fraser, J.-A.; Lambert, L.-K.; Piersen, G.-K.; Bernhardt, P.-V.; Garson, M.-J. Secondary metabolites of the sponge-derived fungus Acremonium persicum. J. Nat. Prod. 2013, 76, 1432–1440.

58. Jansen, N.; Ohlendorf, B.; Erhard, A.; Bruhn, T.; Bringmann, G.; Imhoff, J.-F. Helicuscin E, isochromopholine X and isochromopholine XI: New chlorozaphilones produced by the fungus Bartalinia robillardoides Strain LF550. Mar. Drugs 2013, 11, 800–816. [CrossRef]
56. Ngokpol, S.; Suwakulsiri, W.; Sureram, S.; Lirdprapamongkol, K.; Aree, T.; Wiyakrutta, S.; Mahidol, C.; Ruchirawat, S.; Kittakoop, P. Drimane sesquiterpene-conjugated amino acids from a marine isolate of the fungus Talaraomyces miniatulus (Penicillium miniatulum). Mar. Drugs 2015, 13, 3567–3580. [CrossRef]

57. Qin, C.; Lin, X.; Lu, X.; Wu, H.; Zhou, X.; Liao, S.; Tu, Z.; Xu, S.; Liu, Y. Sesquiterpenoids and xanthurone derivatives produced by sponge-derived fungus Stachybotrys sp. HH1 ZSD51F-2. J. Antibiot. 2015, 68, 121–125. [CrossRef]

58. Elsabr, M.-F.; Ghabbour, H.-A. Isocoumarin derivatives from the marine-derived fungus Phoma sp. 135. Tetrahedron Lett. 2016, 57, 354–356. [CrossRef]

59. McDonald, L.-A.; Abbanat, D.-R.; Barbieri, L.-R.; Berman, V.-S.; Discafani, C.-M.; Greenstein, M.; Janota, K.; Korshalla, J.-D.; Lassota, P.; Tischler, M.; et al. Spirooxins, DNA cleaving antitumor antibiotics from a marine-derived fungus. Tetrahedron Lett. 1999, 40, 2489–2492. [CrossRef]

60. Ando, Y.; Tanaka, D.; Sasaki, R.; Ohmori, K.; Suzuki, K. Stereochemical dichotomy in two competing cascade processes: Total syntheses of both enantiomers of spiroxin A. Angew. Chem. 2019, 131, 12637–12643. [CrossRef]

61. Shao, C.-L.; Wu, H.-X.; Wang, C.-Y.; Liu, Q.-A.; Xu, Y.; Wei, M.-Y.; Qian, P.-Y.; Gu, Y.-C.; Zheng, C.-J.; She, Z.-G.; et al. Potent antifouling resorcylic acid lactones from the gorgonian-derived fungus Cochliobolus lunatus. J. Nat. Prod. 2011, 74, 629–633. [CrossRef] [PubMed]

62. Mahankali, B.; Srirahi, P.-A. Carbohydrate approach for the first total synthesis of cochlomycin C: Stereoselective total synthesis of paecilomycin E, paecilomycin F and 6′-epi-Paecilomycin, C. Eur. J. Org. Chem. 2015, 18, 3983–3993. [CrossRef]

63. Li, H.-J.; Chen, T.; Xie, Y.-L.; Chen, W.-D.; Zhu, X.-F.; Lan, W.-J. Isolation and structural elucidation of chondrosterin F-H from the marine fungus Chondrostereum sp. Mar. Drugs 2013, 11, 551–558. [CrossRef] [PubMed]

64. Wei, M.-Y.; Li, D.; Shao, C.-L.; Deng, D.-S.; Wang, C.-Y. (±)-Pestalachloride D, an antibacterial racemate of chlorinated benzoporphorone derivative from a soft coral-derived fungus Pestalotiopsis sp. Mar. Drugs 2013, 11, 1050–1060. [CrossRef]

65. Arredondo, V.; Roa, D.-E.; Yan, S.; Liu-Smith, F.; Van Vranken, D.-L. Total synthesis of (±)-pestalachloride C and (±)-pestalachloride D through a biomimetic knoevenagel/hetero-diels–alder cascade. Org. Lett. 2019, 21, 1755–1759. [CrossRef]

66. Nielsen, J.; Nielsen, P.-H.; Frisvad, J.-C. Fungal depside, guisinol, from a marine derived strain of Emericella unguis. Phytochemistry 1999, 50, 263–265. [CrossRef]

67. Afifyatullov, S.-S.; Kalinovsky, A.-I.; Antonov, A.-S. New virenesciones from the marine-derived fungus Acremonium striatisporum. Nat. Prod. Commun. 2011, 6, 1063–1068. [CrossRef]

68. Yamada, T.; Iritani, M.; Ohishi, H.; Tanaka, K.; Minourea, K.; Doi, M.; Numata, A. Pericosines, antitumour metabolites from the sea hare-derived fungus Periconia byssoides. Structures and biological activities. Org. Biomol. Chem. 2007, 5, 3979–3986. [CrossRef]

69. Boyd, D.-R.; Sharma, N.-D.; Acaru, C.-A.; Malone, J.-F.; O’Dowd, C.-R.; Allen, C.-C.; Stevenson, P.-J. Chemoenzymatic synthesis of carbasugars (+)-pericosines A-C from diverse aromatic cis-dihydrodiol precursors. Org. Lett. 2010, 12, 2206–2209. [CrossRef]

70. Mizuki, K.; Iwashashi, K.; Murata, N.; Ikeda, M.; Nakai, Y.; Yoneyama, H.; Harusawa, S.; Usami, Y. Synthesis of marine natural product (−)-pericosine E. Org. Lett. 2014, 16, 3760–3763. [CrossRef]

71. Yamada, T.; Doi, M.; Shigeta, H.; Muroga, Y.; Hosoe, S.; Numata, A.; Tanaka, R. Absolute stereostructures of cytotoxic metabolites, chaetomuignulins A-C, produced by a Chaetomium species separated from a marine fish. Tetrahedron Lett. 2008, 49, 4192–4195. [CrossRef]

72. Yasuhide, M.; Yamada, T.; Numata, A.; Tanaka, R. Chaetomuignulins, new selectively cytotoxic metabolites, produced by a marine fish-derived Chaetomium species. J. Antibiot. 2008, 61, 615–622. [CrossRef] [PubMed]

73. Yamada, T.; Yasuhide, M.; Shigeta, H.; Numata, A.; Tanaka, R. Absolute stereostructures of chaetomuignulins G and H produced by a marine-fish-derived Chaetomium species. J. Antibiot. 2009, 62, 353–357. [CrossRef] [PubMed]

74. Muroga, Y.; Yamada, T.; Numata, A.; Tanaka, R. Chaetomuignulins I-O, new potent cytotoxic metabolites from a marine-fish-derived Chaetomium species. Stereochemistry and biological activities. Tetrahedron 2009, 65, 7580–7586. [CrossRef]

75. Yamada, T.; Muroga, Y.; Tanaka, R. New azaphilones, seco-chaetomuignulins A and D, produced by a marine-fish-derived Chaetomium globosum. Mar. Drugs 2009, 7, 249–257. [CrossRef]

76. Muroga, Y.; Yamada, T.; Numata, A.; Tanaka, R. 11- and 4′-Epimers of chaetomuignulin A, novel cystotatic metabolites from marine fish-derived fungus Chaetomium globosum. Heliol. Chim. Acta 2010, 93, 542–549. [CrossRef]

77. Yamada, T.; Muroga, Y.; Jinno, M.; Kajimoto, T.; Usami, Y.; Numata, A.; Tanaka, R. New class azaphilone produced by a marine fish-derived Chaetomium globosum. The stereochemistry and biological activities. Bioorg. Med. Chem. 2011, 19, 4106–4113. [CrossRef]

78. Yamada, T.; Jinno, M.; Kikuchi, T.; Kajimoto, T.; Numata, A.; Tanaka, R. Three new azaphilones produced by a marine fish-derived chaetomium globosum. J. Antibiot. 2012, 65, 413–417. [CrossRef]

79. Watts, K.-R.; Loveridge, S.-T.; Tenney, K.; Media, J.; Valieriote, F.-A.; Crews, P. Utilizing DART Mass Spectrometry to pinpoint halogenated metabolites from a marine invertebrate-derived fungus. J. Org. Chem. 2011, 76, 6201–6208. [CrossRef]

80. Zhang, W.; Shao, C.-L.; Chen, M.; Liu, Q.-A.; Wang, C.-Y. Brominated resorcylic acid lactones from the marine-derived fungus Cochliobolus lunatus induced by histone deacetylase inhibitors. Tetrahedron Lett. 2014, 55, 4888–4891. [CrossRef]

81. Garo, E.; Starks, C.-M.; Jensen, P.-R.; Fenical, W.; Lobkovsky, E.; Clardy, J. Trichoderamamides A and B, cytotoxic modified dipptides from the marine-derived fungus Trichoderma virens. J. Nat. Prod. 2003, 66, 423–426. [CrossRef] [PubMed]

82. Lu, C.-D.; Zakarian, A. Total synthesis of (±)-Trichoderamamide B and of a putative biosynthetic precursor to Aspergillazine A using an oxaza-cope rearrangement. Angew. Chem. Int. Ed. 2008, 47, 6829–6831. [CrossRef] [PubMed]
83. Ferreira, E.-L.; Williams, D.-E.; Ioca, L.-P.; Morais-Urano, R.-P.; Santos, M.-F.; Patrick, B.-O.; Elias, L.-M.; Lira, S.-P.; Ferreira, A.-G.; Passarini, M.-R.; et al. Structure and biogenesis of roussoellatide, a dichlorinated polyketide from the marine-derived fungus Roussoella sp. DLM33. Org. Lett. 2015, 17, 5152–5155. [CrossRef] [PubMed]

84. Yan, D.-F.; Lan, W.-J.; Wang, K.-T.; Huang, L.; Jiang, C.-W.; Li, H.-J. Two chlorinated benzofuran derivatives from the marine fungus Pseudolescheria boydii. Nat. Prod. Commun. 2015, 10, 621–622. [CrossRef] [PubMed]

85. Cueto, M.; Jensen, P.-R.; Kauffman, C.; Fenical, W.; Lobkovsky, E.; Clardy, J. Pestalone, a new antibiotic produced by a marine fungus in response to bacterial challenge. J. Nat. Prod. 2001, 64, 1444–1446. [CrossRef]

86. Slavov, N.; Cvengroš, J.; Neudörfl, J.-M.; Schmalz, H.-G. Total synthesis of the marine antibiotic pestalone and its surprisingly facile conversion into pestalactone and pestalachloride A. Angew. Chem. Int. Ed. 2010, 49, 7588–7591. [CrossRef] [PubMed]

87. Li, X.; Kim, S.-K.; Kang, J.-S.; Choi, H.-D.; Son, B.-W. Polyketide and sesquiterpenediol metabolites from a marine-derived fungus. Bull. Korean Chem. Soc. 2004, 25, 607–608. [CrossRef]

88. Lira, S.-P.; Vita-Marques, A.-M.; Selegheim, M.-H.-R.; Bugni, T.-S.; LaBarbera, D.-V.; Sette, L.-D.; Sponchiado, S.-R.; Ireland, C.-M.; Emericella sp. fungus. Tetrahedron Lett. 2015, 56, 6262–6265. [CrossRef]

89. Li, X.; Zhang, D.; Lee, U.; Li, X.; Cheng, J.; Zhu, W.; Jung, J.-H.; Choi, H.-D.; Son, B.-W. Bromomyrothenone B and botrytinone, chlorinated cyclopentenone derivatives from a marine isolate of the fungus Botrytis. J. Nat. Prod. 2007, 70, 307–309. [CrossRef]

90. Pontius, A.; Mohamed, I.; Krick, A.; Kehraus, S.; König, G.-M. Aromatic polyketides from marine algicolous fungi. J. Nat. Prod. 2008, 71, 272–274. [CrossRef]

91. Pontius, A.; Krick, A.; Kehraus, S.; Brun, R.; König, G.-M. Antiprotozoal activities of heterocyclic substituted xanthones from the marine-derived fungus Chaetomium sp. J. Nat. Prod. 2008, 71, 1579–1584. [CrossRef] [PubMed]

92. Greve, H.; Schupp, P.-J.; Eguereva, E.; Kehraus, S.; König, G.-M. Ten-membered lactones from the marine-derived fungus Curvularia sp. J. Nat. Prod. 2008, 71, 1651–1653. [CrossRef] [PubMed]

93. Nenkep, V.; Yun, K.; Zhang, D.; Choi, H.-D.; Kang, J.-S.; Son, B.-W. Induced production of bromomethylchlamydosporols A and B from the marine-derived fungus Fusarium tricinctum. J. Nat. Prod. 2010, 73, 2061–2063. [CrossRef] [PubMed]

94. Nenkep, V.-N.; Yun, K.; Li, Y.; Choi, H.-D.; Kang, J.-S.; Son, B.-W. New production of haloquinones, bromochlorogentisylquinones A and B, by a halide salt from a marine isolate of the fungus Phoma herbarum. J. Antibiot. 2010, 63, 199–201. [CrossRef]

95. Yamazaki, H.; Takahashi, O.; Murakami, K.; Namikoshi, M. Induced production of a new unprecedented epitrithiodiketopiperazine, chlorotriothibrevamide, by a culture of the marine-derived Trichoderma cf. brevicaespactum with dimethyl sulfoxide. Tetrahedron Lett. 2015, 56, 6262–6265. [CrossRef]

96. Song, Y.-P.; Miao, F.-P.; Fang, S.-T.; Yin, X.-L.; Ji, N.-Y. Halogenated and nonhalogenated metabolites from the marine-derived fungus Rhizovarins A–F, indole-diterpenes from the mangrove-derived fungus Aegiceras corniculatum sp. associated with Sporothrix and diphenyl ether derivatives from the mangrove-derived fungus A. Angew. Chem. Int. Ed. 2007, 46, 363–365. [CrossRef] [PubMed]

97. Wen, L.; Guo, Z.-Y.; Li, Q.; Zhang, D.; She, Z.; Vrijmoed, L.-L. A new griseofulvin derivative from the mangrove endophytic fungus Phoma herbarum. J. Nat. Prod. 2015, 78, 334–338. [CrossRef] [PubMed]

98. Zhang, G.; Sun, S.; Zhu, T.; Lin, Z.; Gu, J.; Li, D.; Gu, Q. Antiviral isoiindolone derivatives from an endophytic fungus Emericella sp. associated with Aegiceras corniculatum. Phytochemistry 2011, 72, 1436–1442. [CrossRef]

99. Klaiklay, S.; Rukchaisirikul, V.; Tadпetch, K.; Sukponmda, Y.; Phongpaichit, S.; Buatong, J.; Sakayaroj, J. Chlorinated chromone and diphenyl ether derivatives from the mangrove-derived fungus Pestalotiopsis sp. LSU-MA69. Tetrahedron 2012, 68, 2299–2305. [CrossRef]

100. Hammerschmidt, L.; Debbab, A.; Ngoc, T.-D.; Wray, V.; Hemphil, C.-P.; Lin, W.; Broetz-Oesterhelt, H.; Kassack, M.-U.; Proksch, P.; Aly, A.-H. Polyketides from the mangrove-derived fungus Acromenium strictum. Tetrahedron Lett. 2014, 55, 3463–3468. [CrossRef]

101. Isaka, M.; Chinthanom, P.; Rachtawee, P.; Srichomthong, K.; Sroikitikulchai, P.; Kongsaeeree, P.; Prabpai, S. Cytotoxic hydroan-thraquinones from the mangrove-derived fungus Paracystoyantheicum daffractum BCC 8704. J. Antibiot. 2015, 68, 334–338. [CrossRef] [PubMed]

102. Chen, S.; Chen, D.; Cai, R.; Cui, H.; Long, Y.; Lu, Y.; Li, C.; She, Z. Cytotoxic and antibacterial preussomerins from the mangrove endophytic fungus Lasidiplodia theobromae ZJ-HQ1. J. Nat. Prod. 2016, 79, 2397–2402. [CrossRef] [PubMed]

103. Gao, S.-S.; Li, X.-M.; Williams, K.; Proksch, P.; Ji, N.-Y.; Yang, B.-G. Rhizovarins A–F, indole-diterpenes from the mangrove-derived endophytic fungus Mucor irregularis QEN-189. J. Nat. Prod. 2016, 79, 2066–2074. [CrossRef] [PubMed]

104. Liu, S.; Zhao, Y.; Heering, C.; Janiak, C.; Müller, W.-E.; Akoné, S.-H.; Liu, Z.; Proksch, P. Sesquiterpenoids from the endophytic fungus Rhinocladiella similis. J. Nat. Prod. 2019, 82, 1055–1062. [CrossRef]

105. Rukachaisirikul, V.; Kannai, S.; Klaiklay, S.; Phongpaichit, S.; Sakayaroj, J. Rare 2-phenylpyran-4-ones from the seagrass-derived fungi Polyporales PSU-ES43 and PSU-ES83. Tetrahedron 2013, 69, 6981–6986. [CrossRef]

106. Uchida, R.; Tomoda, H.; Arai, M.; Omura, S. Chlorogentisylquinone, a new neutral sphenoid myelinase inhibitor, produced by a marine fungus. J. Antibiot. 2001, 54, 882–889. [CrossRef] [PubMed]

107. Niu, S.; Liu, D.; Hu, X.; Proksch, P.; Shao, Z.; Lin, W. Spiromastixones A–O, antibacterial chlorodepsidones from a deep-sea-derived Spiromastix sp. fungus. J. Nat. Prod. 2014, 77, 1021–1030. [CrossRef]

108. Fredimoses, M.; Zhou, X.; Lin, X.; Tian, X.; Ai, W.; Wang, J.; Liao, S.; Liu, J.; Yang, B.; Yang, X.; et al. New prenylbenzoxanes from the deep-sea-derived fungus Emericella sp. SCSIO 05240. Mar. Drugs 2014, 2, 3190–3202. [CrossRef]

109. Zhang, Z.; He, X.; Liu, C.; Che, Q.; Zhu, T.; Gu, Q.; Li, D. Clindanones A and B and cladosporolins F and G, polyketides from the deep-sea-derived fungus Cladosporium cladosporioides HDN14-342. RSC Adv. 2016, 6, 76498–79504. [CrossRef]
110. Wang, W.; Park, C.; Oh, E.; Sung, Y.; Lee, J.; Park, K.-H.; Kang, H. Benzophenone Compounds, from a Marine-Derived Strain of the Fungus Pestalotiopsis neglecta, Inhibit Proliferation of Pancreatic Cancer Cells by Targeting the MEK/ERK Pathway. *J. Nat. Prod.* 2019, *82*, 3357–3365. [CrossRef]

111. Sun, C.; Ge, X.; Mudassir, S.; Zhou, L.; Yu, G.; Che, Q.; Zhang, G.; Peng, J.; Gu, Q.; Zhu, T.; et al. New glutamine-containing azaphilone alkaloids from deep-sea-derived fungus *Chaetomium globosum* HDN151398. *Mar. Drugs* 2019, *17*, 253. [CrossRef] [PubMed]

112. Renner, M.-K.; Jensen, P.-R.; Fenical, W. Neomangicols: Structures and absolute stereochemistries of unprecedented halogenated sesterterpenes from a marine fungus of the genus *Fusarium*. *J. Org. Chem.* 1998, *63*, 8346–8354. [CrossRef]

113. Wang, W.; Liao, Y.; Chen, R.; Hou, Y.; Ke, W.; Zhang, B.; Gao, M.; Shao, Z.; Chen, J.; Li, F. Chlorinated azaphilone pigments with antimicrobial and cytotoxic activities isolated from the deep sea derived fungus *Chaetomium* sp. NA-S01-R1. *Mar. Drugs* 2018, *16*, 61. [CrossRef] [PubMed]