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Marine natural products

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Covering: 2013. Previous review: *Nat. Prod. Rep.*, 2014, **31**, 160–258

This review covers the literature published in 2013 for marine natural products (MNPs), with 982 citations (644 for the period January to December 2013) referring to compounds isolated from marine microorganisms and phytoplankton, green, brown and red algae, sponges, cnidarians, bryozoans, molluscs, tunicates, echinoderms, mangroves and other intertidal plants and microorganisms. The emphasis is on new compounds (1163 for 2013), together with the relevant biological activities, source organisms and country of origin. Reviews, biosynthetic studies, first syntheses, and syntheses that lead to the revision of structures or stereochemistries, have been included.

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1 Introduction

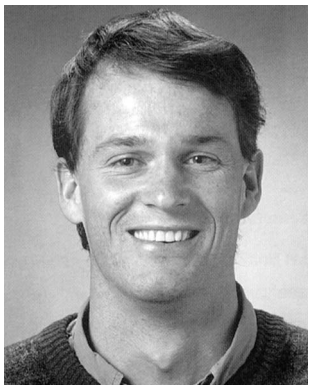
This review is of the literature for 2013 and describes 1163 new compounds from 379 articles, a 6% decrease in the number of compounds reported in 2012.[1] As in previous reviews, the structures are shown only for new compounds, or for previously reported compounds where there has been a structural revision or a newly established stereochemistry. Previously reported compounds for which first syntheses or new bioactivities are described are referenced, but separate structures are generally not shown. Where the absolute configuration has been determined for all stereocentres in a compound, the identifying diagram number is distinguished by addition of the † symbol.

2 Reviews

A selection of the many reviews on various aspects of MNP studies is listed here. A comprehensive review of MNPs reported in 2011 has appeared,[2] as well as the highlights of compounds reported in 2012.[3] Marine pharmacology papers for 2009–2011 have been collated,[4] two reviews summarise natural products (NPs), including from marine sources, as drug leads,[5,6] while another paper describes recent advances in marine drug research.[7] A synopsis of the project BAMMBO for the sustainable production of biologically active molecules of marine based origin has appeared.[8] General classes of compounds have been reviewed in papers on marine triterpenoids as anticancer

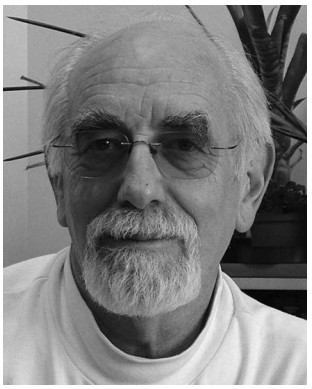
agents,[9] alkaloids from corals,[10] meroterpenes from marine invertebrates,[11] 'head-to-sidechain' cyclodepsipeptides,[12] marine alkaloids containing an 1-(indol-3-yl)ethane-1,2-diamine fragment,[13] tetrahydrofuran-containing macrolides,[14] terpenes from *Sarcophyton* sp.,[15,16] antimicrobial peptides from proteobacteria,[17] diarrhetic shellfish toxins in Washington State.,[18] di- and sesquiterpenes from *Cystosiera* sp.,[19] and halogenated compounds from Rhodomelaceae.[20] Some general reviews on various classes of compounds include data on marine compounds – anticancer steroids,[21] sesterterpenoids,[22] NPs containing a nitrogen–nitrogen bond,[23] and muscarine, imidazole, oxazole and thiazole alkaloids.[24] Reviews on various aspects of specific compounds include lamellarins N and L,[25] STX,[26] lyngbouilloside and related macrolides,[27] thiomarinol and related dithiolopyrrolone compounds,[28] okadaic acid,[29] and the marinopyrroles.[30] There have been many reviews covering a variety of groups of marine organisms, including bioprospecting of plankton,[31] actinomycetes,[32,33] S. China Sea opisthobranch molluscs,[34] actinobacteria,[35,36] filamentous marine cyanobacteria,[37] and microbes in general.[38–40] Reviews on specific organisms include Australian *Dicathais orbita*,[41] metabolites from *Osmundaria* spp.,[42] *Aspergillus* spp.,[43] and *Bacillus* spp.[44] A focus on bioactivities is made in reviews on anti-inflammatory compounds,[45,46] trypanocidal products,[47] neuroprotective compounds,[48] antitumour/anticancer

John Blunt obtained his BSc (Hons) and PhD degrees from the University of Canterbury, followed by postdoctoral appointments in Biochemistry at the University of Wisconsin–Madison, and with Sir Ewart Jones at Oxford University. He took up a lectureship at the University of Canterbury in 1970, from where he retired as an Emeritus Professor in 2008. His research interests are with natural products, the application of NMR techniques to structural problems, and the construction of databases to facilitate natural product investigations.



Brent Copp received his BSc (Hons) and PhD degrees from the University of Canterbury, where he studied the isolation, structure elucidation and structure–activity relationships of biologically active marine natural products under the guidance of Professors Blunt and Munro. He undertook postdoctoral research with Jon Clardy at Cornell and Chris Ireland at the University of Utah. 1992–93 was spent working in industry as an isolation chemist with Xenova Plc, before returning to New Zealand to take a lectureship at the University of Auckland, where he is currently an Associate Professor.

Rob Keyzers carried out his BSc(Hons) and PhD studies at Victoria University of Wellington. His thesis research, carried out under the guidance of Assoc. Prof. Peter Northcote, a former contributor to this review, focused on spectroscopy-guided isolation of sponge metabolites. He then carried out post-doctoral research with Mike Davies-Coleman (Rhodes University, South Africa) and Raymond Andersen (University of British Columbia, Canada) before a short role as a flavour and aroma chemist at CSIRO in Adelaide, Australia. He was appointed to the faculty at his alma mater in 2009 where he is currently a Senior Lecturer.



Murray Munro, Emeritus Professor in Chemistry at the University of Canterbury, has worked on natural products right through his career. This started with diterpenoids (PhD; Peter Grant, University of Otago), followed by alkaloids during a postdoctoral spell with Alan Battersby at Liverpool. A sabbatical with Ken Rinehart at the University of Illinois in 1973 led to an interest in marine natural products with a particular focus on bioactive compounds which has continued to this day. In recent years his research interests have widened to include terrestrial/marine fungi and actinomycetes.

Michèle Prinsep received her BSc (Hons) and PhD degrees from the University of Canterbury, where she studied the isolation and structural elucidation of biologically active secondary metabolites from sponges and bryozoans under the supervision of Professors Blunt and Munro. She undertook postdoctoral research on cyanobacteria with Richard Moore at the University of Hawaii before returning to New Zealand to take up a lectureship at the University of Waikato, where she is currently a Senior Lecturer.

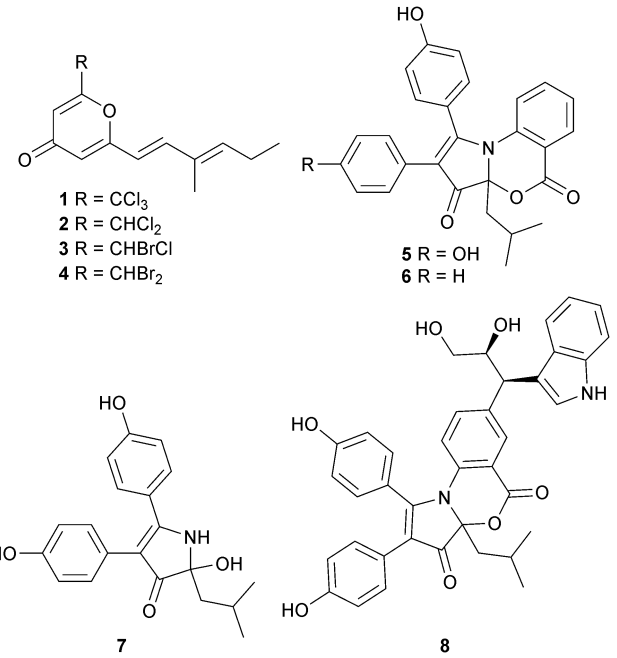
agents,[49–52] kinase inhibitors,[53] anti-*Herpes simplex* agents,[54] anti-HIV actives,[55] angiogenesis inhibitors,[56] cardioprotective peptides,[57] antithrombotic peptides,[58] antimicrobial peptides,[59] therapeutics for Gram-negative sepsis,[60] and bioactives from Antarctic and Arctic organisms.[61] The chemical ecology of plankton[62] and the possible ecological roles of cyanotoxins[63] have been reviewed. The eighth in a companion series providing an overview of synthetic aspects of MNPs has appeared with coverage of publications from 2010.[64] Further reviews of syntheses of specific compounds include marine alkyl purines,[65] tetrodotoxin,[66] (+)-spirastrellolide A methyl ester,[67] and 'upenamide, the structure of which still remains elusive.[68] A number of papers which, while not necessarily being reviews, are useful to reference here as they describe advances in techniques or approaches to discovery that are relevant to MNP studies. These include papers on novel extraction technologies for bioactives from marine algae,[69] dereplication of marine actinomycetes by LCHRMS profiling,[70] X-ray analysis on the nanogram to microgram scale using porous complexes,[71,72] rapid screening of bioactive compounds by integrating 5-channel parallel chromatography coupled with on-line mass spectrometry and microplate based assays,[73] molecular networking as a dereplication strategy,[74] NMR-based metabolomic analysis of macroalgae,[75] biogeography and biodiscovery hotspots of macroalgal compounds,[76] and coral aquaculture to support drug discovery.[77] The MarinLit database has been updated and was used as the literature source for the preparation of this present review. This database has now been transferred to the Royal Society of Chemistry from where it is available as a web-accessible version.[78]

3 Marine microorganisms and phytoplankton

MNP research effort is being increasingly directed towards marine microorganisms with 491 new compounds reported in 2013, an increase of 14% from 2012 (see 15 Conclusion). Unless otherwise stated, compounds described in this section were obtained from cultures of the named microorganisms.

3.1 Marine-sourced bacteria (excluding from mangroves)

The chlorinated pyrones halomadurone A **1** and B **2** were isolated from *Actinomadura* sp. (ascidian *Ecteinascidia turbinata*, Florida Keys, U.S.A.) and with increased concentration of potassium bromide in the growth media produced the brominated analogues halomadurone C **3** and D **4**. The halomadurones A–D activated the nuclear factor E2-related antioxidant response element, an indication of potential for treatment of neurodegenerative diseases.[79] Discoipyrroles A–D **5–8** are alkaloids isolated from *Bacillus hunanensis* (sediment, Galveston Bay, Texas, U.S.A.) that inhibit the signaling pathway of the tyrosine kinase, discoidin domain receptor 2. They were each obtained as racemates and feeding experiments with several substituted benzaldehyde precursors indicated formation through a nonenzymic process, which led to a one-pot total synthesis of discoipyrrole A **5**.[80]

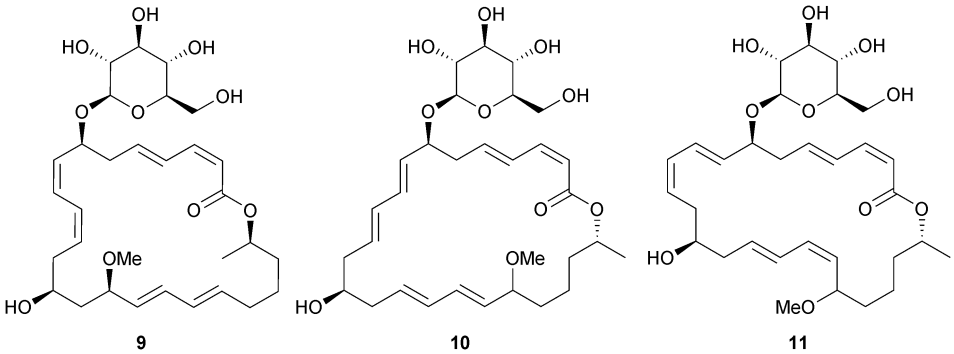


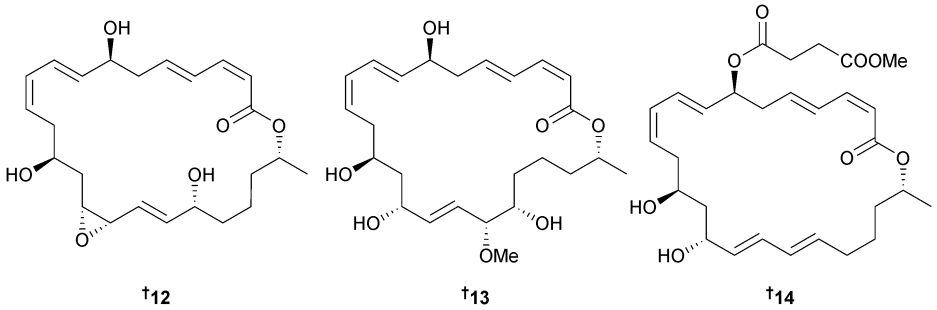
Three glycosylated methoxy-macrolactins **9–11** were isolated from *Bacillus subtilis* (*B. subtilis*) (sediment, Gageocho, S. Korea) and all displayed inhibition of Gram-positive and Gram-negative bacterial strains, in addition to modest antifungal activity.[81] A strain of *B. subtilis* (sponge *Haliclona simulans*, Gurraig Sound, Galway, Ireland) yielded subtilomycin, a partially characterised 32-amino acid compound that was partly responsible for the observed broad spectrum antimicrobial activity of the bacterium.[82]

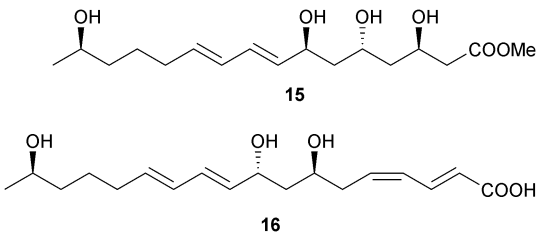
Bacillus sp. (sediment, Ieodo Reef, S. Korea)[83] produced the 24-membered macrolactones macrolactin X–Z **12–14** and the unsaturated fatty acids linieodolide A **15** and B **16**, all with modest antibacterial and antifungal activity.[84]

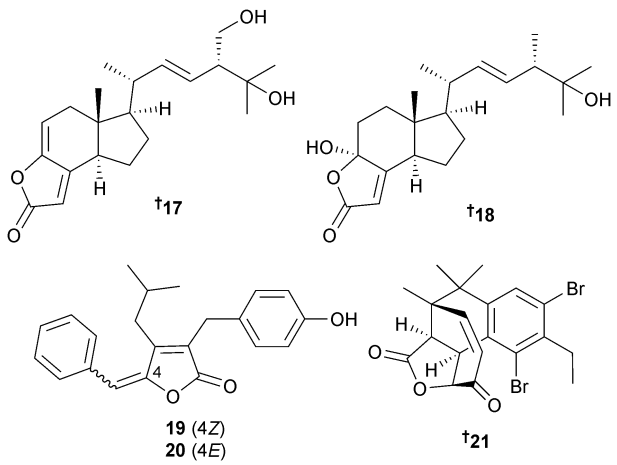
Two separate isolates of the myxobacterium *Enhygromyxa salina* yielded antibiotics. Salimyxins A **17** and B **18** were obtained from one strain (sediment, Santa Barbara, California, U.S.A.) whilst the geometric isomers enhygrolide A **19** and B **20** were isolated from another strain (sediment, Prerow, Germany). Salimyxins A **17** and B **18** are structurally very similar to demethylincisterol obtained from the sponge *Homaxinella* sp.,[85] whilst enhygrolides A **19** and B **20** are structurally related to the nostoclides, first obtained from a *Nostoc* species of cyanobacterium.[86] Salimyxin B **18** and enhygrolide A **19** were moderate growth inhibitors of the Gram-positive bacterium *Arthrobacter cristallopoietes*.[87] The obligatory marine myxobacterium *Enhygromxya salina* (sediment, Prerow Is., Germany) was the source of the tetracyclic salimabromide **21** which was a moderate inhibitor of *Arthrobacter cristallopoietes*.[88]

Kocuria palustris (sponge *Xestospongia muta*, Key Largo, Florida)[89] produced a thiazolyl peptide kocurin **22** with antibacterial activity including strong inhibition of methicillin-resistant *Staphylococcus aureus* (MRSA).[90] A molecule with the same planar structure as **22** was previously isolated from *Kocuria* sp. in Southeast Spain[91] as baringolin and is also



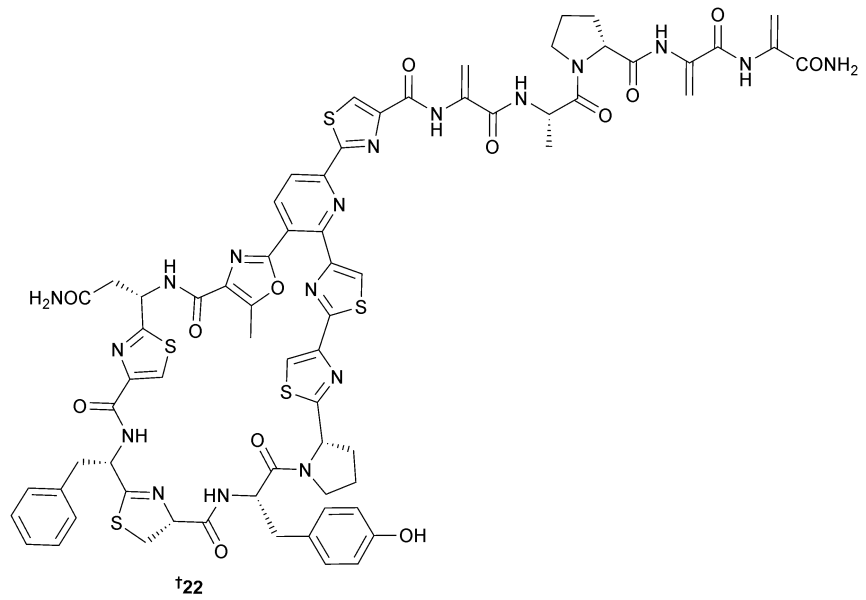






19 (4*Z*)
20 (4*E*)

believed to be a correction of the structure previously assigned to PM181104,[92] (also obtained from a *Kocuria* sp.) mentioned in a patent.[90] Kocurin, also produced by *Kocuria marina* and a *Micrococcus* sp. (Florida Keys),[93] has been synthesised by a convergent strategy in good overall yield.[94] The macrolide juvenimicin C **23** was obtained from *Micromonospora* sp. (sediment, Palau) and enhanced the activity of the enzymes quinone reductase I, glutathione reductase and glutathione peroxidase, suggesting potential as a cancer chemopreventive agent.[95] Levantilide C **24** is a 20-membered macrolide isolated from a *Micromonospora* strain (Golfo Corcovaclo, Chiloe Is., Chile) with moderate antiproliferative activity against human tumour cancer cell lines (HTCLs).[96] Two strains of *Micromonospora* (sediment, North Carolina coast, U.S.A.) yielded the polyene macrolactam micromonolactam **25**, a constitutional isomer of salinilactam A[97] but with a different polyene pattern and a (*Z*)-double bond, in contrast to the all (*E*)-structure of salinilactam A. Genome sequencing of one of the strains determined that **25** was derived from eleven polyketide units and a modified glutamate starter unit.[98] *Nocardiopsis alba* (deep-sea sediment, Indian Ocean) produced several diketopiperazines, including the new C-6 epimers nocazine D **26** and E **27** and the known synthetic compounds (*S*,*Z*)-3-benzylidene-6-methylpiperazine-2,5-dione and (*S*,*Z*)-3-benzylidene-6-isopropylpiperazine-2,5-dione,[99] both isolated for the first time



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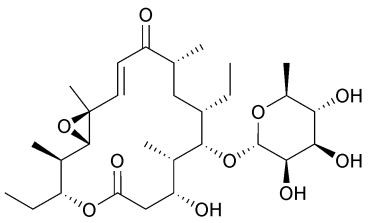

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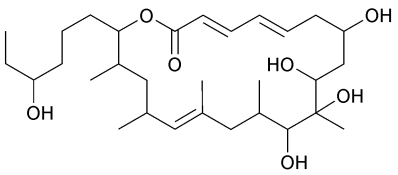

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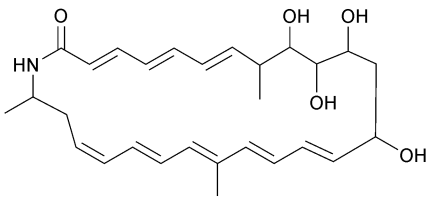

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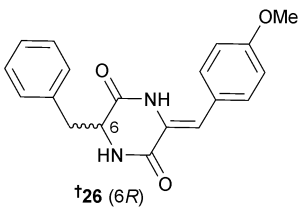
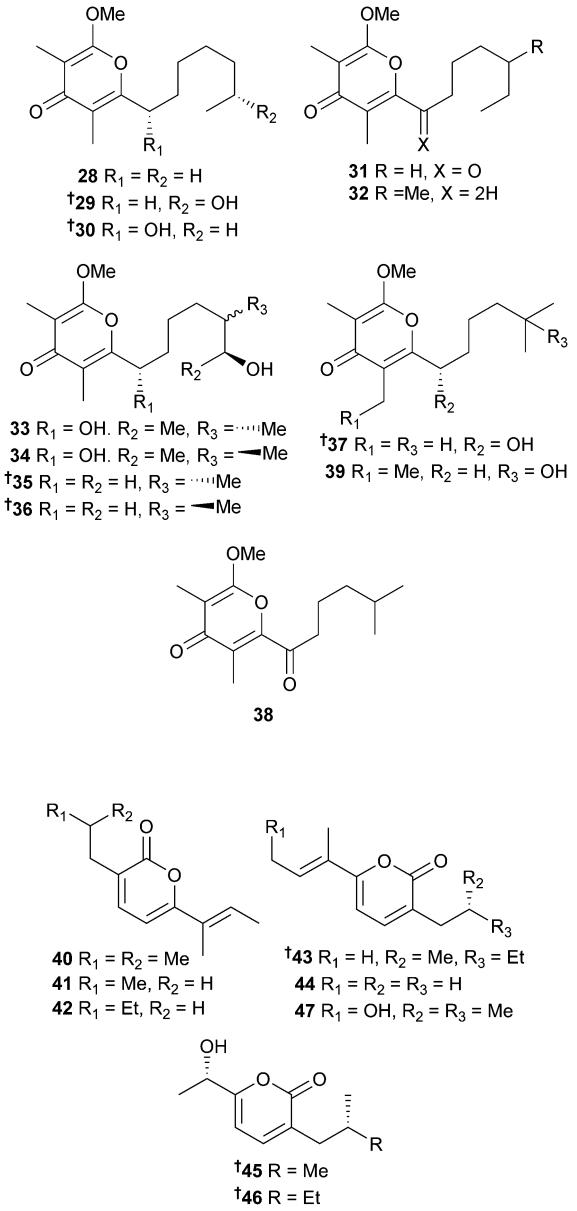


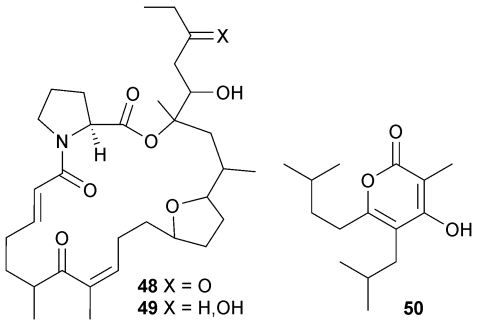
†26 (6*R*)
†27 (6*S*)

as NPs. Methoxyneihumicin was also isolated. This is a structure that had been previously reported in a conference poster[100] but not in the chemical literature. Both methoxyneihumicin and the known bacterial metabolite XR334 (ref. 101) (first time marine isolate) were modestly active against HTCLs.[102]

Three different groups of researchers have isolated metabolites from *Nocardiopsis* species and all have named them nocapyrones. To avoid confusion they are presented here in order of publication. Firstly, symbiotic *Nocardiopsis alba* (cone snail *Conus rolani*, Mactan Is., Philippines) produced the γ-pyrones nocapyrone H–Q **28–39**. Of these, nocapyrone N **35**/**36** was isolated as a mixture of enantiomers in a 10 : 1 ratio and nocapyrone M **33**/**34** occurred as an inseparable mixture of diastereoisomers. Both nocapyrone H **28** and the co-isolated nocapyrone B, previously obtained from a sponge-associated *Nocardiopsis* strain,[103] modulated nerve cell depolarisation and were active against a wide range of dorsal root ganglion neuronal cell types. Nocapyrones B and H were moderately cytotoxic to cancer cell lines.[104] Secondly, three 3,6-disubstituted α-pyrones **40–42** were isolated from *Nocardiopsis* sp. (sediment, Ulleung Basin, Eastern sea, Korea) and named nocapyrones H–J. "Nocapyrone H" **40** inhibited pro-inflammatory factors such as nitric oxide (NO), prostaglandin E2 (PGE2) and interleukin-1β (IL-1β) (potential neuroprotective effects).[105] Lastly, *Nocardiopsis dassonvillei* subsp. *dassonvillei* (sediment, Lianyungang, China) also produced α-pyrones named "nocapyrones H–N". Of these "nocapyrone H" had the same structure as **40**, "nocapyrone K" was identical to **41**, while the balance, **43–47**, were unique. "Nocapyrone I" **43** and "M" **46** displayed inhibition of quorum sensing (QS) controlled gene expression in *Chromobacterium violaceum* CV026 and *Pseudomonas aeruginosa* QSIS-*lasI* biosensors.[106]



Very clearly the naming of these metabolites needs revision. Saline culture of *Nocardiopsis* sp. (sediment, S. Molle Is., Queensland, Australia) previously yielded norcardioazines A and B[107] whilst non-saline culture of the same strain yielded nocardiopsins A and B.[108] Further investigation of the strain cultivated under non-saline conditions has resulted in the isolation of the prolinyl-macrolactam polyketides nocardiopsin C **48** and D **49** and the highly substituted α-pyrone polyketide, nocardiopyrone A **50**.[109] It should be noted that the name nocardiopyrone A has coincidentally been given to a metabolite isolated from a terrestrial species, *Nocardiopsis alkaliphila*,[110] and that the same CAS number appears to have been given to both compounds in error on the Scifinder database, with the terrestrial compound structure showing as corresponding to that CAS number.



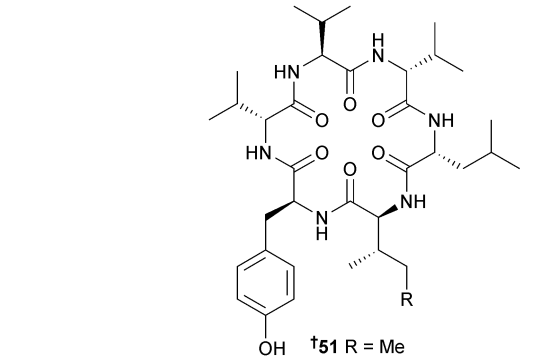
The cyclic hexapeptides nocardiamide A **51** and B **52** were isolated from *Nocardiopsis* sp. (La Jolla Canyon, San Diego, California, U.S.A.) and then synthesised *via* solid-phase peptide synthetic methods.[111] A microorganism, nominally *Paenibacillus profundus* sp. nov., (sediment, Sea of Japan) yielded a linear glyceryl acid derived heptapeptide **53** with strong antibacterial inhibition and moderate inhibition of SK-MEL-28 cells,[112] while a species of *Photobacterium*, closely related to *P. halotolerans* (mussel, Solomon Is., Pacific Ocean), was the source of the cyclodepsipeptides ngercheumicin F–I **54–57** that inhibited quorum sensing in *Staphylococcus aureus*.[113]

A *Pseudoalteromonas* sp. (oil-contaminated surface water, Gulf of Mexico after the Deepwater Horizon oil spill) yielded the siderophores lystabactin A–C **58–60** which contained the unusual nonproteinogenic amino acid 4,8-diamino-3-hydroxyoctanoic acid (LySta). Since lystabactin C is 29-methoxy lystabactin A, it may have been an artefact of isolation.[114]

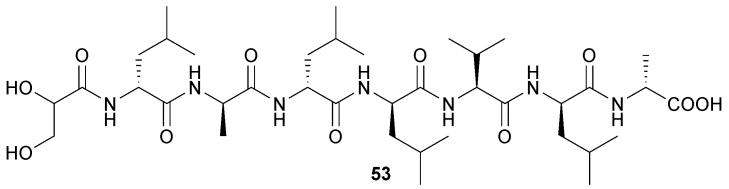
Cyanosporasides A and B are chloro- and cyano-cyclopenta[*a*]indene glycosides originally isolated from a Palauan *Salinispora pacifica* strain,[115] while cyanosporasides C–E **61–63** came from investigation of another *S. pacifica* strain (sediment, Palau) and cyanosporasides D–F **62–64** from a *Streptomyces* sp. (sediment, Bahamas). Cloning, sequencing, and mutagenesis of cyanosporaside biosynthetic gene clusters from both bacteria demonstrated that the cyanosporasides are enediyne polyketides and a two-gene operon was identified which was implicated in the nitrile functionalisation of these metabolites.[116] Further investigation of the strain of *S. pacifica* (USDA Agricultural Research Service) that produced lomaiviticins C–E[117] resulted in the isolation of (−)-homoseongomycin **65**. Synthesis of an isotopically-labelled derivative, homoseongomycin-d_5, clarified aspects of the biosynthetic pathway.[118]

The alkaloid **66** was obtained from *Serinicoccus profundi* sp. nov. (deep-sea sediment, Indian Ocean) (weak activity against *Staphylococcus aureus* (*S. aureus*))[119] and *Staphylococcus* sp. (red alga, *Corallina officinalis*, Nagasaki Shitsu Coast, Japan) provided the diketopiperazine derivatives staphyloamide A **67** and B **68**.[120] *Streptomyces antibioticus* (sediment, source not given) yielded the indanomycin-related antibiotics **69–71** as moderate growth inhibitors of *S. aureus*.[121]

The alkaloids nitrosporeusine A **72** and B **73** with an unprecedented skeleton (benzenecarbothioc cyclopenta[*c*]pyrrole-1,3-dione) were isolated from *S. nitrosporeus* (sediment, Arctic Chukchi Sea). Both nitrosporeusines inhibited the H1N1 virus in infected MDCK cells.[122] Some sesquiterpenoid



†**51** R = Me
†**52** R = H



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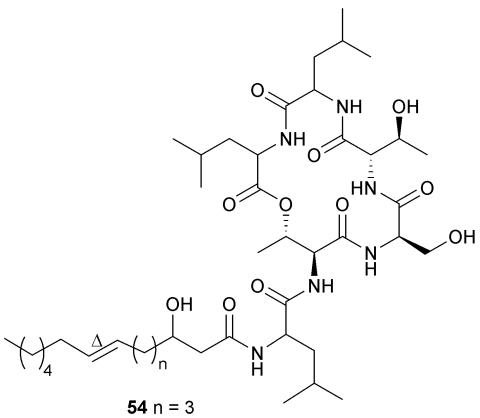


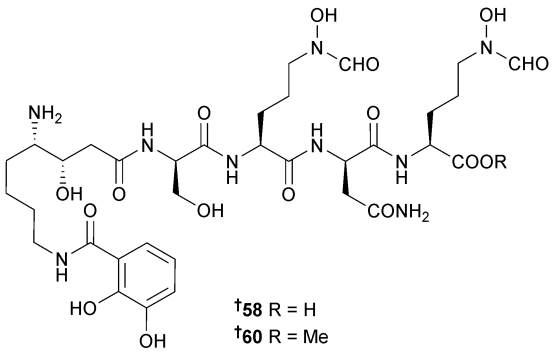
54 n = 3
55 n = 3, Δ saturated
56 n = 5
57 n = 5, Δ saturated

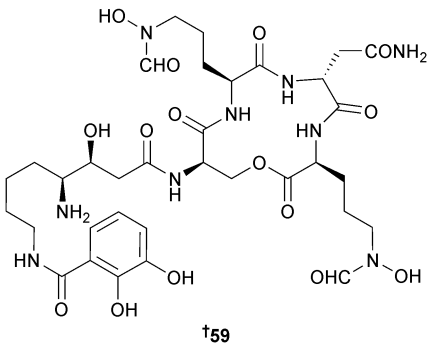
naphthoquinones marfuraquinocin A–D **74–77** and the geranylated phenazines phenaziterpene A **78** and B **79** were isolated from *S. niveus* (sediment, S. China Sea). Marfuraquinocins A **74** and C **76** were growth inhibitors of NCI–H460 cancer cells (moderate) whilst marfuraquinocins A, C and D **77** were moderate growth inhibitors of *S. aureus*, with marfuraquinocins C and D also inhibitors of methicillin-resistant *Staphylococcus epidermidis*.[123]

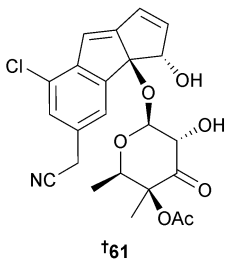
Tetroazolemycins A **80** and B **81** are oxazole/thiazole derivatives obtained from *S. olivaceus* (deep-sea water, southwest Indian Ocean), both of which showed binding affinity for the metal ions Fe^{3+}, Cu^{2+} and Zn^{2+}.[124] *S. seoulensis* (shrimp gut *Penasus orientalis*, Qingdao, China) yielded the neuraminidase inhibitors streptoseolactone **82**, limazepine G **83** and a known synthetic compound[125,126] isolated for the first time as an NP, and named limazepine H.[127] Endophytic *S. sundarbansensis* (brown alga *Fucus* sp., Bejaia, Algeria) provided the polyketide chromanone **84** (modest but selective activity against MRSA).[128]

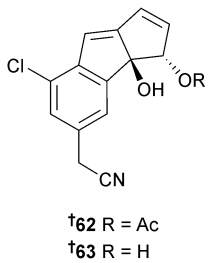
S. tateyamensis (sponge *Haliclona* sp., Tateyama City, Japan)[129] was the source of JBIR-107 **85**,[130] while the phenoxazine-based alkaloids venezueline A–E **86–90** and the aminophenols venezueline F **91** and G **92** were obtained from *S. venezuelae* (sediment, Guam) with the known analogues exfoliazone,[131] chandrananimycin D[132] and carboxyexfoliazone,[133] all previously obtained from terrestrial *Streptomyces* species but now first time marine isolates. Venezueline B **87** was moderately cytotoxic towards a panel of HTCLs.[134]

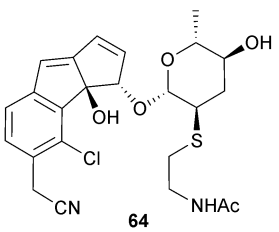
Double mutation of a strain of *S. xiamenensis* (sediment, Eastern Pacific Ocean) led to production of two benzopyran derivatives xiamenmycin C **93** and D **94**, which both inhibited proliferation of human lung fibroblasts (WI26),[135] and *Streptomyces* sp. (unidentified soft coral, Weizhou Is., Guangki Province, China) was the source of the chlorinated polyketides strepchloritide A **95** and B **96** cytotoxic against MCF-7 cells (modest).[136] Chlorizidine A **97**, comprised of a chlorinated 2,3-dihydropyrrolizine ring attached to an unprecedented chlorinated 5*H*-pyrrolo[2,1-*a*]isoindol-5-one, was isolated from a

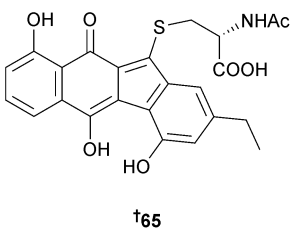


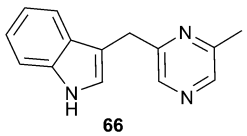


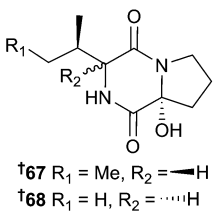


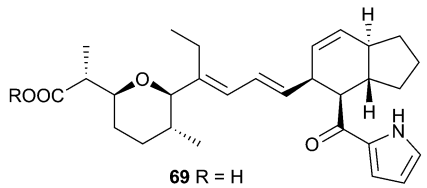


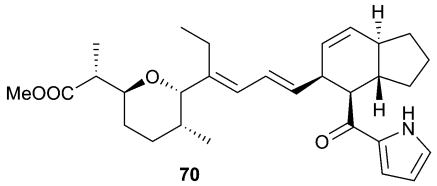


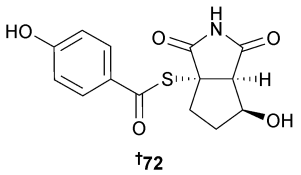


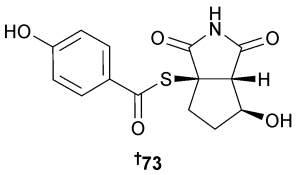


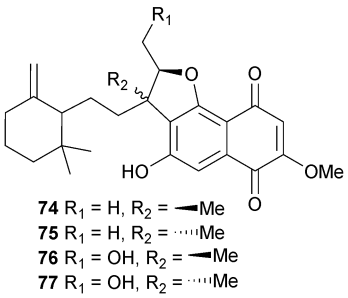


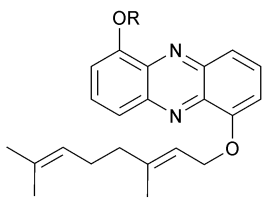








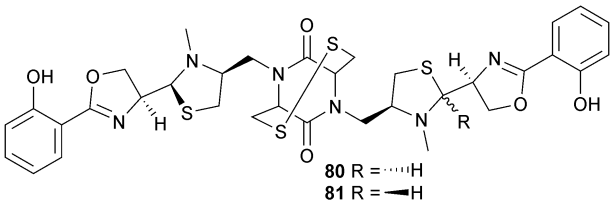


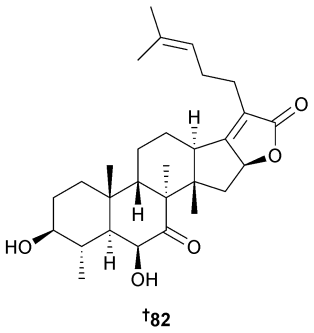


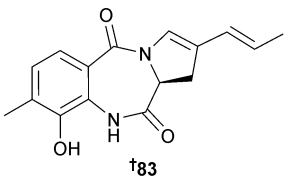
Streptomyces strain (sediment, San Clemente, California, U.S.A.) and was moderately cytotoxic to a panel of HTCLs.[137] The biosynthetic gene cluster of chlorizidine A **97** was identified and whole pathway heterologous expression and genetic manipulations were utilised to show that it is assembled by a polyketide synthase (PKS) that uniquely incorporates a fatty acid synthase-derived dichloropyrrolyl extender unit into the pyrroloisoindolone enzymic product.[138]

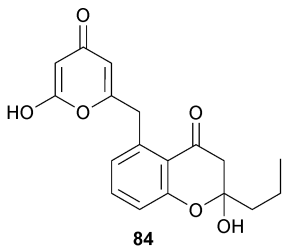
The diketopiperazine derivatives **98–102** were obtained from *Streptomyces* sp. (sediment, Huanghai Beach, Dalian, China) and **100** displayed modest activity against the influenza A (H1N1) virus, whilst the co-isolated fungal metabolites (3*Z*,6*S*)-3-benzylidene-6-isobutylpiperazine-2,5-dione[139] and albomoursin[140] displayed potent inhibition of the virus and were first time marine isolates.[141]

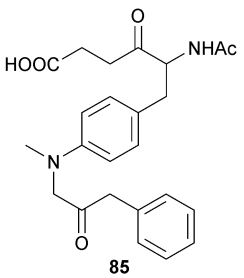
Streptomyces sp. (sediment, S. China Sea) yielded the spirotetronate lobophorin G **103**, a potent inhibitor of both *Mycobacterium bovis* Bacillus Calmette-Guerin (BCG) and *B. subtilis* and a moderate inhibitor of *Mycobacterium tuberculosis* (*M. tuberculosis*).[142] Sungsanpin **104** isolated from a *Streptomyces* sp. (deep-sea sediment, Jeju Is., S. Korea) is an example of a so-called lasso peptide, a ribosomally synthesised peptide of between 16 and 23 amino acids with an N-terminal eight- or nine-residue ring with a linear C-terminus threaded through the ring.[143] Sungsanpin inhibited A549 cells in a cell invasion assay.[144]

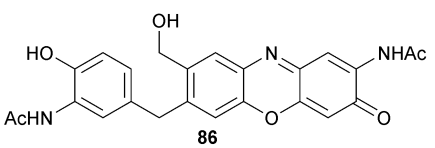


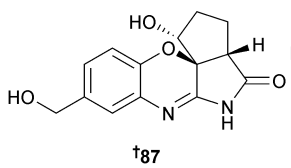


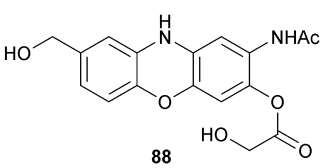


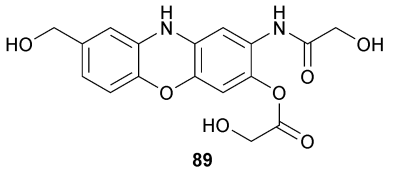


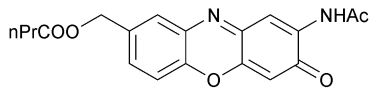


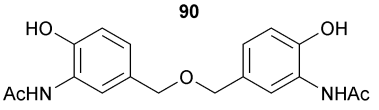


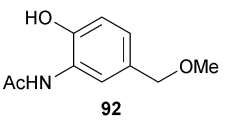


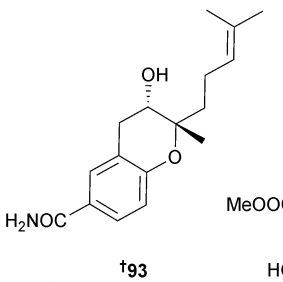


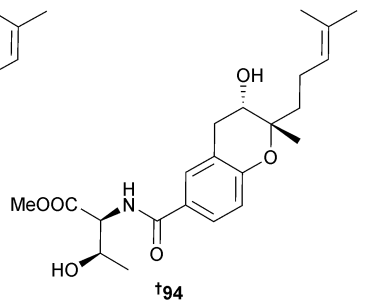


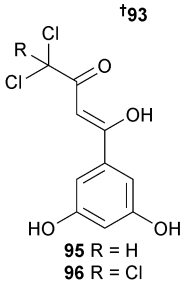


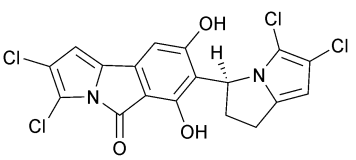


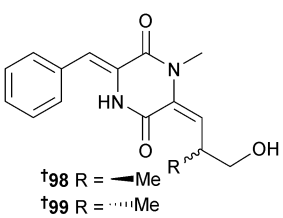


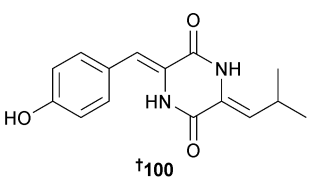


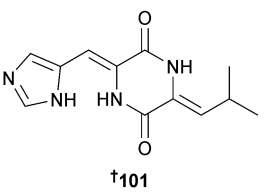


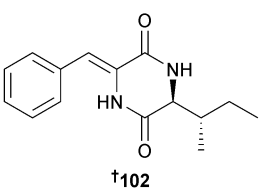








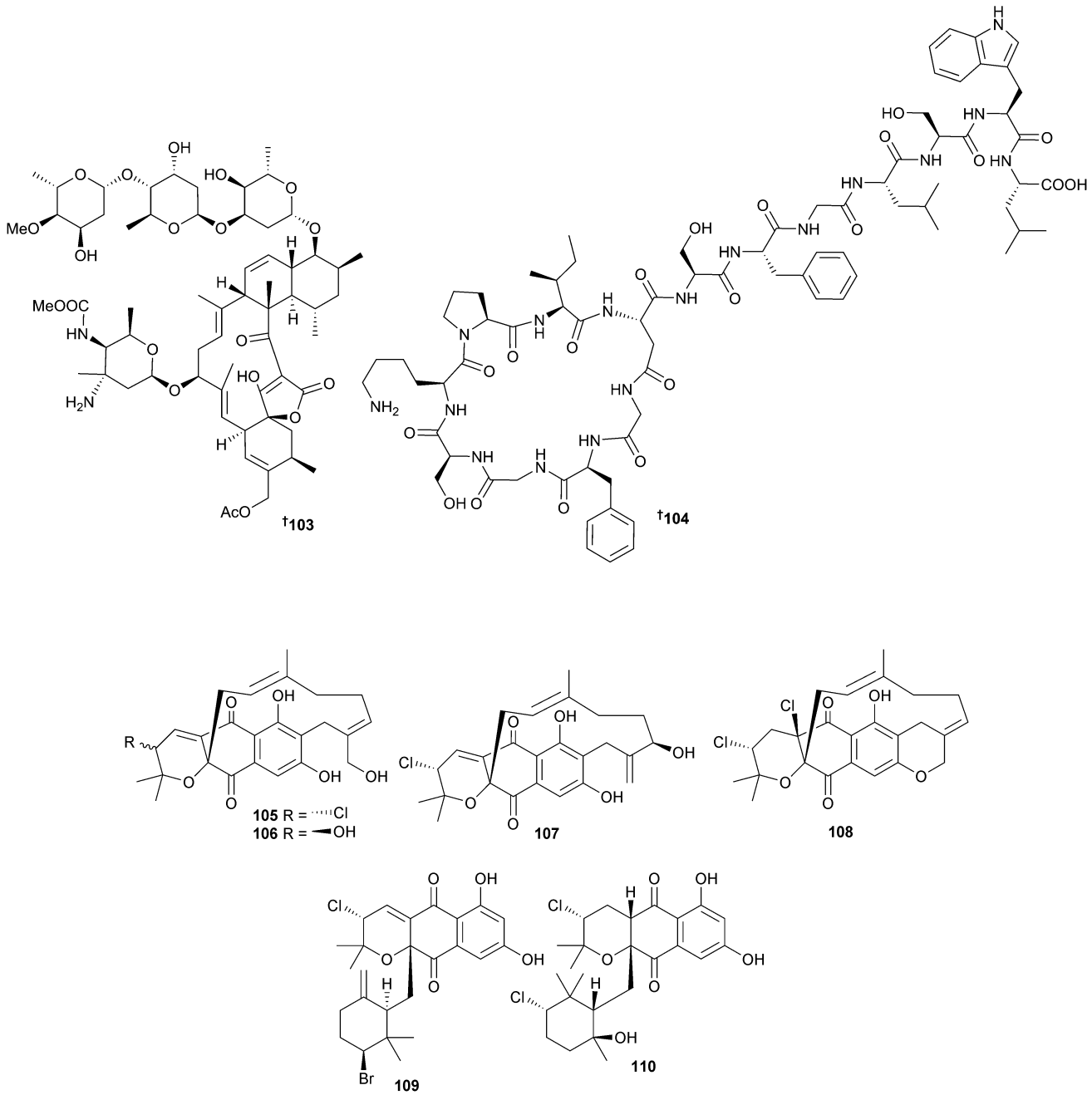




Investigation of two different *Streptomyces* strains identified six new napyradiomycin analogues. The *Streptomyces* strain CNQ-329 (sediment, San Diego, California, U.S.A.) produced napyradiomycins A–E **105–109**, while strain CNH-070 (sediment, San Elijo Lagoon, Encinitas, California, U.S.A.) produced napyradiomycin F **110**.

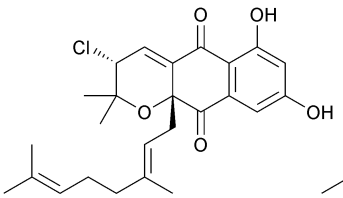
Four of the napyradiomycins A, D–F were cytotoxic (moderate) to HCT-116 cells whilst napyradiomycins A and B inhibited MRSA (moderate).

Also isolated were napyradiomycins B2–B4; B3 (ref. 145) and B4 (ref. 146) as first time marine isolates.[147] Three napyradiomycins, 4-dehydro-4a-dechloronapyradiomycin A1 **111**, 3-dechloro-3-bromonapyradiomycin A1 **112** and 3-chloro-6,8-

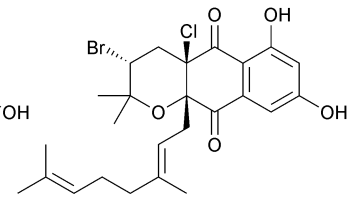


dihydroxy-8-α-lapachone **113** isolated from a *Streptomyces* species (sediment, Xieyang Is., Beihai, Guangxi Province, China) displayed moderate inhibition of several Gram-positive bacteria while 3-dechloro-3-bromonapyradiomycin A1 **112** was moderately active against several HTCLs.[148] A *Streptomyces* sp. (sediment, Santa Barbara, California, U.S.A.) yielded the antibiotic anthracimycin **114**, significantly active against *Bacillus anthracis*. Early *in vivo* results indicated that **114** also provided significant protection against MRSA cell lines. The planar structure of anthracimycin **114** may have been published in a 2011 patent[149] but insufficient detail was given to permit a full comparison.[150]

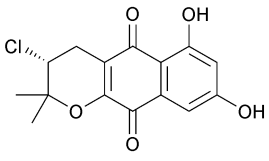
Surugamides A–E **115–119**, cyclic octapeptides with four D-amino acid residues, were obtained from *Streptomyces* sp. (deep-sea sediment, Kinko Bay, Japan) and were modest inhibitors of the protease enzyme bovine cathepsin B.[151] Three strains of *S. champavatii* (sediment, Gotland Deep and Kiel Bight, Baltic Sea and Urania Basin, Eastern Mediterranean) produced the octapeptide champacyclin **120**, an inhibitor of the bacterium *Erwinia amylovora*, the causative agent of fire blight disease in certain plants. Champacyclin **120** has the same



†111



†112



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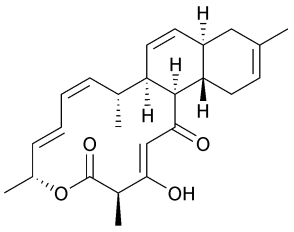
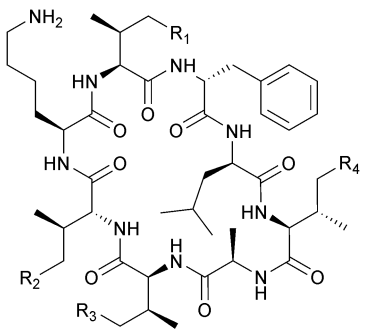
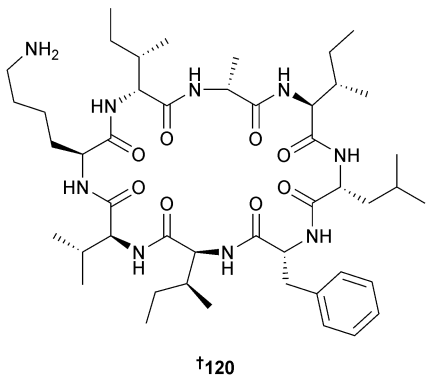


†114

planar structure as surugamide A **115** but different configurations at two amino acid residues. Champacyclin was also prepared by solid-phase peptide synthesis.[152]

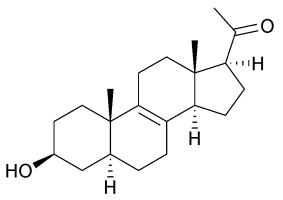


†**115** $R_1 = R_2 = R_3 = R_4 = Me$
†**116** $R_1 = R_3 = R_4 = Me$, $R_2 = H$
†**117** $R_1 = H$, $R_2 = R_3 = R_4 = Me$
†**118** $R_1 = R_2 = R_4 = Me$, $R_3 = H$
†**119** $R_1 = R_2 = R_3 = Me$, $R_4 = H$

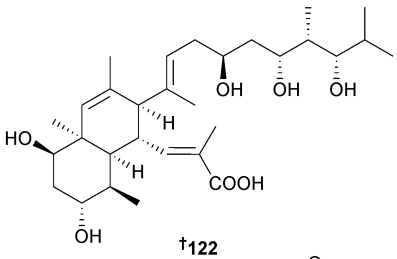


†120

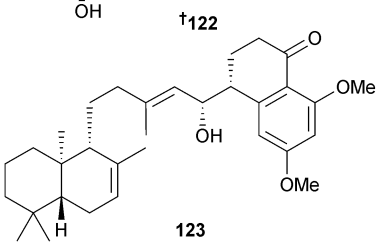
Streptomyces sp. (sediment, S. China Sea) yielded the pregnene steroid 3219A **121** with a rare $\Delta^{8,9}$-double bond in the skeleton,[153] and the polyketide nahuoic acid A **122** was obtained from a *Streptomyces* sp. (sediment, Padana Nahua, Papua New Guinea) as a selective SAM-competitive inhibitor of the histone methyltransferase enzyme SETD8.[154] A meroterpenoid actinoranone **123** was isolated from a bacterium, likely a *Streptomyces* species (sediment, San Diego, California, U.S.A.)[155] as a moderate cytotoxin of HCT-116[156] and *Streptomyces* sp. (sediment, Marsa Matruh city, Egypt) was the source of maroxazinone **124**, moderately cytotoxic to several HTCLs.[157]



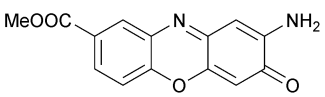
†121



†122

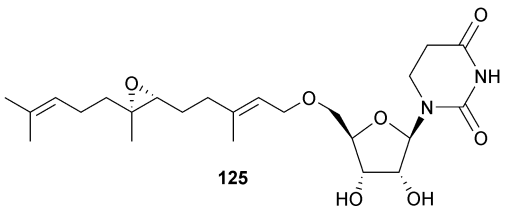


123

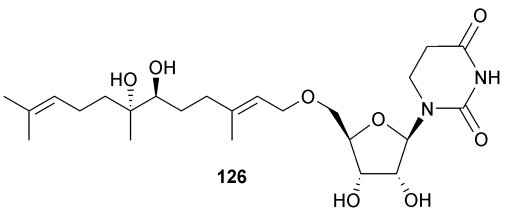


124

Farnesides A **125** and B **126**, linear sesquiterpenoids connected by ether linkages to a ribose dihydrouracil nucleoside, came from *Streptomyces* sp. (sediment, Nacula Is., Yasawa Is., Fiji) with farneside A modestly active against *Plasmodium falciparum* (*P. falciparum*).[158]

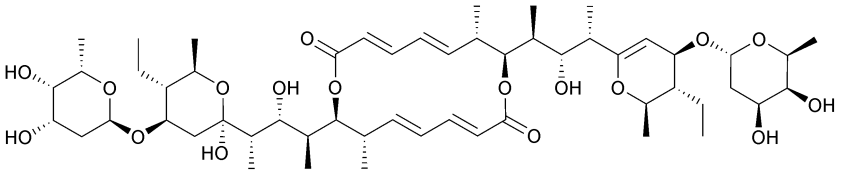


125

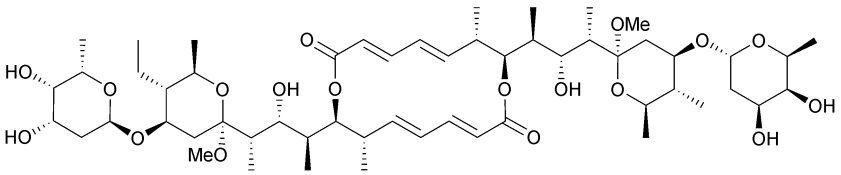


126

A PCR-based genetic screening experiment targeting the dTDP-glucose-4,6-dehydratase gene was used to identify that



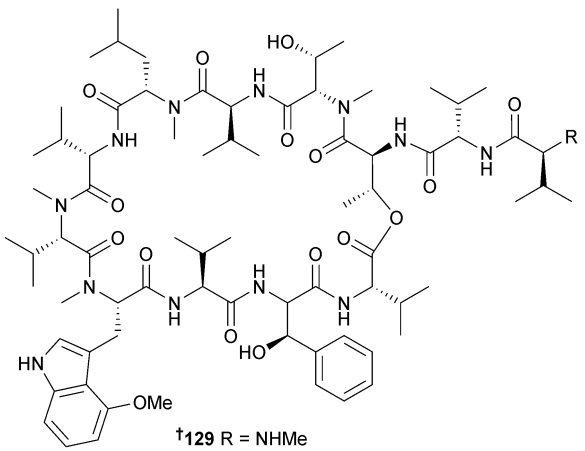
†127



†128

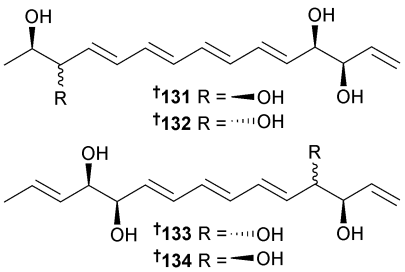
a *Streptomyces* sp. (sediment, Heishijiao Bay, Dalian, China) could potentially produce glycosidic antibiotics. Further investigation of this strain yielded the 6-deoxyhexose-containing antibiotics, 11′,12′-dehydroelaiophylin **127** and 11,11′-*O*-dimethyl-14′-deethyl-14′-methylelaiophylin **128**, of which **127** was an inhibitor of MRSA and vancomycin-resistant *Enterococci* pathogens. The elaiophylin derivative **128** might be an artefact resulting from methanolysis during the isolation procedure.[159]

The cyclic peptides ohmyungsamycin A **129** and B **130** were isolated from a *Streptomyces* sp. (sand, Shinyang Beach, Jeju Is., S. Korea). During determination of configurations a new method to determine the absolute configuration of *N*,*N*-dimethylvaline was developed which utilises phenylglycine methyl ester derivatisation coupled with chromatographic analysis and provides a general and convenient method for determination of the configurations of amino acids with fully substituted amine groups. Ohmyungsamycins A **129** and B **130** inhibited growth of several HTCLs and of Gram-positive and Gram-negative bacteria with ohmyungsamycin A **129** being much more potent than B **130**.[160]



†**129** R = NHMe
†**130** R = NMe_2

Separacenes A–D **131–134** are polyene polyols obtained from *Streptomyces* sp. (sediment, Jeju Is., S. Korea). Separacenes A **131** and B **132** are C-3 epimers whilst separacenes C **133** and D **134** are C-12 epimers. Separacene A **131** was a modest inhibitor of *Candida albicans* (*C. albicans*) isocitrate lyase and two HTCLs.[161]

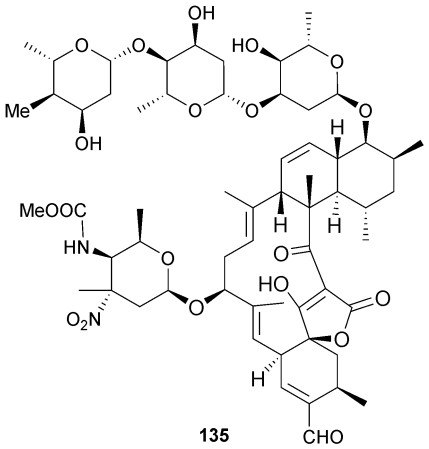


†**131** R = OH
†**132** R = OH
†**133** R = OH
†**134** R = OH

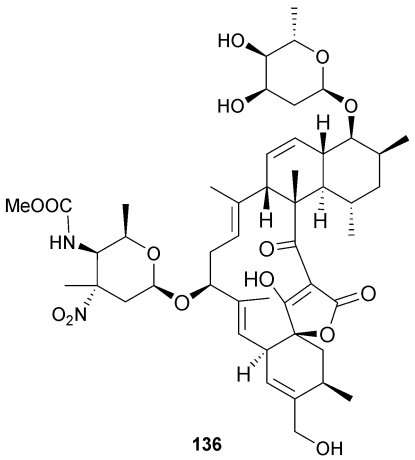
Streptomyces sp. (deep-sea sediment, S. China Sea) was the source of lobophorins H **135** and I **136** of which lobophorin H **135** exhibited significant inhibition of *B. subtilis* and moderate inhibition of *S. aureus* while lobophorin I **136** was much less active.[162]

The polycyclic polyketide akaeolide **137** was isolated from a *Streptomyces* sp. (sediment, Miyazaki Harbour, Japan) as a modest cytotoxin to 3Y1 rat fibroblasts.[163] Strepsesquitriol **138**, a caged sesquiterpene isolated from *Streptomyces* sp. (sediment, Bay of Bengal, Indian Ocean), was a moderate inhibitor of lipopolysaccharide-induced TNFα production in RAW264.7 macrophages,[164] while cycloheximide acid A **139** was obtained from *Streptomyces* sp. (seawater, E. China Sea, Wenzhou, Zhejiang Province, China).[165]

The immunosuppressant cyclic lipopeptides thalassospiramides A and B were originally obtained from the α-proteobacterium *Thalassospira* sp.[166] Reinvestigation of the original producer, a second strain of *Thalassospira* (source not given), *Tistrella mobilis* (Red Sea[167]) and *Tistrella bauzanensis* (Pacific Ocean[167]) led to the isolation of fourteen analogues thalassospiramides A1–A5 **140–144**, C **145** and C1 **146**, E **147** and E1 **148**, B1 **149** and B2 **150**, D **151** and D1 **152** and thalassospiramide F **153** that have been subdivided into six structural classes with variations in the length and composition of the acyl peptide side chain. The planar



135



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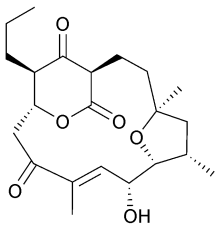
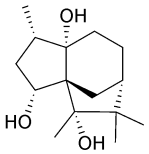
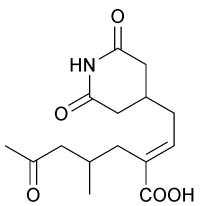


†137



†138



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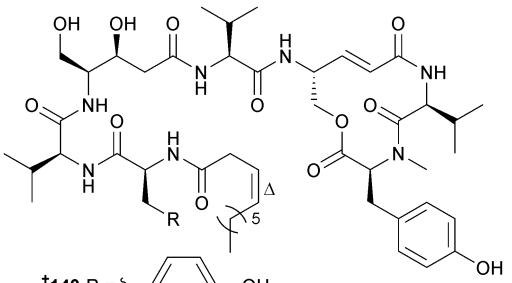
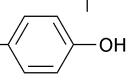
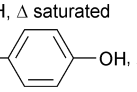


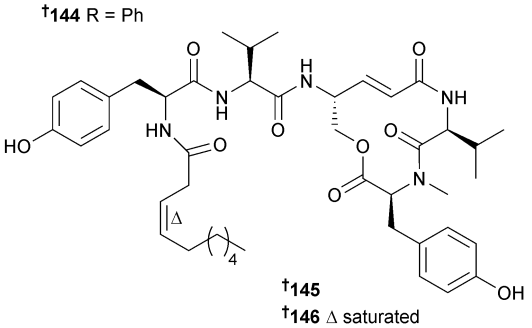
†140 R =  OH

†141 R = OH, Δ saturated

†142 R =  OH, Δ saturated

†143 R = *i*Pr

†144 R = Ph



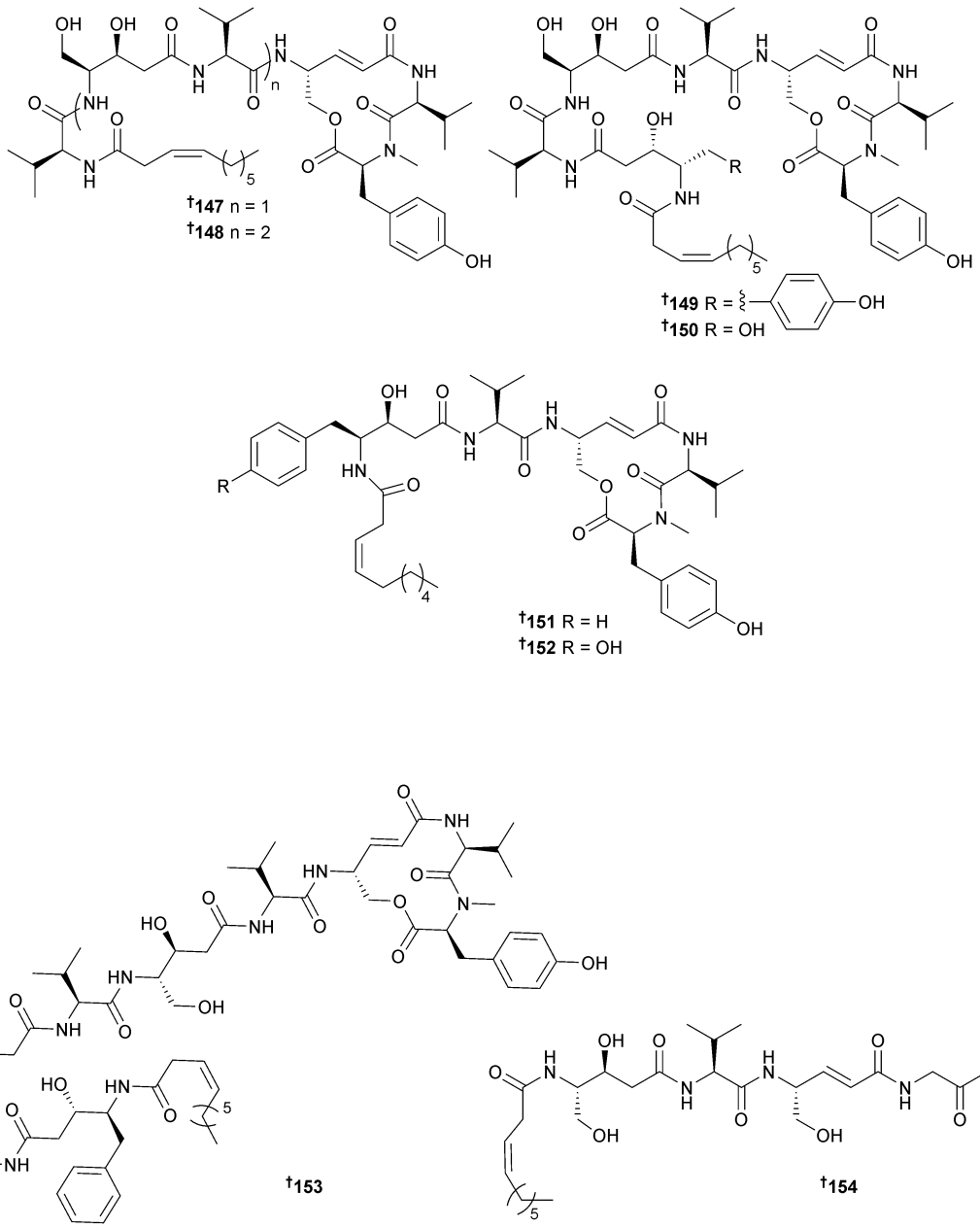
†145

†146 Δ saturated

structures of **149** and **152** were described in a patent as metabolites of another α-proteobacterium, *Oceanospirillum* sp.[168] and potent inhibitors of the cysteine protease calpain 1. In the current study selected thalassospiramides (A, A1, B, C, D1 and E1) were tested and all displayed potent activity against calpain 1. Biosynthetic gene clusters for all four bacterial strains were characterised revealing some atypical NRPS biochemical features such as intrasynthetase *trans* A domain activation, module skipping and multimodule iteration which likely yield the structural diversity.[169] *Thalassospira* sp. (brown alga *Rosenvingea* sp., Bahamas) yielded a further member of the thalassospiramide family of peptides, thalassospiramide G **154**. The co-isolated thalassospiramides A[166] and D[169] were moderate inhibitors of NO production in lipopolysaccharide (LPS)-stimulated mouse macrophage RAW 264.7 cells.[170]

The 18-membered macrolide macplocimine A **155** was obtained from the filamentous sulfur bacterium *Thioploca* sp. (benthic microbial mat, Chile).[171] *Verrucosispora* sp. (deep-sea sediment, S. China Sea) was the source of three further abyssomicin polyketides abyssomicin J–L **156–158**. Abyssomicin C[172] was also isolated and converted to abyssomicin J **156**. *In vitro* and cell-based analytical studies were then used to show that abyssomicin J **156** can act as a prodrug which, upon oxidative activation, will be selectively transformed to *atrop*-abyssomicin C,[173] an anti-TB antibiotic.[174]

Heronamide A, a polyketide macrolactam originally obtained from an Australian, sediment-derived *Streptomyces* sp.,[175] was reisolated from a *Streptomyces* sp. (sediment, Uranouchi Bay, Kochi Prefecture, Japan). Detailed NMR analysis of heronamide A and derivatives resulted in configurational reassignment of heronamide A to **159** and the suggestion that

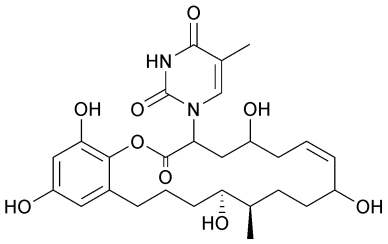


the configurations of heronamides B[175] and C[175] should be reinvestigated.[176]

The configuration of the α-methylserine residue in the tetrapeptides JBIR-34 and JBIR-35 and in the trichostatin analogue JBIR-111, originally obtained from a sponge-derived *Streptomyces* sp.[177,178] have been corrected from (*R*) to (*S*).[179,180] *Tenacibaculum mesophilum* (unidentified sponge, Republic of Palau) yielded a siderophore bisucaberin B. This is an open form of the known macrocyclic dimer bisucaberin[181,182] that has been reported as a degradation product of desferrioxamine B[183] but not as a product of *de novo* biosynthesis.[184]

3.2 Bacteria from mangroves

Bacillus hunanensis (sediment, Trinity Bay, Galveston Texas, U.S.A.) yielded hunanamycin A **160**, the first NP with a pyrido [1,2,3-de]quinoxaline-2,3-dione core, which also displayed modest inhibition of *Salmonella enterica*.[185] Hunanamycin A was subsequently synthesised *via* a simple and scaleable method from 6,7-dimethyl-1,4-dihydroquinoxaline-2,3-dione.[186] An indole alkaloid **161** was obtained from *Pantoea agglomerans* (mangrove *Ceriops tagal*, Zhanjiang, Guangdong, China) along with two phenylethylamine derivatives, 3-(*p*-hydroxy)benzoyl indole[187] and 1,2-di(1*H*-indol-3-yl)ethane,[188] both known synthetic compounds but now isolated for the first time as MNPs.[189]



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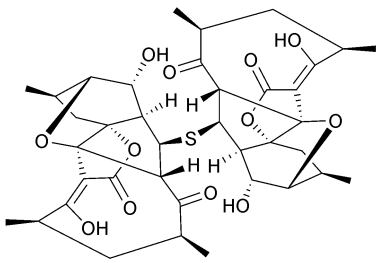
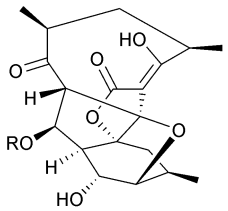
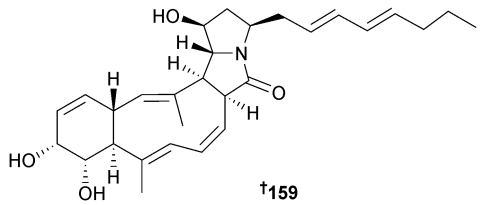


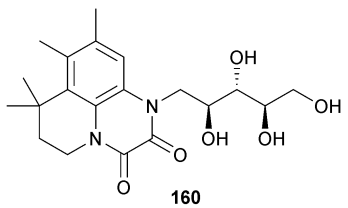
†156



†157 R = H
†158 R = Me



†159



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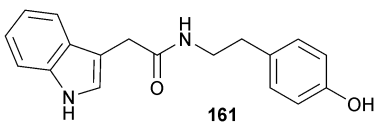
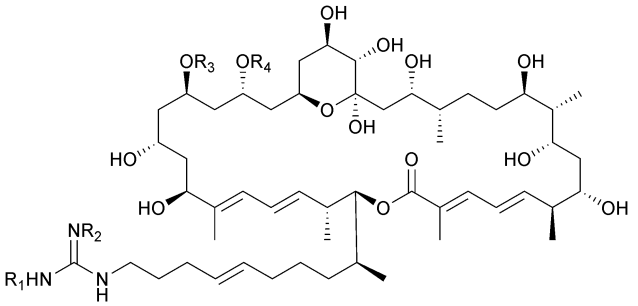
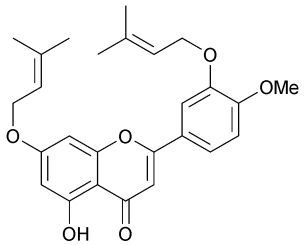


161

Streptomyces sp. (mangrove rhizosphere soil *Heritiera globosa*, Wenchang, China)[190] was the source of a series of azalomycin F analogues **162–168** which were all broad-spectrum antimicrobials and inhibitors of HCT-116 cells.[191] The di-*O*-prenylated flavone **169** was isolated from an endophytic *Streptomyces* sp. (mangrove root *Myoporum bontioides*, Leizhou Peninsula, Guangdong Province, China) and was a moderate inhibitor of the plant pathogenic fungi, *Colletotrichum musae*, *Gibberella zeae* and *Penicillium citrinum*.[192]



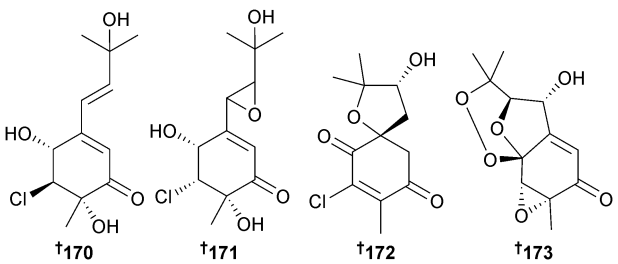
162 $R_1 = R_2 = Me$, $R_3 = COCH_2COOH$, $R_4 = H$
163 $R_1 = R_2 = Me$, $R_3 = H$, $R_4 = COCH(NH_2)CHMe_2$
164 $R_1 = R_2 = R_3 = H$, $R_4 = CO(CH_2)_4CHMe_2$
165 $R_1 = R_3 = H$, $R_2 = Me$, $R_4 = CO(CH_2)_4CHMe_2$
166 $R_1 = R_2 = Me$, $R_3 = H$, $R_4 = CO(CH_2)_4CHMe_2$
167 $R_1 = R_3 = H$, $R_2 = Me$, $R_4 = CO(CH_2)_7CHMe_2$
168 $R_1 = R_3 = H$, $R_2 = Me$, $R_4 = CO(CH_2)_8CHMe_2$



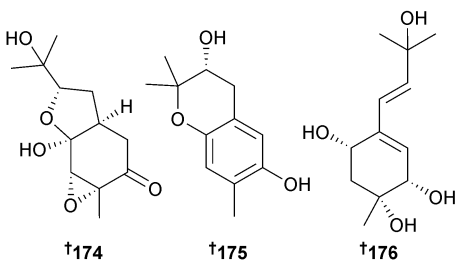
169

3.3 Marine-sourced fungi (excluding from mangroves)

Several acremine metabolites, 5-chloroacremine A **170**, 5-chloroacremine H **171** and acremines O–R **172–175**, together with the known terrestrial fungal metabolite acremine F,[193] were isolated from *Acremonium persicinum* (sponge *Anomoianthella rubra*, Gneering Reef, S. E. Queensland, Australia). The configuration of acremine F was determined as **176** and this was the first isolation as an MNP.[194]

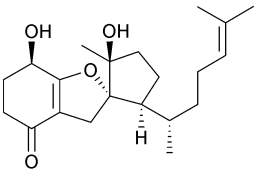


†170 †171 †172 †173

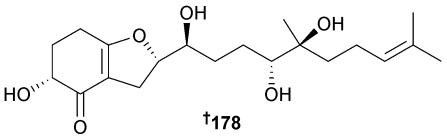


†174 †175 †176

Alternaria sp. (sponge *Callyspongia* sp., Sanya, Hainan Is., China) was the source of a variety of meroterpenoids including tricycloalternarene A **177**, the hydrogenated benzofurans, bicycloalternarene A–D **178–181**, the hydrogenated chromans,



†177



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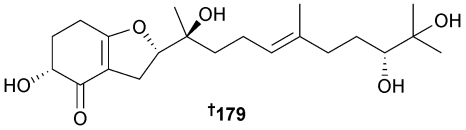
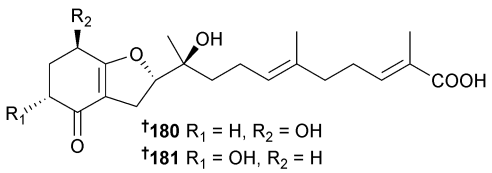
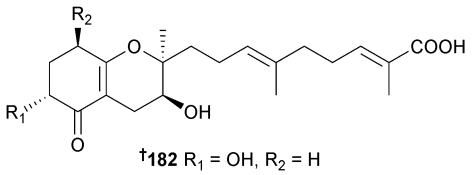


†179

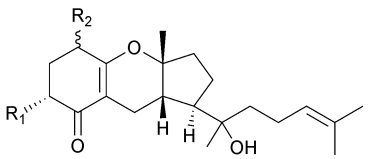
bicycloalternarene E **182** and F **183**, and the hydrogenated cyclopenta-[*b*]-chromans, tricycloalternarene B **184** and C **185**. Four additional monocyclic meroterpenoids monocycloalternarene A[195] **186** and monocycloalternarene B–D **187–189** were obtained when the putative precursors sodium 3,4-dihydroxybenzoic acid or shikimic acid were fed to the fungus, reinforcing the proposed shikimate-isoprenoid hybrid biosynthetic pathway. All the metabolites except bicycloalternarenes E **182** and F **183** were weak to moderate inhibitors of NF-κB in RAW264.7 cells.[196]



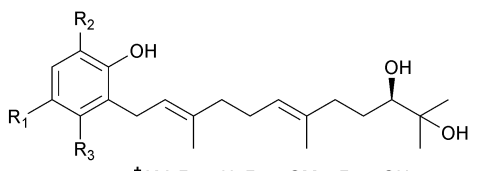
†180 R_1 = H, R_2 = OH
†181 R_1 = OH, R_2 = H



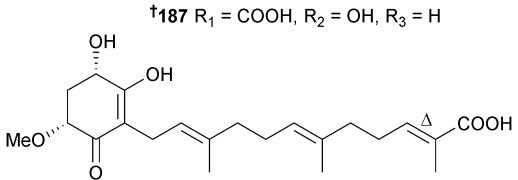
†182 R_1 = OH, R_2 = H
†183 R_1 = H, R_2 = OH



184 R_1 = OMe, R_2 = ⋯OH
185 R_1 = H, R_2 = ▬OH

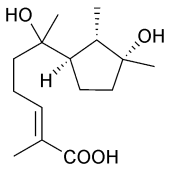


†186 R_1 = H, R_2 = OMe, R_3 = OH
†187 R_1 = COOH, R_2 = OH, R_3 = H



†188 Δ saturated
†189

The sesquiterpene ascotrichic acid **190** was isolated from *Ascotricha* sp. (coastal mud, Fenghua County, Zhejiang, China).[197] The benzoquinone derivatives aculeatusquinone A–D **191–194** were isolated from *Aspergillus aculeatus* (sediment, Langqi Is., Fujian, China) and of these aculeatusquinones B and D were moderately cytotoxic to several HTCLs.[198]



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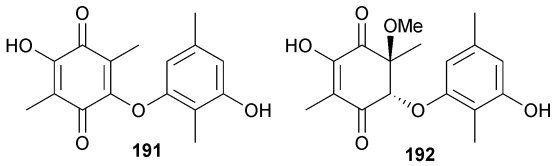
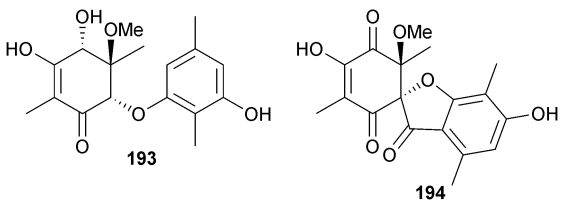
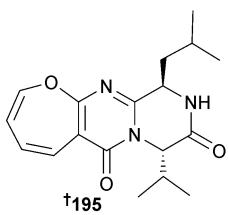


191 192



193 194

An oxepin-containing alkaloid **195**, a quinazolinone-containing alkaloid **196** and a dihydrobenzofuran derivative **197** were obtained from *A. carneus* (brown alga *Laminaria sachalinensis*, Kunachir Is., Russia).[199] Clavatustides A **198** and B **199**, cyclodepsipeptides with an unusual anthranilic acid dimer and a D-phenyllactic acid residue, were isolated from *A. clavatus* (hydrothermal vent crab *Xenograpsus testudinatus*, Kueishantao, Taiwan) and suppressed proliferation of HTCLs.[200]



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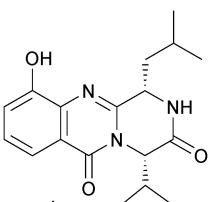

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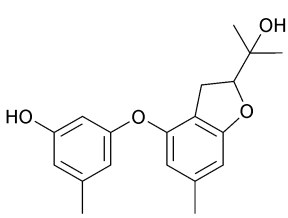

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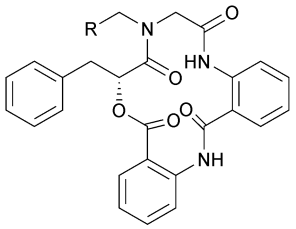
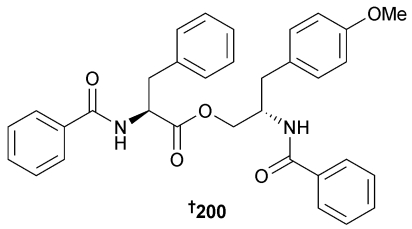
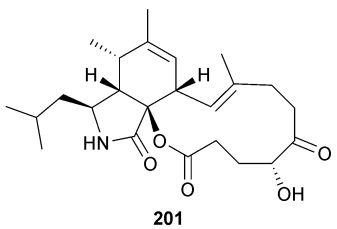
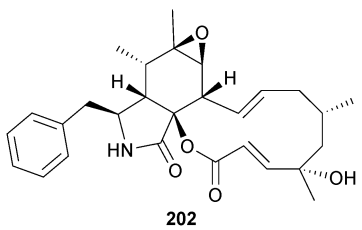


†198 R = Me
†199 R = H

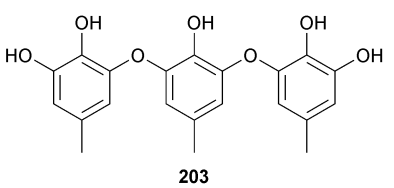
A. elegans (soft coral *Sarcophyton* sp., Weizhou coral reef, S. China Sea) produced the phenylalanine derivative 4′-methoxyasperphenamate **200** and the cytochalasins aspochalasin A1 **201** and cytochalasin Z24 **202**, in addition to a number of known cytochalasin analogues. 4′-Methoxyasperphenamate **200** was modestly active against *Staphylococcus epidermidis* while the known cytochalasins aspochalasin I,[201] J,[201] D[202,203] and H[204] displayed strong antifouling activity against larval settlement of the barnacle *Balanus amphitrite* (*B. amphitrite*). Aspochalasins I, J and H, previously isolated from terrestrial *Aspergillus* species, are first time MNPs.[205]

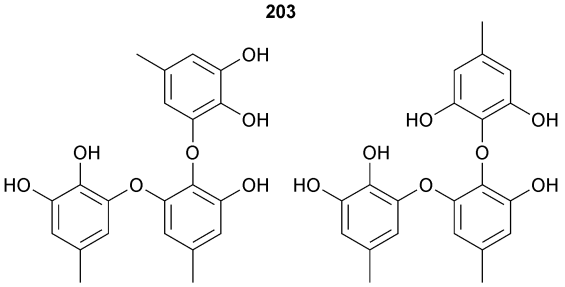


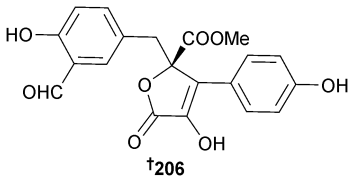




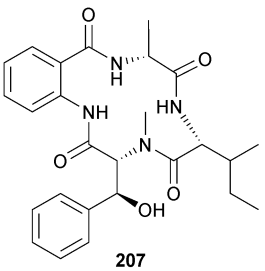
Of the tris-pyrogallol ethers sydowiol A–C **203–205** from *A. sydowii* (sediment, E. China Sea), sydowiols A **203** and C **205** inhibited *M. tuberculosis* protein tyrosine phosphatase A (PTPA).[206] *A. terreus*, *var. boedijnii* (Blochwitz) (red alga *Laurencia ceylanica*, Arugam Bay, Sri Lanka) produced a new butyrolactone **206** which was a strong inhibitor of the enzyme β-glucuronidase.

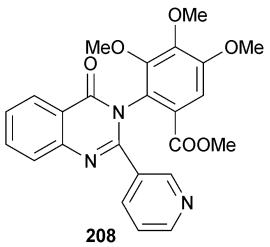


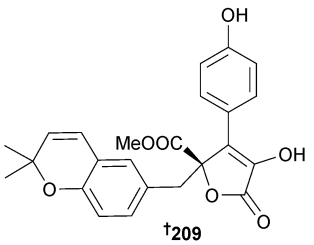




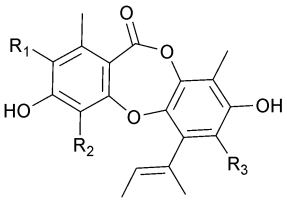
A number of known compounds were also isolated which included (+)-asterrelenin,[207] a moderate inhibitor of β-glucuronidase, (3*R*,4*R*)-6,7-dimethoxy-4-hydroxymellin[208] and (+)-territonin A,[207] all reported as first time MNPs.[209] The cyclic tetrapeptide asperterrestide A **207**, the alkaloid terremide C **208** and an aromatic butenolide aspernolide E **209** were obtained from *A. terreus* (gorgonian *Echinogorgia aurantiaca*, Sanya, Hainan Province, China). Asperterrestide A **207** inhibited influenza virus strains H1N1 and H3N2 and was cytotoxic to HTCLs.[210]



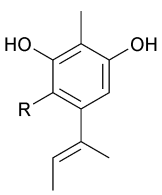




Cultivation of *A. unguis* (unidentified sponge, Tub-La-Mu Bay, Pang-nga Province, Thailand) in media containing different halogen salts led to the production of "unnatural natural" depsidones. Growth in media containing KBr produced the brominated depsidones aspergillusidone D–F **210–212** and the orcinol derivatives aspergillusidone A **213** and B **214**, whilst culture in KI produced another new depsidone 2,4-dichlorounguinol **215**. Of these, aspergillusidones D–F **210–212** inhibited aromatase, a therapeutic target for breast cancer treatment.[211]

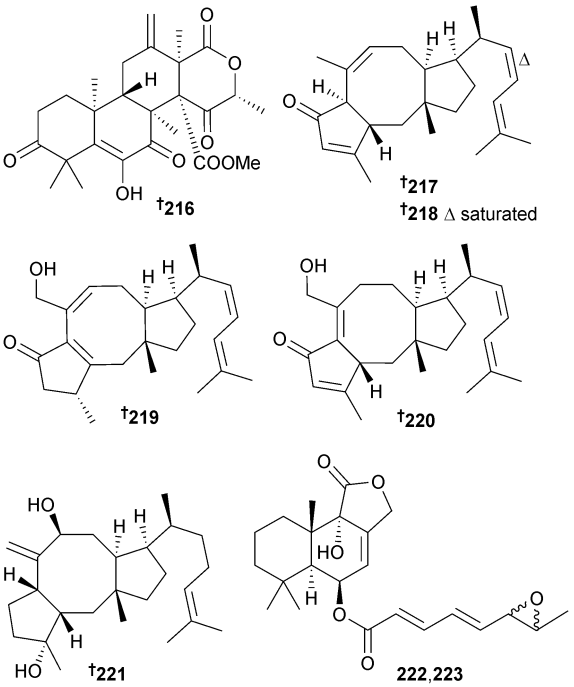


210 $R_1 = R_3 = Br$, $R_2 = H$
211 $R_1 = Br$, $R_2 = R_3 = H$
212 $R_1 = H$, $R_2 = R_3 = Br$
215 $R_1 = R_2 = Cl$, $R_3 = H$

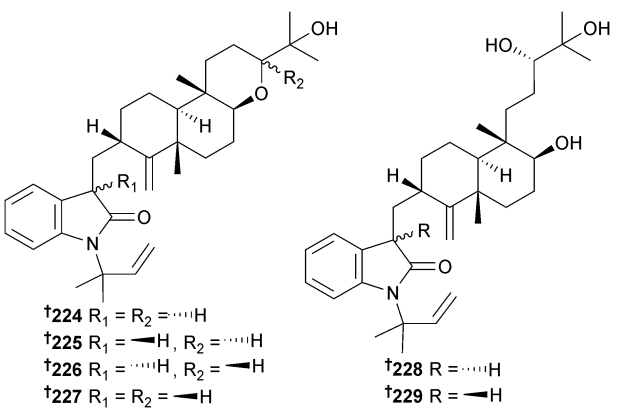


213 R = H
214 R = Br

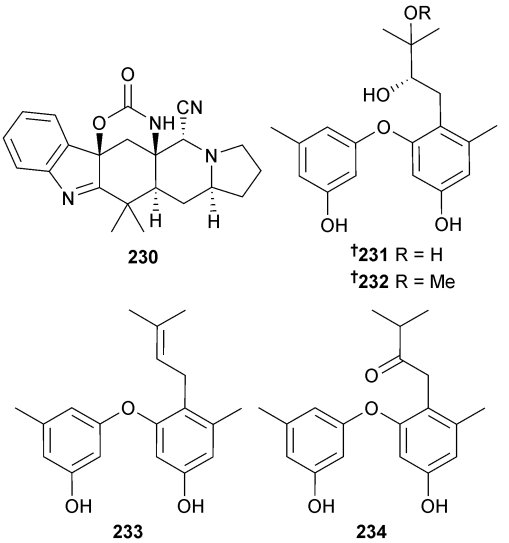
A large number of terpenes were sourced from *A. ustus* (green alga *Codium fragile*, Zhoushan Is., Zhejiang Province, China) and included the meroterpene 1,2-dihydroterretonin F **216**, the sesterterpenes (6α)-21-deoxyophiobolin G **217**, (6α)-16,17-dihydro-21-deoxyophiobolin G **218**, ophiobolins U–W **219–221** and the diasteroisomeric sesquiterpenes, (6-strobilactone-B) esters of (*E*,*E*)-6,7-epoxy-2,4-octadienoic acids **222** and **223** as new compounds. Ophiobolin F[212] was obtained from the marine environment for the first time. Ophiobolin U **219** and the co-isolated known (5α,6α)-ophiobolin H[213] moderately inhibited growth of *E. coli*.[214]



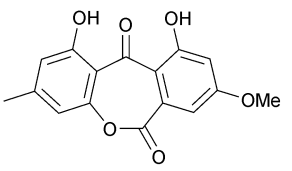
Anthcolorins A–F **224–229**, tetrahydropyran diterpene metabolites containing an oxoindoline moiety were isolated from *A. versicolor* (sea urchin *Anthocidaris crassispana*, Tanabe Bay, Wakayama, Japan), as three sets of epimeric pairs with moderate growth inhibition (P388) noted for anthcolorins B–D **225–227**.[215,216]

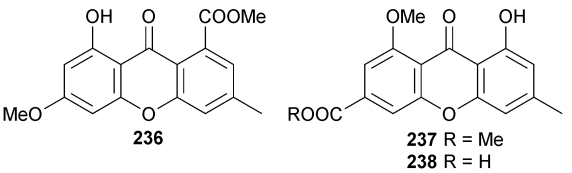


Aspeverin **230** isolated from *A. versicolor* (green alga *Codium fragile*, Dalian, China) was a moderate growth inhibitor of the phytoplankton *Heterosima akashiwo*.[217] Four prenylated diphenyl ethers diorcinol B–E **231–234** were obtained from *A. versicolor* (mud, Yellow Sea),[218] of which two, diorcinols D and E were toxic to HTCLs.[219]

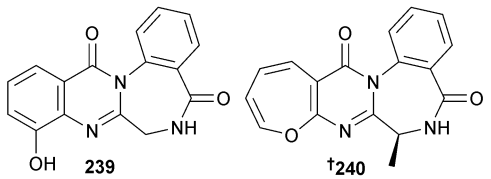


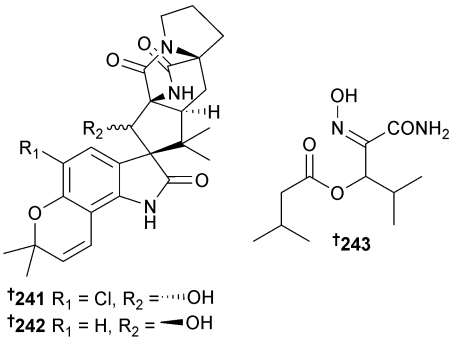
Endophytic *A. wentii* (brown alga *Sargassum* sp., no location specified) produced wentiquinone A **235**, along with another secoanthraquinone derivative which was claimed as new and named wentiquinone B. A compound of this structure had already been isolated as guepinone from the terrestrial fungus *Pestalotiopsis guepinii*,[220] but this was the first isolation from the marine environment.[221] The xanthone derivatives yicathin A–C **236–238** were isolated from endophytic *A. wentii* (red alga *Gymnogongrus flabelliformis*, Pingtan Is., China). Yicathins B and C had antimicrobial activities.[222]

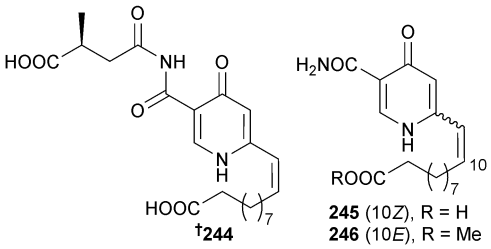




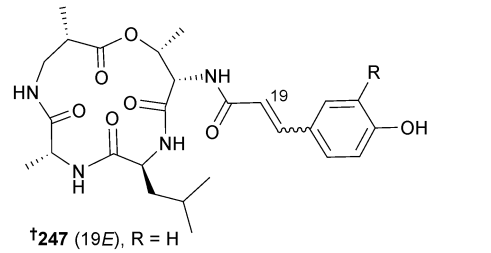
A. westerdijkiae (deep-sea sediment, S. China Sea) was the source of the benzodiazepine alkaloids circumdatin K **239** and L **240**, the prenylated indole alkaloids 5-chlorosclerotiamide **241** and 10-*epi*-sclerotiamide **242** and the amide aspergilliamide B **243** (ref. 223) whilst *Aspergillus* sp. (mussel *Mytilus edulis*, Toyama Bay, Japan Sea)[224] produced himeic acids E–G **244–246**.[225]

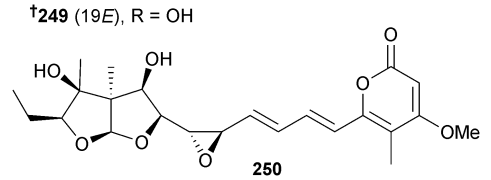






The cyclic tetrapeptides aspergillipeptide A–C **247–249** and asteltoxin B **250** were isolated from *Aspergillus* sp. (gorgonian *Melitodes squamata*, Sanya, Hainan province, China) with aspergillipeptide C **249** showing strong antifouling activity against *Bugula neritina* (*B. neritina*) larvae settlement.[226]





Aspergillus sp. (sponge *Tethya aurantium*, Limski canal, N. Adriatic Sea, Croatia) produced seven new alkaloids, tryptoquivaline K **251** and fumiquinazolines K–P **252–257**, the latter group containing the rare 1-aminocyclopropane-1-carboxylic acid residue.[227]

The prenylated indole alkaloids 17-*epi*-notoamide Q **258** and M **259** and the phenyl ether derivative cordyol D **260** were obtained from *Aspergillus* sp. (gorgonian *Dichotella gemmacea*, Xisha Is., S. China Sea). A further phenyl ether was isolated and claimed as new but had already been reported from the mangrove-associated fungus *Penicillium expansum*.[228] The synthetic compound dehydronotoamide C[229] was obtained for the first time as an NP and the fungal metabolite notoamide C[230] was also reisolated and the absolute configuration previously proposed[231] for this metabolite proven as **261**.[232] As a consequence the configurations of the *Aspergillus*-derived notoamides J,[233] Q[234] and M,[235] have been corrected from (3*S*) to (3*R*) for notoamide J[235,236] and from (3*R*) to (3*S*) for notoamides Q and M.[237,238]

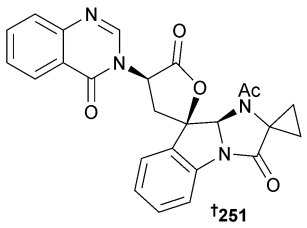
Aspergillide D **262**, a 16-membered macrolide, was isolated from *Aspergillus* sp. (gorgonian *Melitodes squamata*, Sanya, Hainan Province, China).[239] Co-isolated were two known sesquiterpenoid nitrobenzoyl esters, 9α,14-dihydroxy-6β-*p*-nitrobenzoylcinnamolide[240] and 7α,14-dihydroxy-6β-*p*-nitrobenzoylconfertifolin,[240] moderate inhibitors of H1N1.[239] Two aspergillic acid group toxins aspergilliamide **263** and ochratoxin A butyl ester **264** were obtained from *Aspergillus* sp. (gorgonian *Melitodes squamata*, Sanya, Hainan Province, China), both modestly toxic to brine shrimp (*Artemia salina*). Co-isolated was the known neoaspergillic acid[241] and, surprisingly, the aluminium and zirconium salts of the acid.[242]

A racemic mixture of a γ-lactone derivative **265** was isolated from *Aspergillus* sp. (gorgonian *Melitodes squamata*, Sanya, Hainan Province, China) with significant toxicity to brine shrimp.[243] A lactam derivative was also obtained and the structure proposed as a dehydrated pyrrolyl 1-isoquinoline alkaloid,[243] a structure originally proposed for marinamide, but which was subsequently revised to that of the dehydrated quinoline alkaloid penicinoline (in section 3.4 below this same problem is addressed with respect to two unidentified microorganisms grown in co-culture).[244,245] While it might be possible that these two compounds have very similar NMR data, X-ray crystallography of this new marinamide is required to resolve the doubt.

Bartalinia robillardoides (sponge *Tethya aurantium*, Limsky Channel, Croatia) was the source of the chloroazaphilone helicusin E **266** and the pentaketide bartanolide **267**. Isochromophilones X[246] and XI[246] were also isolated and claimed as new but are known terrestrial fungal metabolites. Isochromophilone XI,[246] along with other known fungal metabolites helicusin A[247] and deacetylsclerotiorin,[248] had a variety of moderate to weak antimicrobial activities.[249]

Calcarisporium sp. (seawater, Wadden Sea, Germany) generated macrocyclic and linear polyesters including calcarides A–E **268–272**, out of which calcarides A–C **268–270** and the co-isolated analogues 15G256α and 15G256β, previously obtained from the marine fungus *Hypoxylon oceanicum*,[250] inhibited growth of *Staphylococcus epidermidis* and *Xanthomonas campestris* while the linear ester 15G256π inhibited growth of *Propionibacterium acnes*.[251]

Two lanostanes **273** and **274**, with the latter previously reported in the patent literature as a metabolite of the mushroom *Fomitopsis pinicola*,[252] were obtained from endophytic *Ceriporia lacerate* (starfish *Acanthaster planci*, Hainan Sanya National Coral Reef Reserve, China).[253] Although a further lanostane, 3β-acetoxy-15α-hydroxylanosta-8,24-dien-21-oic acid



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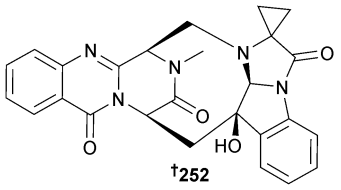
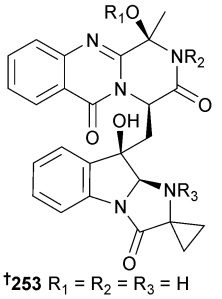
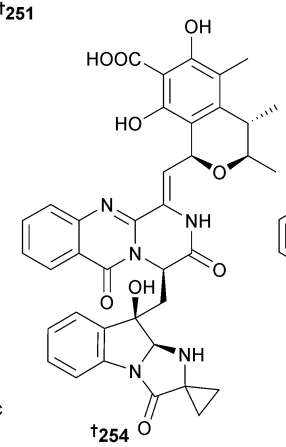


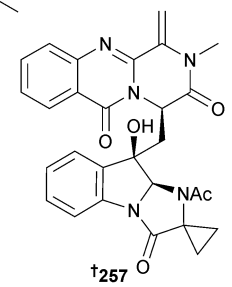
†252



†253 $R_1 = R_2 = R_3 = H$
†255 $R_1 = H$, $R_2 = Me$, $R_3 = Ac$
†256 $R_1 = R_2 = Me$, $R_3 = Ac$



†254



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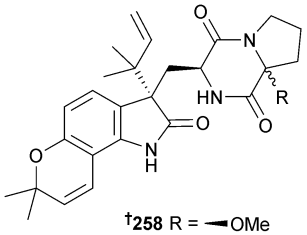
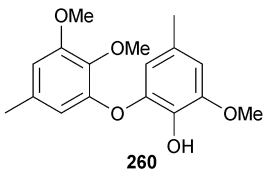


†258 R = OMe
†259 R = OH
†261 R = H



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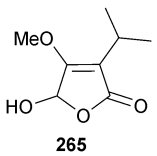

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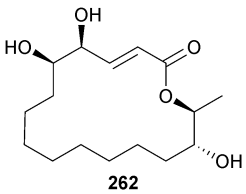

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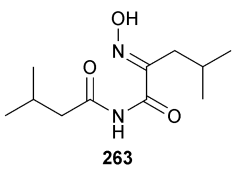

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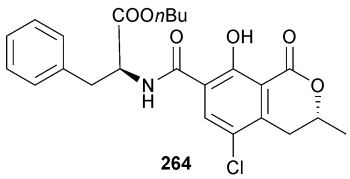
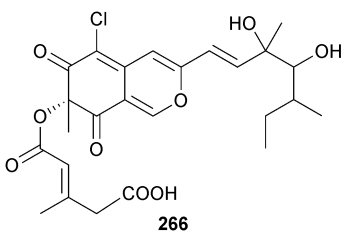
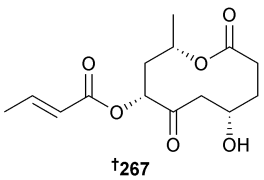


264



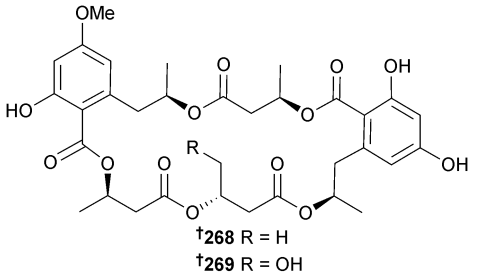
266

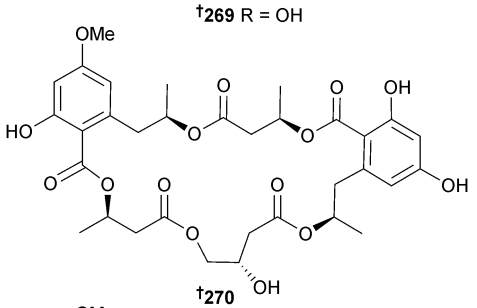


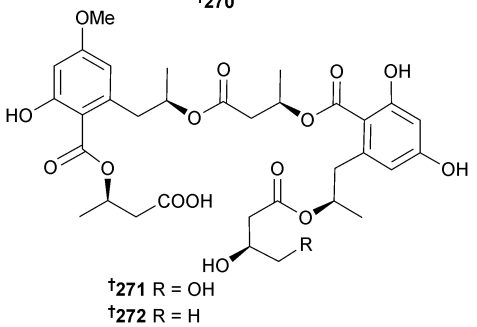
†267

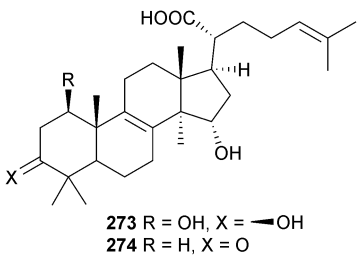
was also claimed as new, it had previously been isolated from a fungal endophyte of a traditional Chinese medicinal plant *Huperzia serrata*.[254]

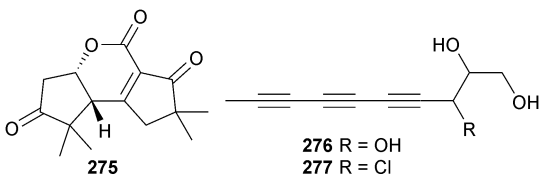
Chondrostereum sp. (soft coral *Sarcophyton tortuosum*, Hainan Sanya National Coral Reef Reserve, China), previously the source of chondrosterins A–E,[255] produced further chondrosterins F–H **275–277**. The terrestrial fungal metabolites incarnal[256] and arthrosporone,[257] and the plant metabolite (2*E*)-decene-4,6,8-triyn-1-ol,[258] were also all isolated for the first time as MNPs.[259] The benzolactone metabolites chrysoarticulin A–C **278–280** were isolated from *Chrysosporium articulatum*, (unidentified dictyoceratid sponge, Gagu-do, S. Korea) with chrysoarticulin C **280** active against the bacterial transpeptidase enzyme sortase A.[260]

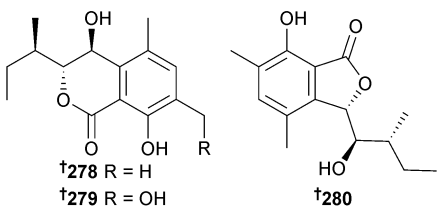




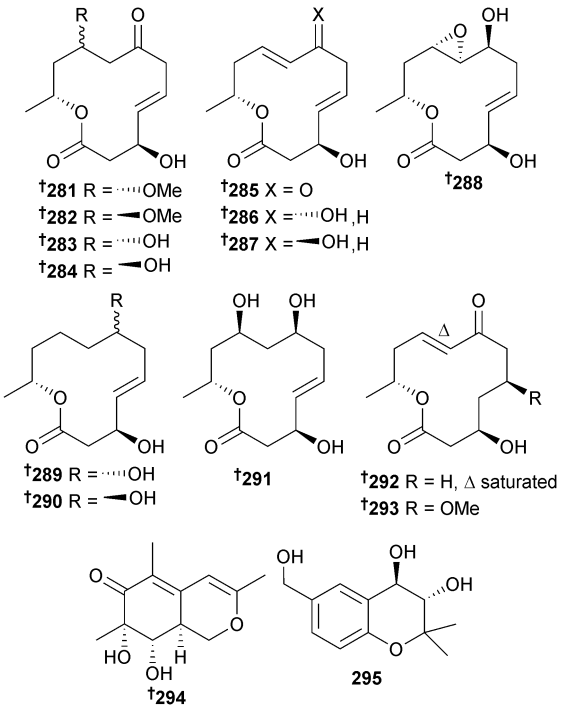




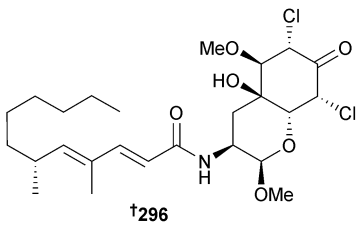


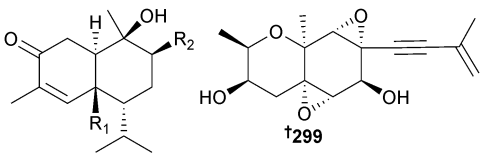


Dendrodochium sp. (sea cucumber *Holothuria nobilis*, S. China Sea) produced the 12-membered macrolides dendrodolide A–M **281–293** (dendrodolides A–E, G–I, K and L had modest inhibitory activity against two HTCLs),[261] while the polyketides **294** and **295** were obtained from *Eutypella scoparia* (sediment, S. China Sea).[262]



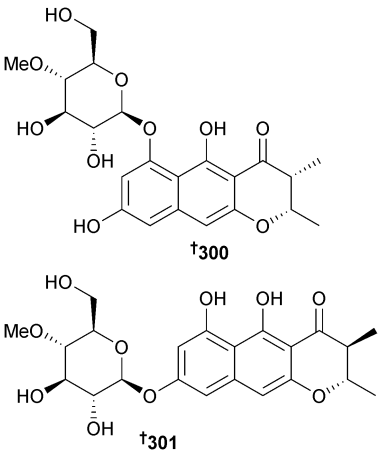
Gymnascella dankaliensis (sponge *Halichondria japonica*, Osaka Bay, Japan)[263] provided dankastatin C **296**, a polyketide tyrosine derivative with potent growth inhibition of P388 cells.[264] *Hypocreales* sp. (sponge *Gelliodes carnosa*, S. China Sea) was the source of the cadinane-type sesquiterpenes hypocreaterpene A **297** and B **298**. The known terrestrial plant metabolites, (1*R*,6*R*,7*R*,10*S*)-10-hydroxy-4(5)-cadinen-3-one[265] and (*R*)-5,6-dihydro-6-pentyl-2*H*-pyran-2-one[266] were also isolated for the first time as MNPs and both had moderate anti-inflammatory activity (inhibition of NO production).[267] Oxirapentyn E **299**, a highly oxidised chromene was isolated from *Isaria felina* (sediment, Vietnam) as a growth stimulant of corn (*Zea mays* L.) and barley (*Hordeum vulgare* L.) rootlets.[268]



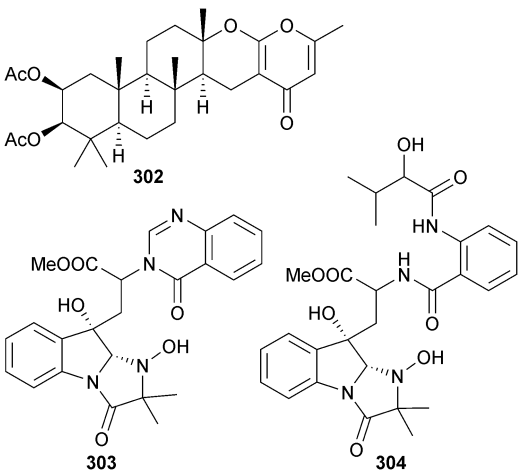


†297 R_1 = OH, R_2 = H
†298 R_1 = H, R_2 = OH

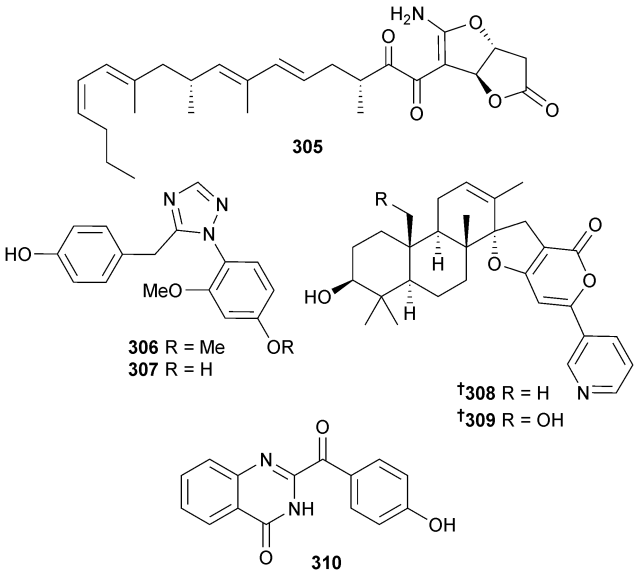
Metarhizium anisopliae (unidentified sponge, Naozhou Is., Guangxi, China) generated two naphtho-γ-pyrone glycosides indigotide G **300** and H **301**. The known compounds isochaetochromin B2 (ref. 269) and ustilaginoidin D[270] were obtained for the first time from a marine source and displayed modest inhibition of *Mycobacterium phlei*.[271]



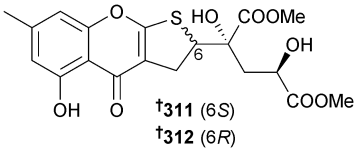
Sartorypyrone B **302**, a moderate inhibitor of HTCLs, was obtained from *Neosartorya tsunodae* (sponge *Aka coralliphaga*, Similan Is., Phagna Province, Thailand),[272] while tryptoquivalines R **303** and S **304** are indole alkaloids obtained from *Neosartorya* sp. (intertidal mud, Hainan Province, China),[273] previously the producer of tryptoquivalines P and Q.[274]



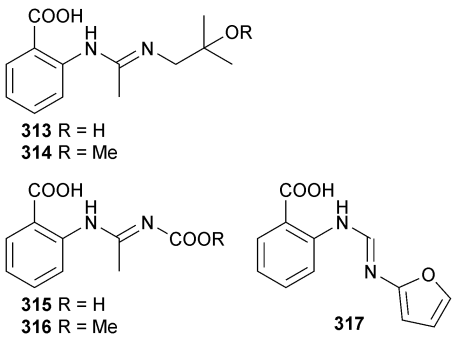
Paecilomyces sp., (unspecified sponge, Tinggi Is., Malaysia) was the source of the dione **305**,[275] while the chrysotriazoles A **306** and B **307** were obtained from endophytic *Penicillium chrysogenum* (brown alga *Sargassum palladium*, Fujian, China).[276] *P. oxalicum* (sediment, Bohai Bay, Liaoning Province, China) produced decaturins E **308** and F **309**,[277] and 2-(4-hydroxybenzoyl) quinazolin-4(3*H*)-one **310** was isolated from *P. oxalicum* (strain 0312F1, Genbank accession no. EU926977) as a moderate inhibitor of tobacco mosaic virus (TMV) and the human gastric cancer cell line SGC-7901.[278]



The dihydrothiophene-condensed chromones oxalicumone A **311** and B **312** were obtained from *P. oxalicum* (gorgonian *Muricella flexuosa*, Sanya, China) with oxalicumone A **311** moderately cytotoxic to HTCLs.[279] A further chromone was also claimed as new and named as oxalicumone C but while isolated from a natural source for the first time, is a known reaction product of chloromonilicin, a metabolite of the cherry rot fungus *Monilinia fructicola*.[280]

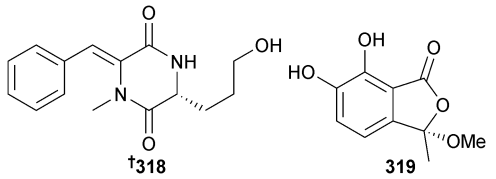


The anthranilic acid derivatives penipacid A–C **313–315**, E **316** and G **317** were isolated from *P. paneum* (sediment, S. China Sea) together with a known analogue, 2-[(1-methyl-2-oxopropylidene)aminobenzoic acid,[281] previously synthesised but now isolated as an NP. Penipacids A **313** and E **316** inhibited human colon cancer RKO cells and 2-[(1-methyl-2-oxopropylidene)aminobenzoic acid was cytotoxic to HeLa cells.[282]

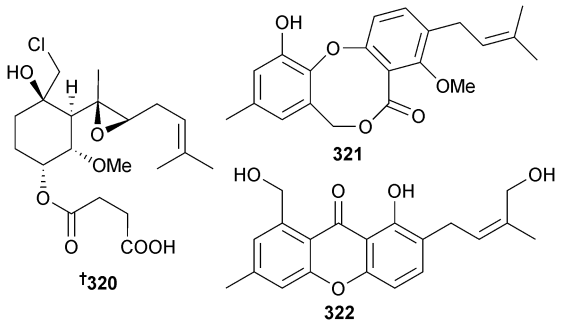


P. pinophilum (sediment, Pearl River Estuary, S. China Sea) yielded pinodiketopiperazine A **318** and 6,7-dihydroxy-3-methoxy-3-methylphthalide **319** and the known synthetic

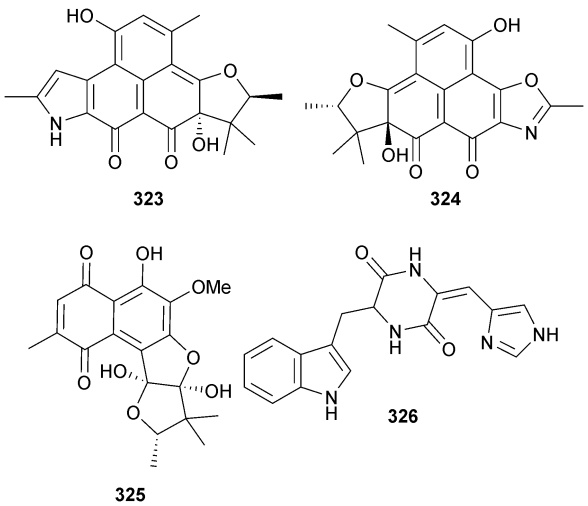
compounds, alternariol 2,4-dimethyl ether[283,284] and L-5-oxoproline methyl ester[285] as first time NPs. The phthalide **319** displayed potent cytotoxicity to brine shrimp and pinodiketopiperazine A **318**, alternariol 2,4-dimethyl ether[283,284] and the co-isolated known metabolites *N*-methylphenyldehydroalanyl-L-proline-anhydride[286] and rubralide C[287] all exhibited moderate inhibition of *E. coli* growth.[288]



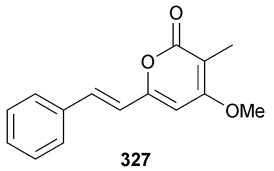
The chlorinated sesquiterpenoid ligerin **320** came from a *Penicillium* strain (seawater, La Prée, Loire Atlantique, France) and strongly inhibited the osteosarcoma cell line POS1,[289] while another *Penicillium* sp. (sediment, Jiaozhou Bay, China) yielded prenpenicillide **321** and prenxanthone **322**.[290]



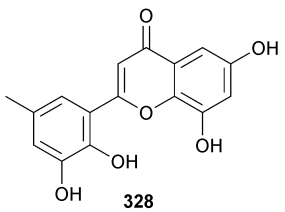
The polyaromatic metabolites herqueiazole **323**, herqueioxazole **324** and herqueidiketal **325** were obtained from *Penicillium* sp. (sediment, Gagu-do, S. Korea). Herqueidiketal **325** was moderately cytotoxic to A549 cells and significantly inhibitory against sortase A.[291] *Penicillium* sp. (gorgonian *Dichotella gemmacea*, Sanya, Hainan Province, China) produced the indolyl diketopiperazine penilloid A **326** in addition to a number of known indole alkaloids.

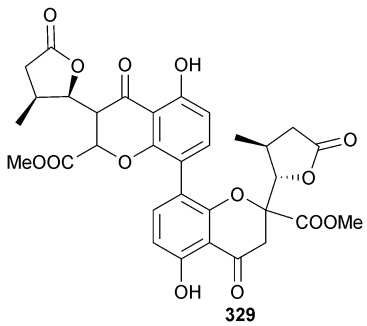


Aspergillus sydowii (gorgonian *Verrucella umbraculum*, Sanya, Hainan Province, China) also yielded additional known indole alkaloids including fumiquinazoline D,[292] cyclotryprostatin B[293] and fumiquinazoline G,[294] which in addition to (*E*)-3-(1*H*-imidazol-4-ylmethylene)-6-(1*H*-indol-3-ylmethyl)-2,5-piperazinedione,[295] meleagrin,[296] roquefortine C,[297] and 11α-methoxy roquefortine C[298] from the *Penicillium* sp. exhibited significant antifouling activity towards *B. amphitrite* and/or *B. neritina* larvae. Meleagrin also exhibited moderate activity against the larvae settlement-inducing bacterium *Micrococcus luteus*.[299] Penstyrylpyrone **327** and the known terrestrial fungal metabolite anhydrofulvic acid (first time MNP)[300] were obtained from *Penicillium* sp. (unidentified sponge. Jeju Is., S. Korea) as inhibitors of protein tyrosine phosphatase 1B (PTP1B) activity. Furthermore, penstyrylpyrone **327** suppressed production of pro-inflammatory mediators *via* the NF-κB pathway through expression of the anti-inflammatory enzyme, heme oxygenase.[301]

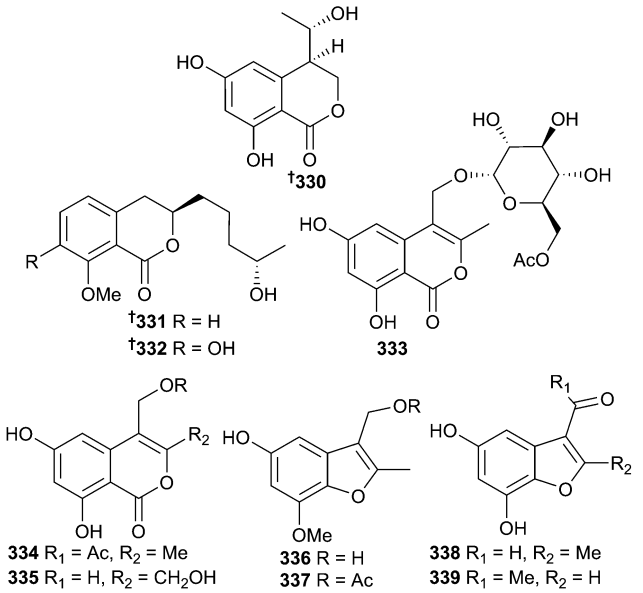


Penicillium sp. (gorgonian coral *Dichotella gemmacea*, Sanya, Hainan, China) was the source of the polyketides **328** and paecilin C **329**, and some known analogues. 6,8,5′,6′-Tetrahydroxy-3′-methylflavone **328**, emodin,[302] citreorosein[302] and isorhodoptilometrin[303] exhibited significant antifouling activity against *B. amphitrite* larvae settlement while penicillixanthone A[304] was moderately antibacterial.[305]

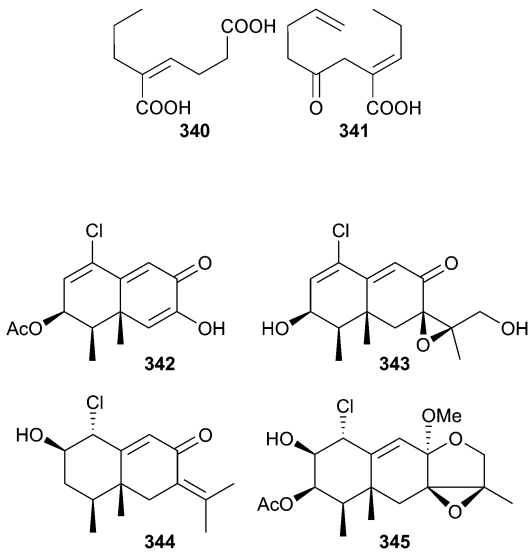




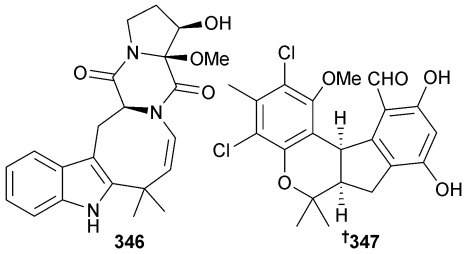
Endophytic *Penicillium* sp. (unidentified sponge, Weizhou, S. China Sea) was the source of the hydroisocoumarins penicimarin A–C **330–332**, the isocoumarins penicimarin D–F **333–335** and the benzofurans penicifuran A–D **336–339**, out of which only penicifuran A **336** was cytotoxic to *Staphylococcus albus* (moderate).[306]



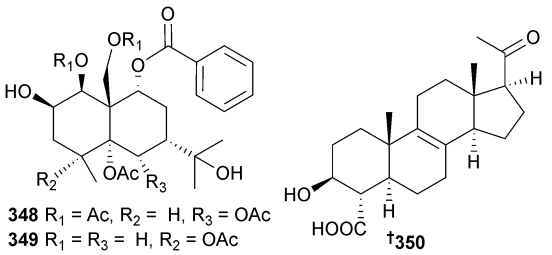
Co-cultivation of *Penicillium* sp. (sponge *Mycale angulosa*, Toque-Toque Is., Brazil)[307] and *Trichoderma* sp. (sponge *Geodia corticostylifera*, same location)[307] led to the unusual polyketides, (*Z*)-2-ethylhex-2-enedioic acid **340** and (*E*)-4-*oxo*-2-propylideneoct-7-enoic acid **341**.[308] A chloro-trinoreremophilane sesquiterpene **342** and three chlorinated eremophilane sesquiterpenes **343–345** were isolated from *Penicillium* sp. (deep-sea sediment, Prydz Bay, Antarctica). Just **342** was cytotoxic to HTCLs (moderate).[309]



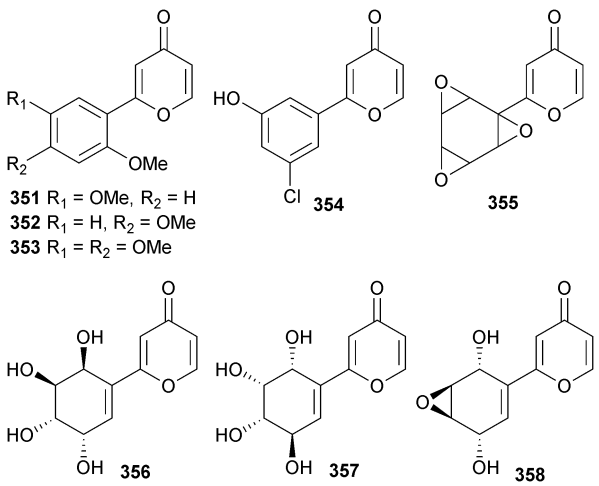
The isoaustamide alkaloid **346** was obtained from *Penicillium* sp. (unidentified sponge, Jeju Is., S. Korea). Also isolated for the first time as an NP was deoxydihydroisoaustamide, previously reported as an intermediate in the total synthesis of (+)-deoxyisoaustamide.[310,311] *Pestalotiopsis* sp. (soft coral *Sarcophyton* sp., Yongxing Is., S. China Sea) was the source of the chlorinated benzophenone derivative (±)-pestalachloride D **347** (moderate antibacterial activity against several Gram-positive strains). Co-isolated was (±)-pestalachloride C, known as a metabolite of terrestrial endophytic *Pestalotiopsis adusta*[312] but now a first time MNP.[313]

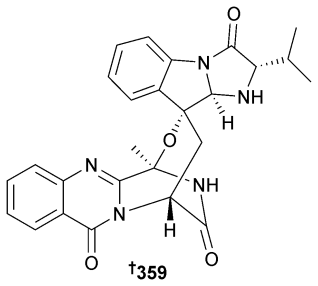


The eudesmane sesquiterpenes **348** and **349** were produced by *Pestalotiopsis* sp. (brown alga *Sargassum horneri*, Wenzhou, China) in response to abiotic stress elicitation by addition of $CuCl_2$ to the growth media and both were both potent inhibitors of tyrosinase.[314] Endophytic *Phaeosphaeria spartinae* (red alga *Ceramium* sp., North Sea, Büsum, Germany) was the source of spartopregnenolone **350**.[315]



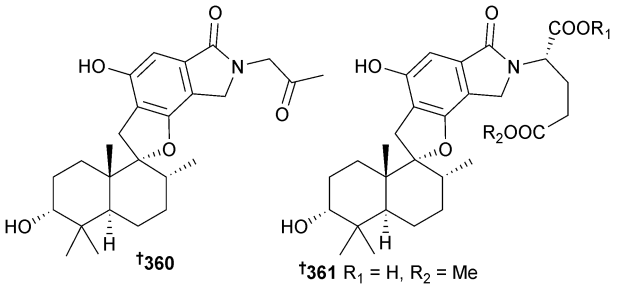
Polyporapyranones A–H **351–358** were isolated from two *Polyporales* species (seagrass *Thalassia hemprichii*, location unspecified, presumably Thailand). Polyporapyranones A **351** and D **354** exhibited moderate and weak inhibition of the Vero cell line respectively.[316] *Scopulariopsis* sp. (gorgonian *Carijoa* sp., Weizhou, S. China Sea) was the source of fumiquinazoline L **359**, an alkaloid with a heptacyclic skeleton.[317]

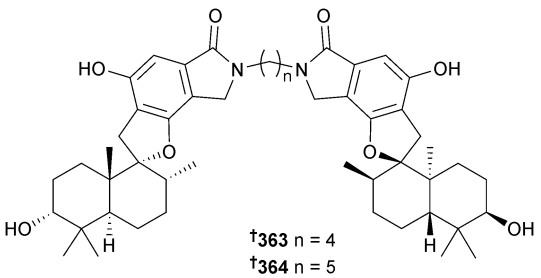


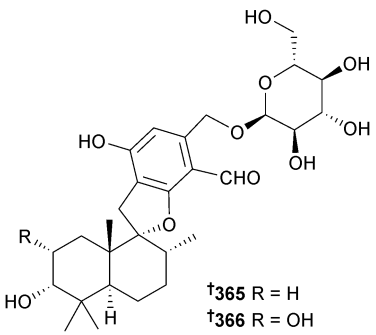


†359

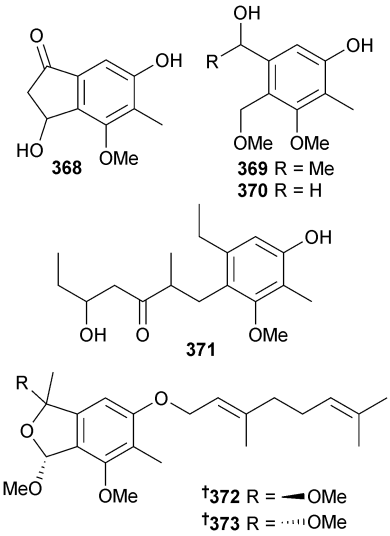
Stachybotrys chartarum (sponge *Xestospongia testudinaris*, Xisha Is., China) yielded new phenylspirodrimanes stachybotrin D–F **360–362**, stachybocin E **363** and F **364** and stachyboside A **365** and B **366**, of which stachybotrin D **360** inhibited replication of HIV-1 by targeting reverse transcriptase and blocked non-nucleoside reverse transcriptase inhibitors-resistant strains as well. The absolute configuration of a co-isolated known terrestrial sesquiterpenoid **367** (*S. chortarum*[318]) was determined.[319]



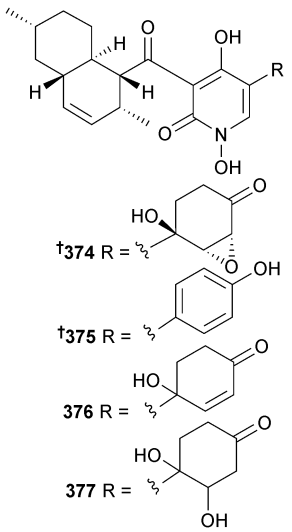




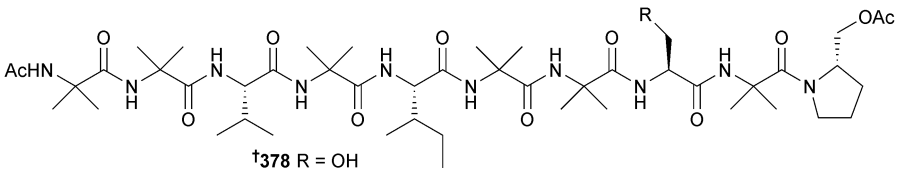
Several polyketides were obtained from *Stachylidium* sp. (sponge, *Callyspongia* sp. *cf. C. flammea*, Bear Is., Sydney, Australia) including cyclomarinone **368**, maristachone A–E **369–373** and marilactone.[320] Due to rotation values being close to zero, racemic mixtures were assumed for cyclomarinone **368**, maristachone A **369** and the epimers **372** and **373**. Marilactone[320] is a known synthetic compound but now a first time NP. From a biosynthetic perspective, all of the isolated compounds are unusual due to the presence of an additional carbon atom over the basic polyketide skeleton.[321]



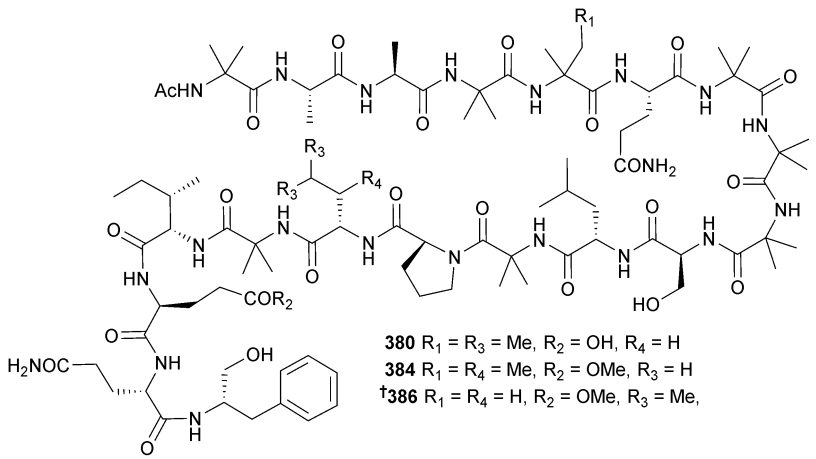
Stagonosporopsis cucurbitacearum (unidentified sponge, Atami-shi, Shizuoka Prefecture, Japan) yielded the alkaloids didymellamides A–D **374–377**. Didymellamide A **374** inhibited growth of several pathogenic fungi including azole-resistant *C. albicans*.[322]



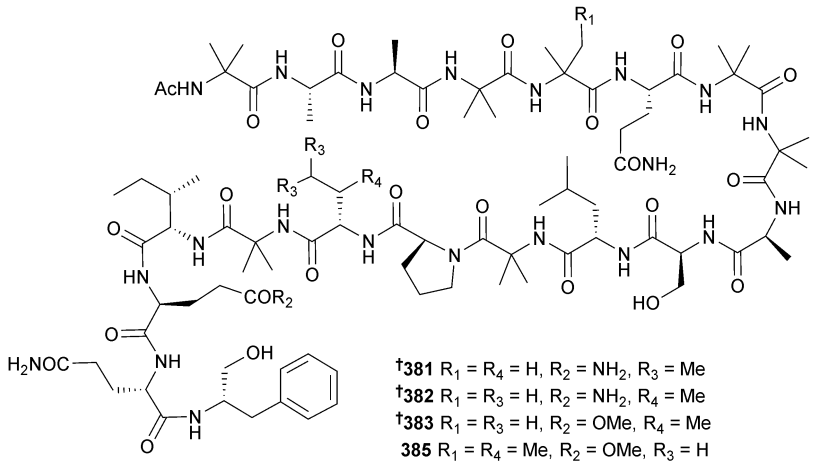
The peptaibols aspereline G **378** and H **379** were obtained from *Trichoderma asperellum* (sediment, Langqi Is., Fujian, China),[323] while asperelines G-Z_{13} are thirty-two new short peptaibols detected from *T. asperellum* (sediment, Penguin Is., Antarctica) by ultrahigh pressure liquid chromatography in combination with electrospray-ionisation tandem mass



†**378** R = OH
†**379** R = H



380 $R_1 = R_3 = Me$, $R_2 = OH$, $R_4 = H$
384 $R_1 = R_4 = Me$, $R_2 = OMe$, $R_3 = H$
†**386** $R_1 = R_4 = H$, $R_2 = OMe$, $R_3 = Me$,

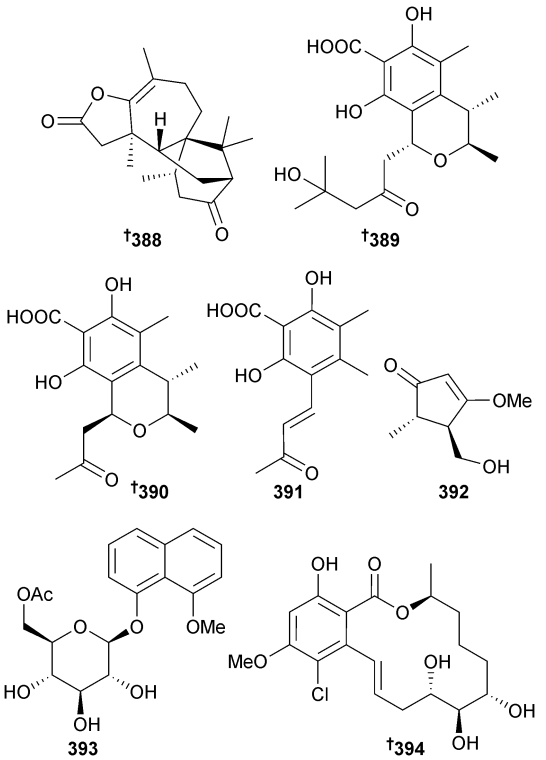


†**381** $R_1 = R_4 = H$, $R_2 = NH_2$, $R_3 = Me$
†**382** $R_1 = R_3 = H$, $R_2 = NH_2$, $R_4 = Me$
†**383** $R_1 = R_3 = H$, $R_2 = OMe$, $R_4 = Me$
385 $R_1 = R_4 = Me$, $R_2 = OMe$, $R_3 = H$
387 $R_1 = R_4 = Me$, $R_2 = NH_2$, $R_3 = H$

spectrometry (UHPLC-ESIMS/MS).[324] Several strains of marine-derived *T. atroviride* (University of Nantes culture collection) produced two series of 17-residue peptaibiotics with a common C-terminus[325] and eight new peptaibols **380–387**, trichorzianine 1938, 1909, 1895, 1896, 1924, 1910, 1924A and 1909A, linear 19-residue hydrophobic peptides were obtained from *T. atroviride* (Axinellid sponge, Akhziv, Mediterranean coast, Israel).[326]

The diterpenoid lactone trichodermaerin **388** was isolated from endophytic *T. erinaceum* (sea star *Acanthaster planci*, Hainan Sanya National Coral Reef Reserve, China).[327] A *Xylariaceae* sp. (gorgonian coral *Melitodes squamata*, S. China Sea) produced a number of polyketides including penicitrinol F **389**, 7-carboxypenicitrinol C **390** and **391–393**. Several known polyketides were also isolated and of these, dihydrocitrinin[328] and phenol acid A[328] strongly inhibited settlement of *B. neritina* larvae with dihydrocitrinin[328] also an inhibitor of the enzymes SHP2 and IMPDH. Phenol acid A[328] and dihydrocitrinone[329] inhibited cathepsin B and (3*R*,4*S*)-(+)-4-hydroxy-6-deoxyscytalone[330] inhibited the enzymes SHP2, PTP1B and IMPDH and is a first time MNP.[331] There is considerable confusion surrounding this report: the name penicitrinol F has been given previously to a citrinin derivative obtained from a *Penicllium* sp.[332] so **389** should be renamed. Also, for 7-carboxypenicitrinol C **390** there is a discrepancy between the configuration in the diagram and in the text. The text gives (1*R*) but the diagram gives (1*S*). If the diagram is correct, this is a known compound from both terrestrial[333] and marine[334,335] fungi. The configuration of cochliomycin C, a resorcylic acid lactone obtained from

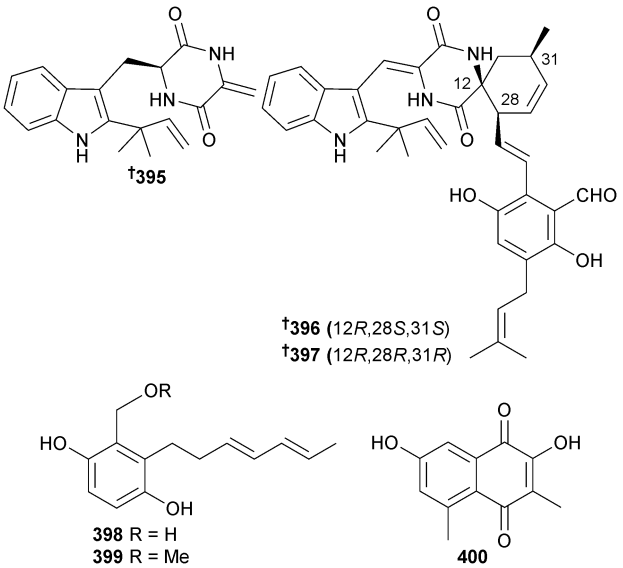
the gorgonian-derived fungus *Cochliobolus lunatus*[336] has been corrected to **394**.[337]



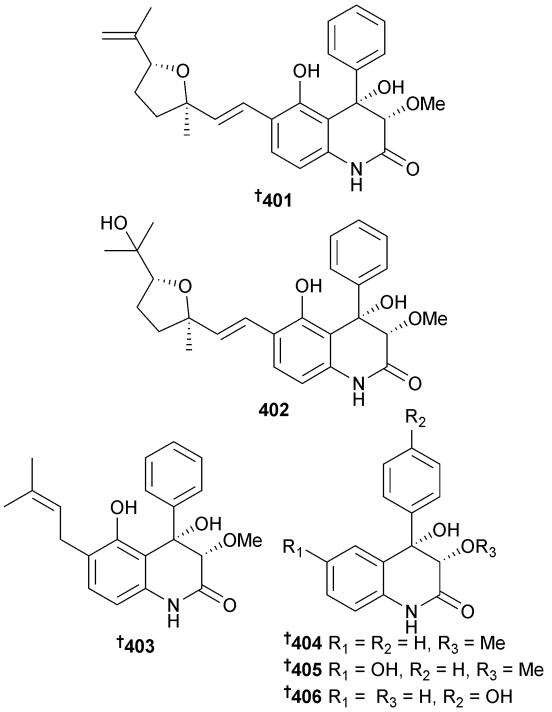
Addition of sodium bromide to a culture of *Aspergillus ochraceus* (red alga *Chondria crassicualis*, Yokji Is., Kyeongnam Province, S. Korea) resulted in medium-induced production of (*R*)-(−)-5-bromomellein as a modest radical scavenger (against 1,1-diphenyl-2-picrylhydrazyl (DPPH)). Both the racemate[338] and antipode[339] have been previously synthesised but this is the first report of their isolation as NPs.[340] The sesquiterpene helminthosporic acid has been reported previously as a semi-synthetic derivative of the fungal metabolite helminthosporol aldehyde[341] but has been isolated for the first time as an NP from *Drechslera* sp. (green alga *Ulva* sp., Tönning, North Sea).[342] Also as a first time MNP was the terrestrial fungal metabolite epiepoformin[343] isolated from an endophytic *Penicillium* sp. (brown alga *Fucus spiralis*, Bridge End, Shetland Is., U.K.).[344]

3.4 Fungi from mangroves

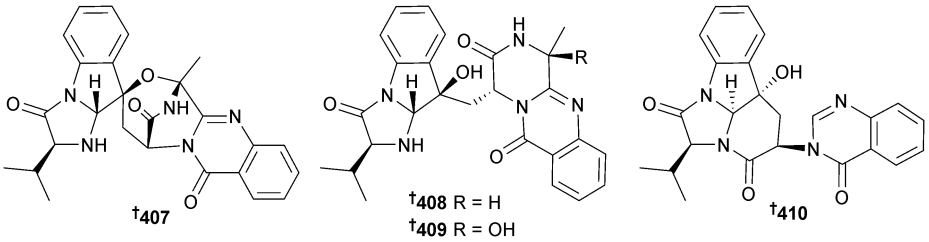
Aspergillus effuses (rhizosphere soil, unidentified mangrove, Fujian Province, China) produced the prenylated indole diketopiperazine alkaloid dihydroneochinulin B **395** and the enantiomeric spiro-polyketide-diketopiperazine hybrids cryptoechinuline D **396** and **397**. The latter compound has been isolated previously from terrestrial[345] and marine[346] fungi but in this study was resolved into enantiomers and absolute configurations assigned.[347] The benzyl derivatives aspergentisyl A **398** and aspergentisyl B **399** and a naphthoquinone derivative aspergiodiquinone **400** were isolated from *A. glaucus* (mangrove sediment, unspecified species, Fujian Province, China). Aspergentisyls A **398** and B **399** were strong radical-scavengers (DPPH).[348]



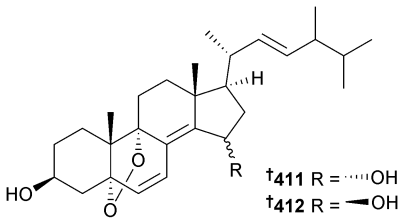
Some 4-phenyl-3,4-dihydroquinolone derivatives were obtained from *A. nidulans* (mangrove leaves *Rhizophora stylosa*, source not given, presumably China), namely aniduquinolone A–C **401–403**, 6-deoxyaflaquinolone E **404**, isoaflaquinolone E **405** and 14-hydroxyaflaquinolone F **406**. Of these, aniduquinolones B **402** and C **403** and the co-isolated aflaquinolone A[349] were moderately toxic to brine shrimp. Aflaquinolone A, previously obtained from a terrestrial *Aspergillus* sp., was obtained for the first time as an MNP.[350]

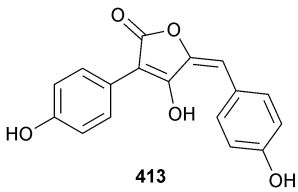


Aniquinazolines A–D **407–410** are quinazolinone alkaloids from the endophytic *A. nidulans* (mangrove leaves *Rhizophora stylosa*, unspecified location, presumably China) and were all strongly cytotoxic to brine shrimp.[351] The nigerasterols A **411** and B **412** were obtained from endophytic *A. niger* (mangrove

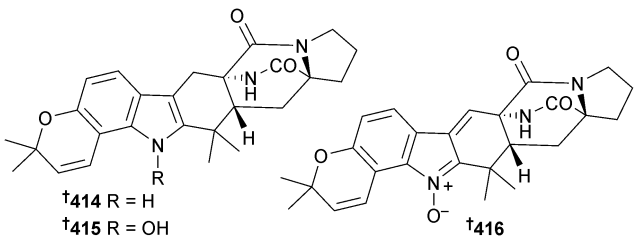


Avicennia marina, Hainan, China) as relatively potent inhibitors of the HTCLs HL60 and A549.[352] The butenolide isoaspulvinone E **413** came from *A. terreus* (mangrove rhizospehere soil, Fujian Province, China) along with the known butenolides aspulvinone E[353] and pulvic acid.[354] All exhibited significant H1N1 virus inhibition but only isoaspulvinone E inhibited H1N1 viral neuraminidase. Pulvic acid was a first time MNP.[355]

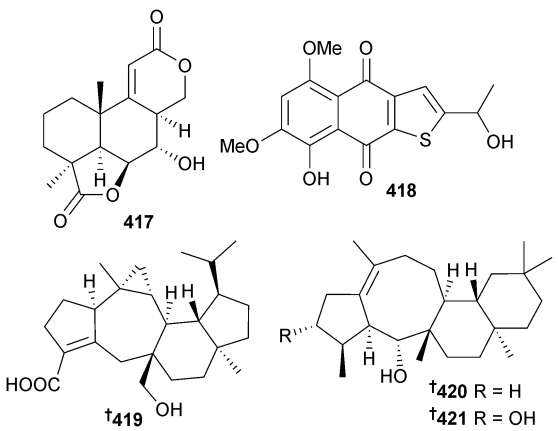




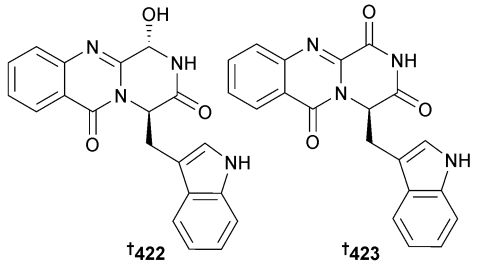
A. taichungensis (mangrove root soil *Acrostichum aureum*, no location given)[356] was the source of the prenylated indole alkaloids 6-*epi*-stephacidin A **414**, *N*-hydroxy-6-*epi*-stephacidin A **415** and 6-*epi*-avrainillanide **416**, and of these **415** and **416** were cytotoxic to two HTCLs. On exposure to light and air **415** converted to a complex mixture of analogues, including (+)-versicolamide B,[357] a mixture of two compounds (here named versicolamide C) and **416**, which suggested that **416** may be an artefact. 6-*Epi*-stephacidin A **414** was stable under the same conditions.[358]

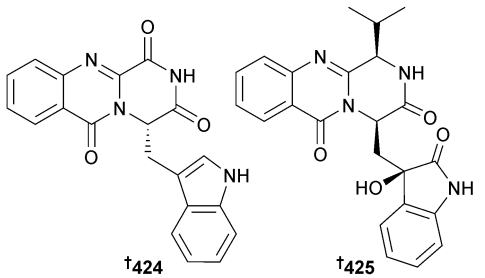


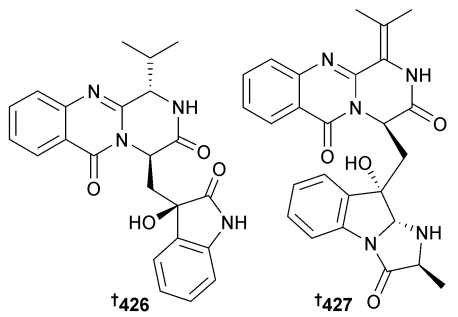
Botryosphaerin F **417** was obtained from endophytic *A. terreus* (mangrove branch *Bruguiera gymnorhiza*, Guangxi, China) and inhibited growth of HTCLs.[359] Several known compounds were also isolated including LL-Z1271β,[360] which although reported as active against the HL60 cell line used here, had previously been reported as being inactive against a number of other HTCLs.[361,362] Endophytic *A. terreus* (mangrove branch *Bruguiera gymnorhiza*, Guangxi province, China) was the source of a thiophene compound **418**. The co-isolated 6-ethyl-5-hydroxy-3,7-dimethoxynaphthoquinone,[363] a known synthetic compound, was a first time NP.[364] Asperterpenoid A **419**, a sesterterpenoid with a new carbon skeleton, was isolated from endophytic *Aspergillus* sp. (mangrove species not specified, no location given) and displayed inhibitory activity against *M. tuberculosis* protein tyrosine phosphatase B (mPTPB).[365] Asperterpenols A **420** and B **421** are sesterterpenoids with an unusual 5/8/6/6 tetracyclic ring skeleton. Both were acetylcholinesterase inhibitors and were obtained from endophytic *Aspergillus* sp. (mangrove, S. China Sea).[366]

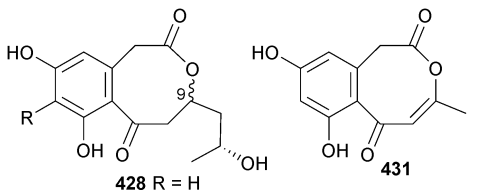


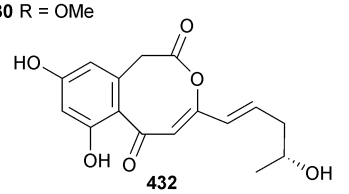
Cladosporium sp. (mangrove soil, Guangzhou, China) was the source of a number of indole alkaloids including five glyantrypine derivatives; 3-hydroxyglyantrypine **422**, oxoglyantrypine **423**, **424**, cladoquinazoline **425** and *epi*-cladoquinazoline **426** and a pyrazinoquinazoline derivative norquinadoline A **427**. Of these alkaloids, oxoglyantrypine **424** and norquinadoline A **427**, together with the co-isolated known terrestrial *Aspergillus* alkaloid metabolites, deoxynortryptoquivaline,[367] deoxytryptoquivaline,[367] tryptoquivaline[368] and quinadoline B[369] had significant activities against H1N1. The latter four were also obtained for the first time as MNPs. Over time, a solution of oxoglyantrypine **423** partially converted into **424**, leading to the proposal that **424** was an artefact.[370]

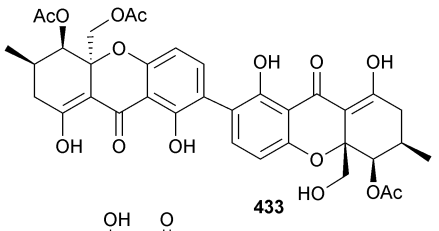


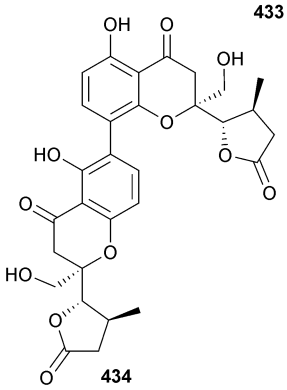


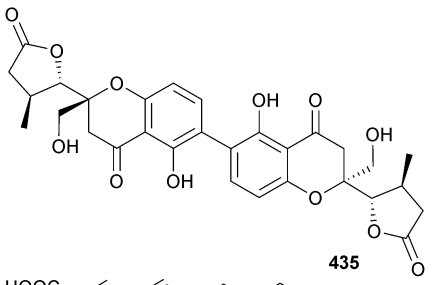


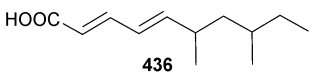


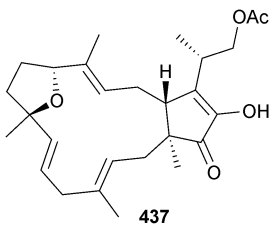


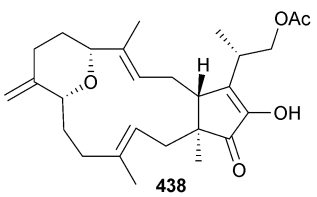


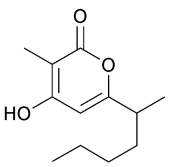


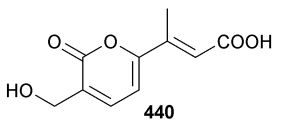


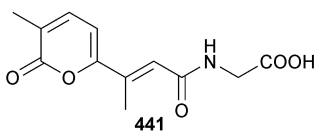












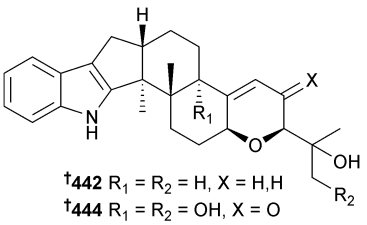
Further investigation of endophytic *Corynespora cassiicola* (mangrove leaf *Laguncularia racemosa*, Hainan Is., China), which originally yielded some decalactone derivatives,[371] yielded some minor metabolites coryoctalactone A–E **428–432**, of which coryoctalactones A **428** and B **429** were assumed to be C-9 epimers.[372]

As part of a screening programme for new antimalarial compounds, four metabolites were obtained from several species of Chinese mangrove endophytic fungi from either Mai Po Nature Reserve, Hong Kong or Hainan Is., Taiwan. Despite lack of a tight correlation between location and source microorganism, this study described the isolation of a dimeric tetrahydroxanthone dicerandrol D **433** from a *Diaporthe* sp., diaporthochromes A **434** and B **435** from another *Diaporthe* sp. and the lipid **436** was obtained from *Xylaria* sp. Dicerandrol D **433** exhibited potent activity against *P. falciparum* with relatively low toxicity to A549 cells.[373]

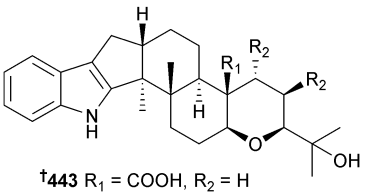
Endophytic *Fusarium proliferatum* (mangrove *Bruguiera sexangula*, Hainan Is., China) produced the tricyclic

sesterterpenes fusaprolifin A **437** and B **438** and the 2*H*-pyran-2-one derivatives prolipyrone A–C **439–441**. Fusaprolifins A and B had modest activity against brine shrimp.[374]

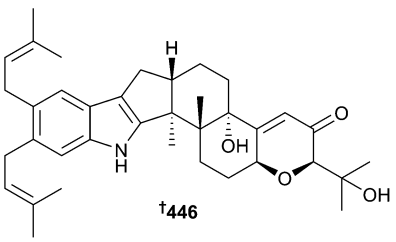
Penicillium camemberti (mangrove soil *Rhizophora apiculata*, Wenchang, Hainan Province, China) produced the indole diterpenoids **442–447**, as well as some known analogues. Of these, emindole SB,[375] 21-isopentenylpaxilline,[376] paspaline,[377,378] and paxilline[379] displayed significant activity against H1N1 as did indole diterpenoids **442–444**, **446** and **447**. 21-Isopentenylpaxilline[376] and dehydroxypaxilline[380] were obtained for the first time as MNPs.[381]



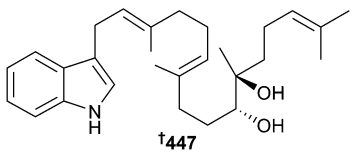
†**442** $R_1 = R_2 = H$, X = H,H
†**444** $R_1 = R_2 = OH$, X = O



†**443** $R_1 = COOH$, $R_2 = H$
†**445** $R_1 = R_2 = OH$

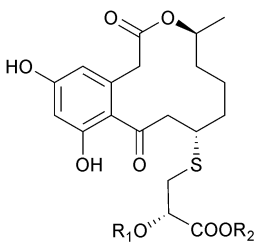


†**446**

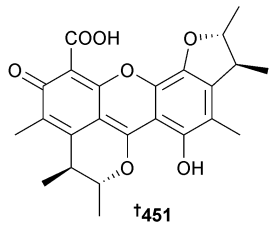


†**447**

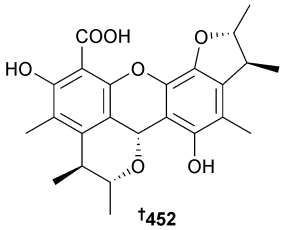
Penicillium sumatrense (mangrove rhizosphere *Lumnitzera racemosa*, WenChang, Hainan Is., China) yielded sumalarins A–C **448–450**, sulfur-containing curvularin derivatives which were cytotoxic to several HTCLs.[382] The planar structure of sumalarin C **450** had previously been reported as part of several compound libraries.[383–385] The citrinin dimers penicitrinone E **451** and penicitrinol J **452** and the citrinin monomers penicitrinol K **453** and citrinolactone D **454** were isolated from *Penicillium* sp. (mangrove sediment, Fu Gong, Long Hai, Taiwan Strait, China).[386]



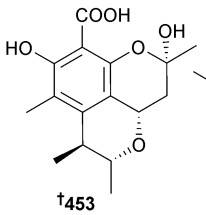
†**448** $R_1 = H$, $R_2 = Me$
†**449** $R_1 = Ac$, $R_2 = CH_2CH_2OAc$
†**450** $R_1 = R_2 = H$



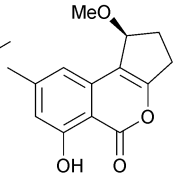
†**451**



†**452**



†**453**

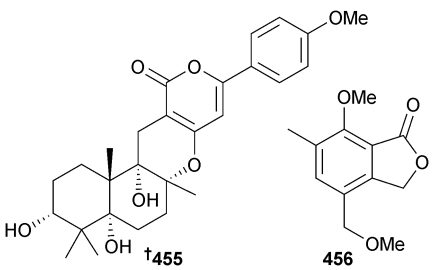


†**454**

Arisugacin I **455**, an α-pyrone meroterpene, was obtained from endophytic *Penicillium* sp. (mangrove leaves *Kandelia candel*, Shankou, Guangxi Province, China) as an inhibitor of acetylcholinesterase.[387] The known fungal metabolite arisugacin F[388] was also obtained for the first time from the marine environment.[387] Endophytic *Penicillium* sp. (mangrove leaves *Avicennia* sp., Dong Sai, Hainan, China) yielded the isobenzofuranone **456** which was moderately cytotoxic to KB and KB_{V200} cells.[389]

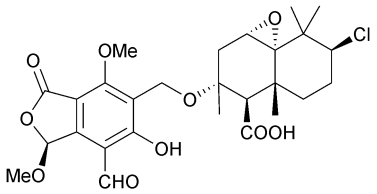
Pestaliopens A **457** and B **458**, hybrid sesquiterpene–cyclopaldic acid metabolites with an unusual carbon skeleton, were isolated from endophytic *Pestalotiopsis* sp. (mangrove leaves *Rhizophora mucronata*, Hainan Is. China). Pestaliopen A **457** exhibited modest inhibition of *E. faecalis*.[390]

P. virgatula (mangrove leaf *Sonneratia caseolaris*, Dong Zhai Gang mangrove garden, Hainan Is., China) yielded the α-pyrone derivatives pestalotiopyrone I–L **459–462** as well as (6*S*,1′*S*,2′*S*)-

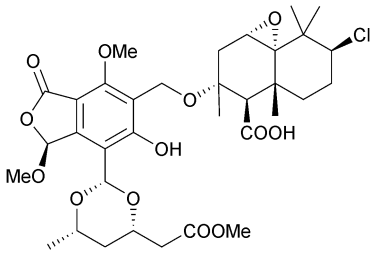


†**455**

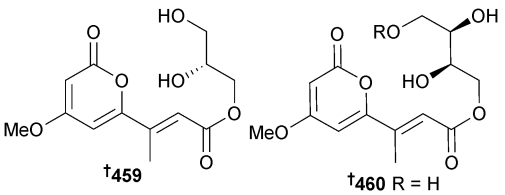
456



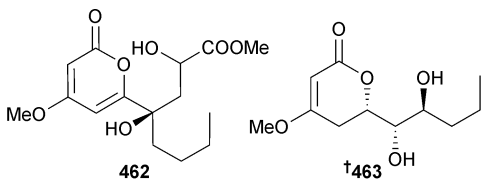
†457



†458



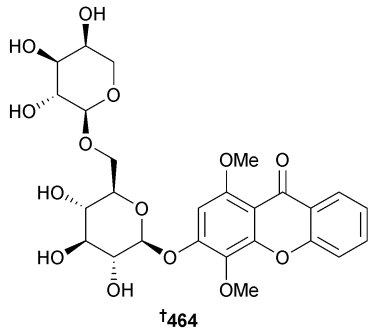
†459 †460 R = H †461 R = Ac



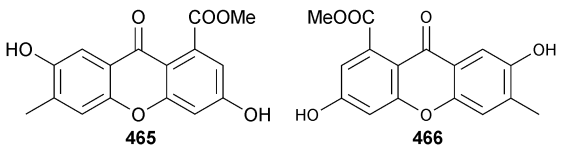
462 †463

hydroxypestalotin **463**,[391] a diastereoisomer of a metabolite isolated from a plant associated *Penicillium* sp.[392]

The xanthones *O*-glycoside **464** isolated from endophytic *Phomopsis* sp. (mangrove stem *Excoecaria agallocha*, Dong Zai, Hainan, China)[393] and **465** and **466** isolated from *Phomopsis* sp. (mangrove sediment, Shankou, Hainan, China)[394,395] were moderate inhibitors of HEp-2 and HepG2 cells.

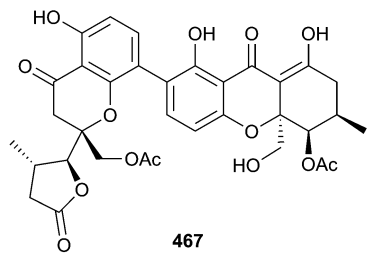


†464



465 466

Three new phomoxanthone compounds phomolactonexanthone A **467**, B **468** and deacetyl-phomoxanthone C **469** were obtained from *Phomopsis* sp. (mangrove branch *Acanthus ilicifolius*, Hainan, S. China Sea) along with five phomoxanthones known as endophytic metabolites of terrestrial fungi, namely dicerandrol A,[396] dicerandrol B,[396] dicerandrol C,[396] deacetylphomoxanthone B[397] and penexanthone A,[398] all isolated as first time MNPs.[399]



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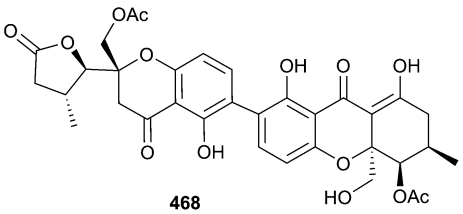

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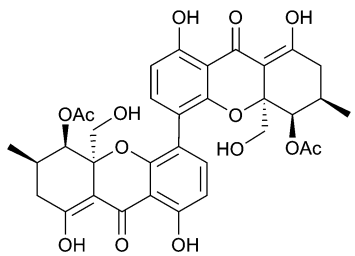
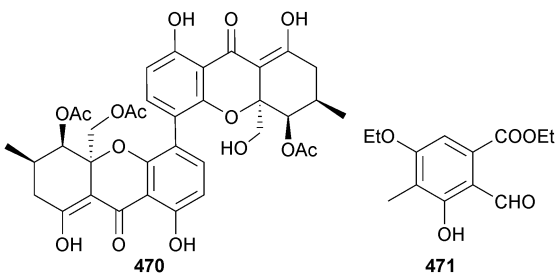


469

Phomopsis sp. (mangrove plant *Rhizhopora mucronata*, Muara Angke, Jakarta, Indonesia) was the producer of the dimeric tetrahydroxanthone 12-*O*-deacetyl-phomoxanthone A **470** which exhibited moderate inhibition of several Gram-positive bacteria.[400] A polysubstituted benzaldehyde derivative **471** was isolated from co-culture of two unidentified mangrove fungi (S. China Sea coast).[401]



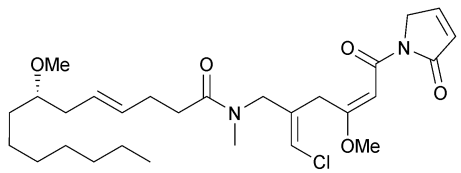
470 471

Marinamide and the methyl ester, methyl-marinamide were originally isolated from a co-culture of two mangrove

endophytic fungi from the S. China Sea Coast and assigned as pyrrolyl 1-isoquinolone alkaloids.[402] Subsequently, the fungus *Auxarthron reticulatum* (sponge *Ircinia variabilis*) yielded the quinolinone methyl-penicinoline, shown to be identical to methyl-marinamide requiring structural revision.[244] The revised structure of marinamide is identical to that of penicinoline, previously obtained from a mangrove endophytic fungus.[403] This problem has already been addressed above in Section 3.3. Both marinamide/penicinoline[403] and its methyl ester[245] displayed potent cytotoxicity to several HTCLs.

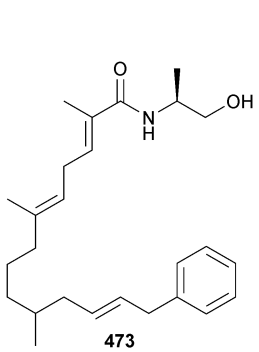
3.5 Cyanobacteria

There has been a marked drop in the number of new metabolites reported from cyanobacteria, continuing the downward trend from 2012. The lipopeptide malyngamide 4 **472** was isolated from *Moorea producens* (Red Sea, Jeddah, Saudi Arabia) as a moderate inhibitor of several HTCLs.[404]

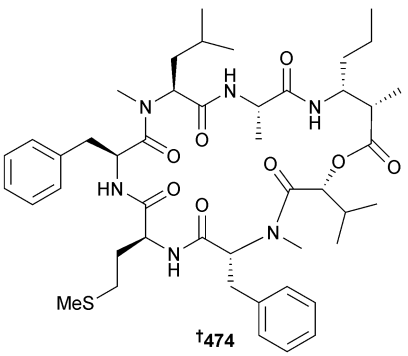


†472

M. producens (La Parguera, Puerto Rico) was the source of the lipopeptides parguerene **473** and precarriebowmide **474**. Studies of the stability of precarriebowmide **474** to atmospheric oxygen indicated that carriebowmide[405] and carriebowmide sulfone,[406] previously isolated from *Lyngbya polychroa* and *Lyngbya majuscula* respectively, may in fact be isolation artefacts of precarriebowmide **474**.[407]



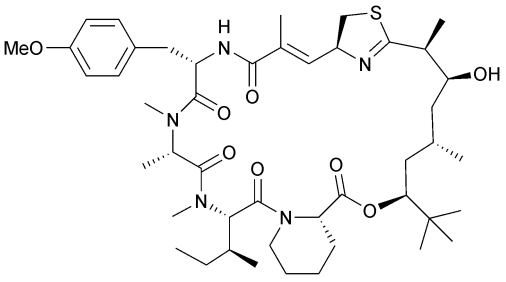
473



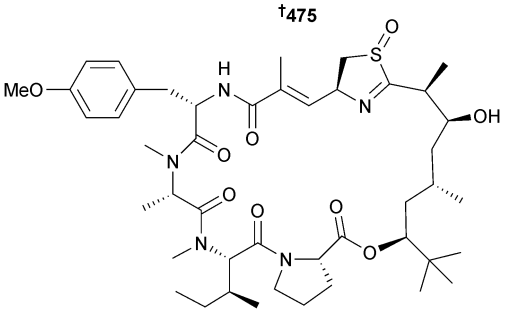
†474

Two new aprataoxin analogues, apratoxin H **475** and apratoxin A sulfoxide **476**, were obtained from *M. producens*, (Nabq Mangroves, Gulf of Aqaba, Red Sea) and both exhibited cytotoxicity to NCI-H460 lung cancer cells, but apratoxin H **475** was much more potent than apratoxin A sulfoxide **476**.[408]

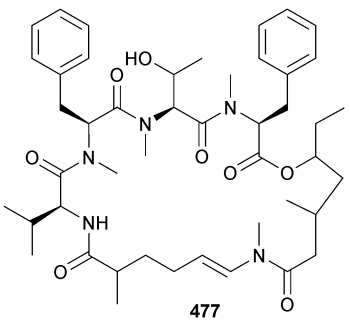
M. bouillonii (New Britain, Papua New Guinea) was the source of bouillonamide **477**, a cyclic depsipeptide which contained two unique polyketide-derived moieties, a 2-methyl-6-methylamino-hex-5-enoic acid residue and a unit of 3-methyl-5-hydroxy-heptanoic acid. Bouillonamide **477** displayed moderate toxicity to neuron 2a mouse neuroblastoma cells.[409]



†475

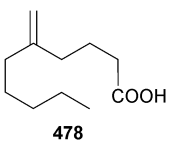


†476

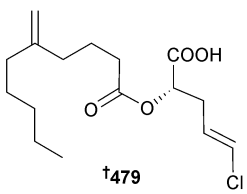


477

A cyanobacterium of similar morphology to *Lyngbya* sp. (Piti Bay, Guam) produced the lipids pitinoic acid A **478** and B **479**. Pitinoic acid A **478** inhibited quorum sensing in *Pseudomonas aeruginosa* and pitinoic acid B **479** exhibited anti-inflammatory activity, inhibiting production of pro-inflammatory cytokine expression. Pitinoic acid B **479** has been synthesised.[410] A species resembling the genus *Symploca* (Santa Cruz Is., Coiba National Park, Panama) yielded santacruzamate A **480**, a potent and specific inhibitor of histone deacetylase 4 and cytotoxic to several HTCLs. Santacruzamate A **480** was synthesised from γ-aminobutyric acid.[411]



478



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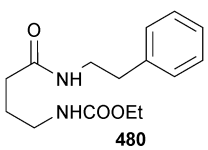
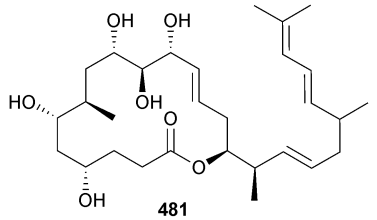


480

3.6 Dinoflagellates

An *Amphidinium* sp. (sediment, Iriomote Is., Japan) was the producer of iriomoteolides-4a **481** and -5a **482**, which displayed

moderate cytotoxicity against human B lymphocyte DG-75 cells.[412]



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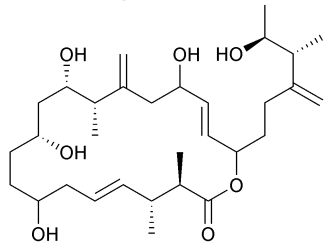
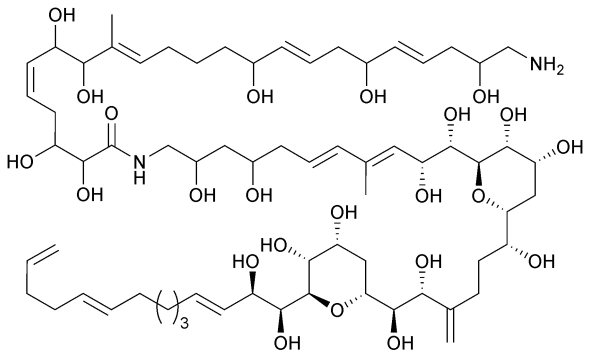


482

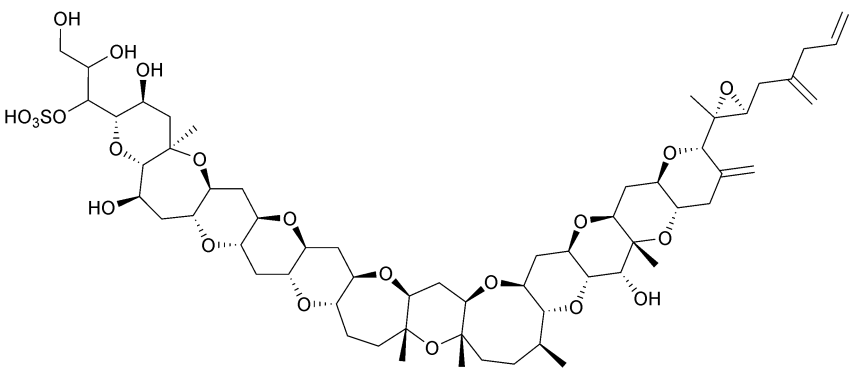
An epoxy polyether with twelve contiguous *trans*-fused ether rings, gambieroxide **483** was obtained from *Gambierdiscus toxicus* (Papeete, Tahiti, French Polynesia).[413] Gymnocin-A2 **484** was isolated from *Karenia* (formerly *Gymnodinium*) *mikimotoi* (Kushimoto Bay, Wakayama, Japan) as a moderate cytotoxin to P388 cells, along with the known synthetic analogue, gymnocin-A carboxylic acid[414] (first isolation from a natural source).[415]

The epiphytic, benthic dinoflagellate *Ostreopsis cf. ovata* (Jeju Is., S. Korea) was the source of ostreol A **485**, significantly cytotoxic to brine shrimp,[416] whilst the IK2 strain of *O. ovata* (Ikei Is., Okinawa, Japan) produced ovatoxins-a, -d and -e, each tentatively assigned by negative fast-atom bombardment collision-induced tandem mass spectrometry (FAB CID MS/MS).[417]



485

Pyrocystis lunula (University of Texas Culture Collection) yielded three polyunsaturated C27 hydrocarbons; *n*-heptacosa-3,6,9,12,15,18-hexaene (C27:6) **486**, (approx. 0.7 ng per sheathed cell), *n*-heptacosa-3,6,9,12,15,18,21-heptaene (C27:7) **487** and *n*-heptacosa-3,6,9,12,15,18,21,24-octaene (C27:8) **488**.[418] The benthic dinoflagellate *Vulcanodinium rugosum* (Northland, New Zealand) yielded portimine **489**, a polycyclic ether toxin containing a five-membered imine ring, which exhibited potent toxicity to P388 cells, in addition to activation of caspases, as an indication of apoptotic activity.[419]



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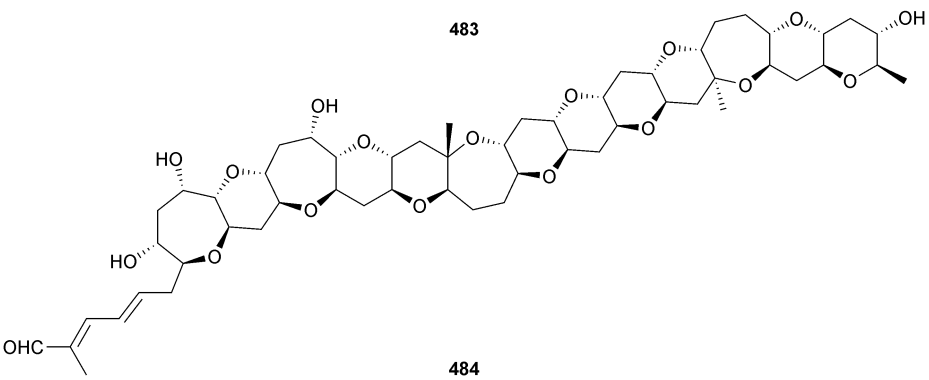
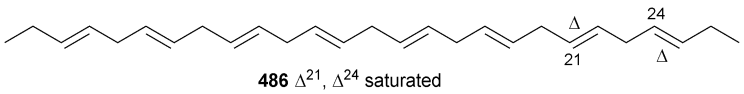
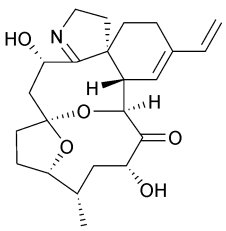


484

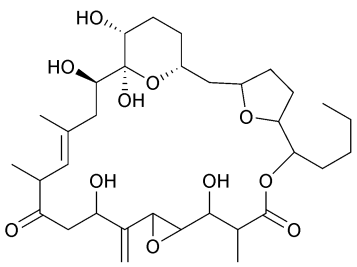


486 Δ^{21}, Δ^{24} saturated
487 Δ^{24} saturated
488

The structure of amphidinolide N, the most potent cytotoxic macrolide isolated from *Amphidinium* sp. to date[420] has been revised to **490** (and the relative configuration has been assigned).[421]



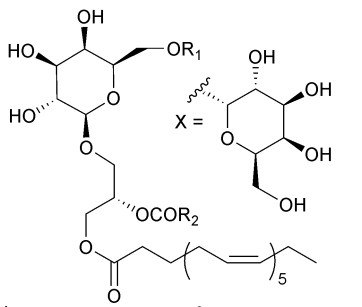
489



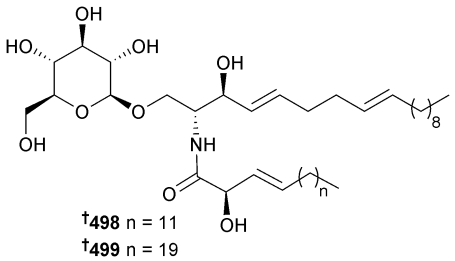
490

3.7 Microalgae

The microalga *Nannochloropsis granulata* (Provasoli-Guillard National Centre for Culture of Marine Phytoplankton, West Boothbay Harbour, Maine) was the source of the digalactosyldiacylglycerols **491**, **492** and the known **493** (ref. 422) and **494**,[422] whose configurations were determined. Also isolated were the monogalactosyl analogues **495**,[422] **496** (ref. 423) (first time as an NP) and **497**.[423] All of the isolated metabolites exhibited strong NO inhibitory activity against LPS-induced NO production in RAW264.7 macrophage cells suggesting potential as anti-inflammatory agents.[424] The green microalga *Tetraselmis* sp. (National Institute of Technology and Evaluation Biological Resource Centre, Chiba, Japan) was a producer of the glycosylceramides GT1 **498** and GT2 **499**.[425]



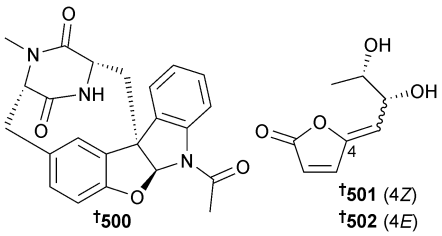
†**491** R_1 = X, R_2 = (*Z*) Δ^9 $nC_{15}H_{31}$
†**492** R_1 = X, R_2 = $nC_{13}H_{27}$
†**493** R_1 = X, R_2 = $nC_{15}H_{31}$
†**494** R_1 = X, R_2 =
†**495** R_1 = H, R_2 = $nC_{15}H_{31}$
496 R_1 = H, R_2 = $nC_{13}H_{27}$
497 R_1 = H, R_2 =



†**498** n = 11
†**499** n = 19

3.8 Synthetic aspects

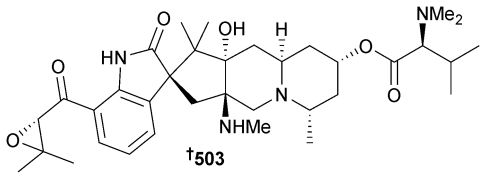
Synthesis of acremolin, originally isolated from sponge-associated *Acremonium strictum* and assigned as containing a 1*H*-aziridine moiety[426] proved that the alternative structure independently proposed (an isomeric, substituted N^2,3-ethenoguanine)[427] was indeed correct.[428] Total synthesis of *ent*-(−)-azonazine utilising a hypervalent iodine-mediated biomimetic oxidative cyclisation to construct the core, has resulted in revision of the absolute configuration of natural (+)-azonazine, originally obtained from Hawaiian *Aspergillus insulicola*[429] to **500**,[430] while syntheses of versicolactones A and B, lactones originally isolated from coral-associated *Aspergillus versicolor*,[431] have resulted in revision of the absolute configurations of the NPs to (4*Z*,6*R*,7*S*)-**501** and (4*E*,6*R*,7*S*)-**502** respectively.[432] It should be noted that the names versicolactones A and B have also been used to refer to unrelated sesquiterpene lactones isolated from the plant *Aristolochia versicolor*.[433,434]



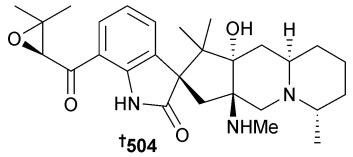
†**500**

†**501** (4*Z*)
†**502** (4*E*)

Citrinadins A and B are pentacyclic alkaloids, originally obtained from a red alga-associated strain of *Penicillium citrinum*.[435,436] An enantioselective total synthesis of (−)-citrinadin A has been achieved in twenty steps from commercially available materials which featured an asymmetric vinylogous Mannich addition of a dienolate to a chiral pyridinium salt to set the initial chiral centre. The synthesis led to revision of the core stereochemistry of the citrinadins and thus of citrinadin A to **503**.[437] An enantioselective total synthesis of (+)-citrinadin B featuring a stereoselective intermolecular nitrone cycloaddition reaction as a key step, similarly led to revision of the configuration of citrinadin B to (+)-**504**.[438]

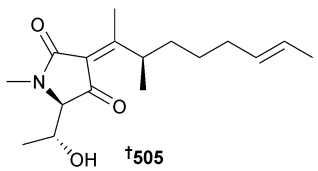


†503

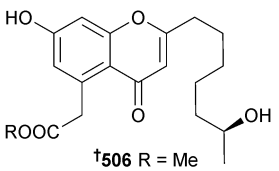


†504

Trichodermatide A, a polyketide isolated from the fungus *Trichoderma reesei*,[439] has been synthesised from L-tartaric acid utilising an intramolecular ketal formation reaction to construct the core of the molecule.[440] The total syntheses of the putative structures of (±)-trichodermatides B and C featuring the oxa-[3 + 3] annulation strategy have also been accomplished but mismatch of spectroscopic data between the synthetic and NP samples has indicated that the structural assignments of these metabolites may need revision.[441] Syntheses of two diastereoisomers of penicillenol C1, originally obtained from an endophytic, mangrove-associated *Penicillium* species,[442] have led to reassignment of the absolute configuration as **505** (5*S*,6*R*,9*S*).[443] The absolute configurations of the endophytic mangrove *Pestalotiopsis* sp. metabolites, pestalotiopsones D and E[444] were determined through total syntheses as **506** and **507** respectively.[445]

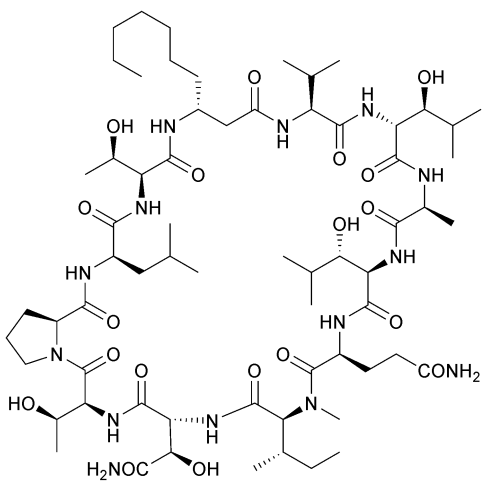


†505



†506 R = Me
†507 R = Et

Synthesis of the reported structure of xylopyridine A, a DNA-binding agent originally obtained from a mangrove-associated *Xylaria* sp.,[446] has indicated that the reported structure is incorrect and requires revision.[447] Total synthesis of laxaphycin



†508

B, a metabolite of terrestrial *Anabaena laxa*[448] and of marine *L. majuscula*,[449] was achieved through stepwise automated solid-phase peptide synthesis, which led to revision of configuration to **508**. The related *L. majuscula* metabolite lyngbyacyclamide A[450] was also synthesised by a similar procedure.[451]

The dolastatin 14 analogue, malevamide E, was originally obtained from the cyanobacterium *Symploca laete-viridis* and the stereochemistry of the peptidic portion assigned.[452] Convergent synthesis of (29*S*,37*S*)-malevamide E involving Julia-Kocienski olefination, Urpi acetal aldol and Shiina macrolactonisation reactions has been achieved but a mismatch of the NMR data between the synthetic and natural samples indicated that the originally assigned configurations of some of the amino acids need revision.[453] A stereoselective synthesis of the C-43–C-67 fragment of amphidinol 3, originally obtained from the dinoflagellate *Amphidinium* klebsii,[454] revised the originally assigned configuration at C-51 from (*R*) to (*S*).[455] Ieodomycins A and B are antimicrobial fatty acids originally obtained from a *Bacillus* sp.[456] The first[457] of several total syntheses of these published in 2013,[458–460] has been achieved in fifteen steps *via* the chiral pool approach from D-glucose.[457] Syntheses of the glycolipopeptides ieodoglucomide A and B, originally obtained from *Bacillus licheniformis*,[461] have been accomplished *via* a method involving β-glycosylation and Grubbs olefin cross-metathesis as key steps. The syntheses highlighted that the optical rotation values were originally misreported as being of opposite sign to their actual values and the authors of the isolation paper had noted this also.[462,463] Syntheses of marinacarbolines A–D, antimalarial β-carboline alkaloids originally obtained from *Marinactinospora thermotolerans*[464] were achieved in four steps from methyl 1-chloro-β-carboline-3-carboxylate[465] and the cyclic peptide urukthapelstatin A, originally isolated from the bacterium *Mechercharimyces asporophorigenens*[466,467] has been synthesised *via* a convergent strategy.[468] Trioxacarcin A, a structurally complex glycosidic metabolite of terrestrial[469] and marine[470] *Streptomyces* species, has been synthesised *via* a method which utilised late-stage stereoselective glycosylation reactions of aglycon substrates.[471] Indoxamycins A, C, and F, cytotoxic tricyclic polypropionates originally obtained from a *Streptomyces* sp.[472] and whose stereochemistry has also been revised as a result of a synthesis of indoxamycin B,[473] have been synthesised *via* a divergent approach with an Ireland-Claisen rearrangement, a stereodivergent reductive 1,6-enyne cyclisation and a tandem 1,2-addition/oxa-Michael/methylenation reaction sequence as key steps.[474] Cytosporin D, an epoxyquinone metabolite of *Eutypella scoparia*,[475] has been prepared from the Diels–Alder adduct of cyclopentadiene and 2-prenyl-*p*-benzoquinone,[476] while helicascolide B, a lactone originally obtained from the fungus *Helicascus kanaloanus*,[477] has been synthesised in seven steps from commercially available tiglic aldehyde.[478] Leptosin D, originally obtained from a *Leptosphaeria* sp. associated with a brown alga[479] has been synthesised *via* a strategy which first prepared the known terrestrial[480] and marine[481] fungal metabolite gliocladine C, which was then manipulated to access various tryptophan-derived epidithiodioxopiperazine NPs.[482] Enantioselective total synthesis of (−)-penicipyrone, a polycyclic

4-hydroxy-2-pyrone metabolite of a *Penicillium* species associated with a Thai sea fan *Annella* sp.,[483] was achieved in twelve steps by a biomimetic bimolecular cascade cyclisation featuring an intermolecular Michael addition/cyclo-(spiro-) ketalisation sequence[484] and total syntheses of plectosphaeroic acids A–C (indoleamine 2,3-dioxygenase inhibitors from the fungus *Plectosphaerella cucumerina*[485]) have been accomplished.[486,487] The quinoline alkaloid, 4,8-dimethyl-6-*O*-(2′,4′-di-*O*-methyl-β-D-xylopyranosyl)hydroxyquinoline, originally obtained from a Caribbean collection of *Lyngbya majuscula*,[488] has been synthesised by a method which utilises unusual silyl group migrations[489] and synthesis of nhatrangin A, an aplysiatoxin-related metabolite isolated from Vietnamese *Lyngbya majuscula*,[490] has been accomplished and confirmed the absolute configuration originally proposed.[491] (+)-Serinolamide A, a cannabinomimetic lipid metabolite of Panamanian *Lyngbya majuscula*[492] has been synthesised from L-serine in nine steps with 30% overall yield[493] and total synthesis of viequeamide A, a cyclic depsipeptide metabolite of the Puerto Rican "button" cyanobacterium *Rivularia* sp.,[494] was achieved in ten linear steps based on three retrosynthetic fragments.[495] Amphidinolide C, a macrocyclic lactone metabolite of the dinoflagellate *Amphidinium* sp.,[496] has been synthesised through the use of a common intermediate to access both the C-1–C-8 and the C-18–C-25 sections.[497]

3.9 Assorted bioactivities

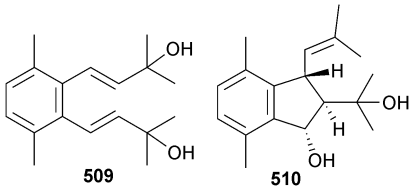
The sesterterpenes ophiobolin K,[498,499] 6-*epi*-ophiobolin K[498,499] and 6-*epi*-ophiobolin G,[499] known metabolites of both terrestrial[498] and marine[499] fungi were isolated from *Emericella variecolor* (sediment, Gokasyo Gulf, Mie Prefecture, Japan) as inhibitors of biofilm formation of *Mycobacterium smegmatis* and of *M. bovis* BCG at concentrations below those required for antimicrobial activity.[500] Toluquinol, a methylhydroquinone known as a metabolite of the soil fungus *Nectria erubescens*[501] was isolated from a *Penicillium* sp. (Instituto Biomar, León, Spain) as an antiangiogenesis agent, inhibiting the growth of endothelial and tumour cells *via* apoptosis after a cell cycle block and caspase activation.[502] Several known fungal metabolites were isolated as selective inhibitors of PTP1B, a potential target for the treatment of type 2 diabetes and obesity.[503] *Penicillium* sp. (sediment, Wan Is., S. Korea) yielded fructigenine A[504] and cyclopenol,[505] *Eurotium* sp. (sediment, Wan Is., Korea) yielded echinulin[506] and flavoglaucin[507] and a further *Penicillium* sp. (unidentified sponge, Jeju Is., S. Korea) was the source of viridicatol.[505] Bis-*N*-norgliovictin, a known terrestrial[508] and marine[509,510] metabolite was isolated from a marine-derived endophytic fungus (no other details given), as an anti-inflammatory agent that inhibited LPS-induced TNF-α production in RAW264.7 cells.[511]

3.10 Biosynthesis

The gene cluster responsible for the biosynthesis of the glycosylated diazofluorene polyketides lomaiviticins A–E,[512,117] originally isolated from *Salinispora pacifica* (formerly *Micromonospora lomaivitiensis*), was identified in wild-type *Salinispora tropica* and several mutant strains through bioactivity-guided genome mining.[513] An investigation of 163 strains of actinomycetes isolated from mangrove sediments *via* homologous screening of the biosynthetic genes and bioassay identified 16% of the strains as possessing the potential to produce halogenated NPs.[514] The stephacidin and notoamide families of NPs occur in various *Aspergillus* species, both terrestrial[515] and marine.[516] In a further elaboration of the biosynthesis of these metabolites, notoamide T was identified as the likely precursor to stephacidin A and synthesised along with the C-6-epimer, 6-*epi*-notoamide T. Stephacidin A was chemically converted to notoamide T by reductive ring opening while notoamide T also underwent oxidative conversion to stephacidin A. $[^{13}C]_2$-Notoamide T was synthesised and fed to two *Aspergillus* strains resulting in significant incorporation into the advanced metabolite notoamide B.[517] Analysis of transcriptome data of a number of saxitoxin (STX)-producing dinoflagellates, especially *Alexandrium tamarense* strains, identified 265 putative homologues of 13 cyanobacterial STX synthesis genes, including all of the genes directly involved in toxin synthesis. Putative homologues of four proteins group closely in phylogenies with cyanobacteria but the phylogenies do not support transfer of these genes directly between toxic cyanobacteria and dinoflagellates, suggesting that the STX synthesis pathway was likely to have been assembled independently in cyanobacteria and dinoflagellates, but using some evolutionarily related proteins.[518]

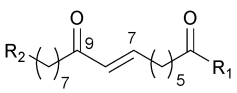
4 Green algae

Interest in green alga chemistry continued at a low ebb in 2013. Further work on *Caulerpa racemosa* (Zhanjiang coastline, China), previously the source of caulerpin and two related caulerpin derivatives,[519] led to the discovery of two prenylated *para*-xylenes caulerprenylol A **509** and B **510** that were each weakly antifungal.[520]



509 **510**

Interesting results were uncovered from the screening and careful bioassay-guided analysis of a collection of Floridian marine eukaryotic algae using an ARE-luciferase reporter gene assay that led to the detection and isolation of three monounsaturated fatty acids **511–513** from *Ulva lactuca* as activators of the ARE response. Each contained the identical Δ^7,9-keto motif.[521]



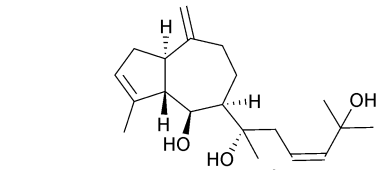
511 R_1 = OH, R_2 = C_2H_5
512 R_1 = OH, R_2 = H
513 R_1 = NH_2, R_2 = C_2H_5

A stereoselective synthesis of the C-8′–O–C-6″ ether of the antimitotic agent nigricanoside A[522] was successfully applied in model systems.[523] Included in the green algal literature for 2013

were reports on the cytotoxic effects of clerosterol from *Codium fragile*[524] on HTCLs[525] and the spasmolytic effects of caulerpine[526] on guinea pig ileum.[527]

5 Brown algae

The number of new compounds characterised in 2013 from the Ochrophyta was again relatively low and was dominated by terpenoid chemistry. Based on the *in vitro* cytotoxicity of a crude *Dictyota dichotoma* (Abu-Bakr, Red Sea, Egypt) extract an investigation was mounted and three new diterpenoids (*Z*)-pachydictyol B **514**, (*E*)-pachydictyol B **515** and pachydictyol C **516** were characterised along with the known pachydictyol A[528] and several other well-known brown algal metabolites.[529]



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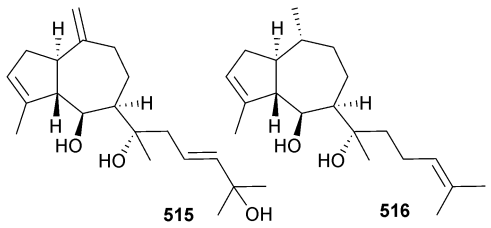
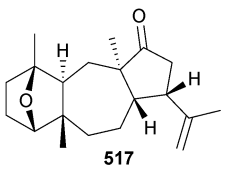


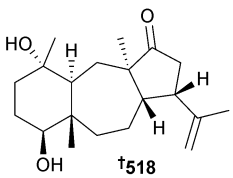
515

516

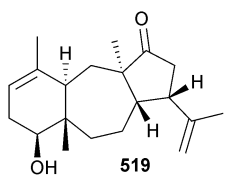
Re-investigation of *Dilophus spiralis* (Elafonissos Is., Greece) resulted in the isolation of three new dolastanes **517–519** and five previously reported perhydroazulenes. The relative configurations were established for all three dolastanes and the absolute configuration of **518** established by conversion to a compound of known absolute configuration. The absolute configurations of **517** and **519** were assumed on the basis of biogenetic considerations.[530]



517

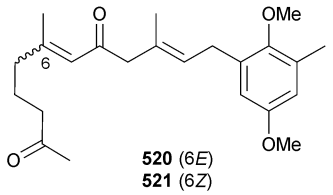


†**518**

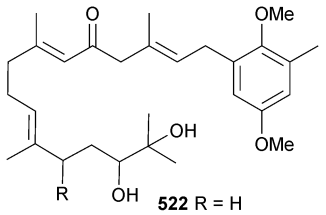


519

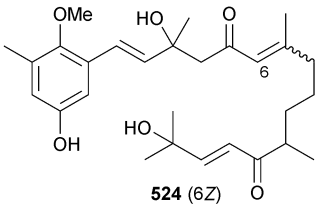
The cytotoxic meronorsesquiterpenoids cystoazorone A **520** and B **521** and meroditerpenoids cystoazorol A **522** and B **523** were isolated from *Cystoseira abies-marina* (Mosteiros, Sao Miguel Is., Azores)[531] while a series of meroditerpenoids cystodione A–F **524–529**, all with strong antioxidant properties in the ABTS assay, were isolated from *Cystoseira usneoides* (Gibraltar Strait).[532]



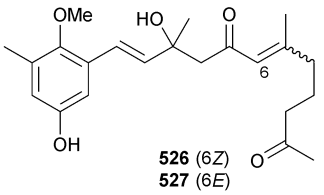
520 (6*E*)
521 (6*Z*)



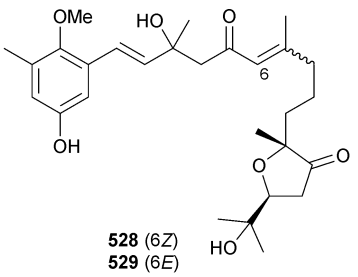
522 R = H
523 R = OH



524 (6*Z*)
525 (6*E*)

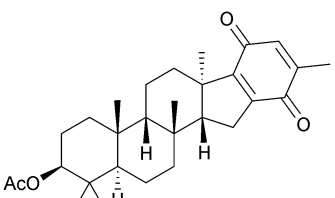


526 (6*Z*)
527 (6*E*)



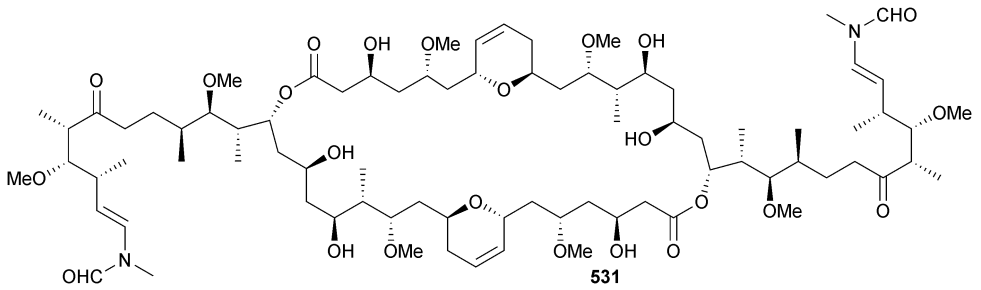
528 (6*Z*)
529 (6*E*)

The mildly antiproliferative meroditerpenoid zonaquinone acetate **530** was obtained from a Jamaican *Stypopodium zonale*.[533] Other known brown algal metabolites were co-isolated and these included flabellinone,[534] not previously identified in *S. zonale*, stypoldione,[535] and sargaol.[536] The absolute configuration of **530** was determined by vibrational circular dichroism (VCD) calculations at several levels of theory.[533]



†**530**

The synthesis of the core framework of the proposed structure of sargafuran[537] was achieved but the ^{1}H and ^{13}C NMR



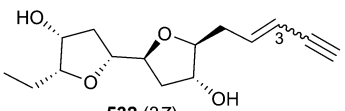
531

spectral data of the synthetic analogue did not match suggesting that the originally proposed structure of sargafuran is incorrect.[538] The data matched better with the known sargachromenol.[539] Another total synthesis of (−)-ecklonialactone B,[540] as well as the non-natural (+)-9,10-dihydro-ecklonialactone B, was reported.[541] In papers covering biological properties of brown algal metabolites, four papers were published on the eckol group of phlorotannins describing anti-inflammatory properties,[542,543] induction of apoptosis in carcinoma cells[544] and potential as SARS inhibitors.[545] Two surveys were published on the antioxidant potential of brown algal extracts which included an excellent summary from species across the phylum as well as the properties of individual brown algal metabolites.[546,547] The antiviral properties of sulfoquinovosyldiacylglycerols from *Sargassum vulgare* (Ilha de Itacuruçá, S.E. Brazil) were evaluated[548] and the antiviral activity of *Dictyota* diterpenes assessed in docking studies against HIV-1 reverse transcriptases.[549] A putative inhibitory mechanism for RANK-induced osteoclast formation by sargachromanol G from *Sargassum siliquastrum*[550] has been proposed[551] and the antiplatelet and antithrombotic effects of sargahydroquinoic and sargaquinoic acids determined.[552] In other reports of biological testing, the strong antimelanogenic properties of an extract from *Dictyota coriacea* (Jeju Is., S. Korea) were attributed to 1,9-dihydroxycrenulide[553] and epiloliolide,[554] known compounds.[555] Seven known meroditerpenoids were isolated from *Sargassum siliquastrum* (Jeju Is., S. Korea) and evaluated for cytotoxicity against a range of HTCLs,[556] while the cytotoxic sterol (24*R*)-hydroperoxy-24-vinylcholesterol[557] was reported for the first time from *Nizamuddinia zanardinii* (Oman Sea).[558] In a comprehensive study the anticancer effects of fucoxanthin were examined from a mechanistic perspective.[559] In another wide-ranging study, 20 green and brown algal extracts from the French coast were evaluated against *Trypanosoma brucei rhodesiense* (*T. b. rhodesiense*).[560] The *Bifurcaria bifurcata* extract showed the strongest trypanocidal activity which was tracked to eleganolone.[561] The potential of the HPLC/NMR technique for chemical profiling and dereplication was illustrated with the characterisation of nine known compounds from *Cystophora torulosa* (Pt. Lonsdale, Victoria, Australia).[562]

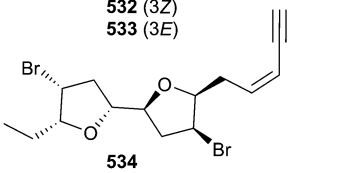
6 Red algae

The nine new compounds reported from red algae in 2013 is a marked reduction in the number reported from the previous year (47). The relative configurations of the 30 stereogenic centres in the macrodiolide luminaolide **531** (*Hydrolithon reinbodii*)[563] were assigned from NMR data, although the relationships of the two side chains to the macrolide ring are still to be established.[564]

The structures of laurefurenynes A **532** and B **533** (*Laurencia* sp.)[565] were reassigned following syntheses of **532**[566] and **533**,[567] respectively, and density functional theory (DFT) calculations of NMR chemical shift data.[567] There is still doubt about the configuration of the closely related elatenyne (*L. elata*).[568] Computational[569] and synthetic[570] efforts suggested a revised structure. However, recent more extensive NMR and chemical derivatisation studies proposed a further revision **534** but were unable to establish the absolute configuration.[571]

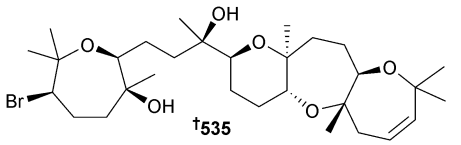


532 (3*Z*)
533 (3*E*)

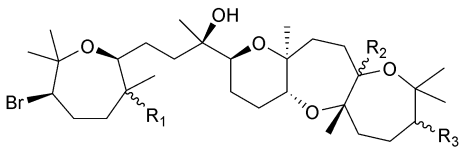


534

Various aspects of the configurations of armatols A–F (*Chondria armata*)[572] have now been clarified through the total synthesis of armatol A **535** and hence by analogy to the structures for armatols B–F **536–540**.[573] This paper also reported the first total synthesis of dioxepandehydrothyrsiferol (*Laurencia viridis*)[574] as the enantiomer.

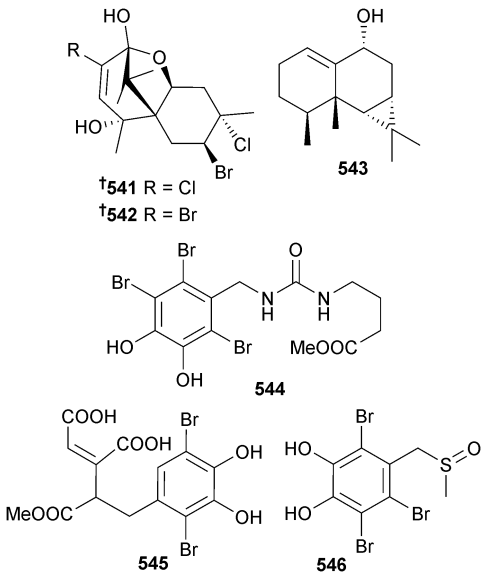


†**535**

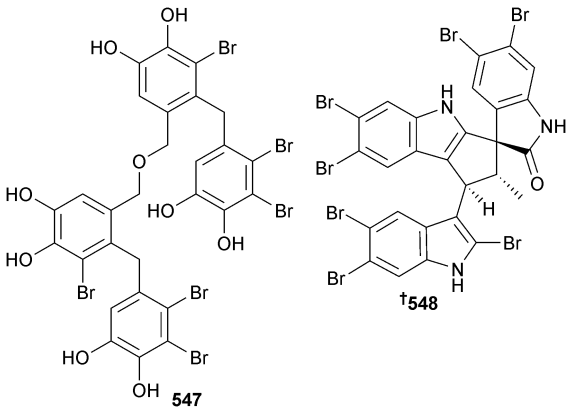


536 R_1 = OH, R_2 = H, R_3 = Br
537 R_1 = OH, R_2 = H, R_3 = Br
538 R_1 = OH, R_2 = H, R_3 = Br
539 R_1 = OH, R_2 = H, R_3 = Br
540 R_1 = OH, R_2 = H, R_3 = Br

The chamigrane sesquiterpenes yicterpene A **541** and B **542** were isolated from *L. composita* (Pingtan Is., China).[575] Of the 7 compounds isolated from *L. similis* (Sepanggar Is., Kota Kinabalu, Sabah), *ent*-1(10)-aristolen-9β-ol **543** was claimed as an enantiomer of a known compound.[576,577] Two bromophenols **544** and **545** with radical scavenging activity were obtained from *Symphyocladia latiuscula* (Qingdao, Shandong Province, China).[578] This same collection of *S. latiuscula* also provided the weakly antifungal bromophenol sulfoxide **546**.[579]



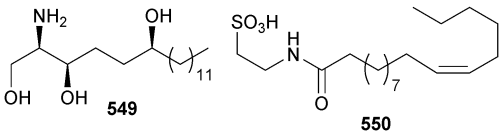
One new (**547**) and three known bromophenols isolated from *Vertebrata lanosa* (Oldervik, Ullsfjorden, Norway) had cellular antioxidant activities, the first time this activity has been reported for this class of compounds.[580] The unprecedented polybrominated spiro-trisindole similisine A **548** and its enantiomer similisine B were obtained from *Laurencia similis* (S. China Sea).[581]



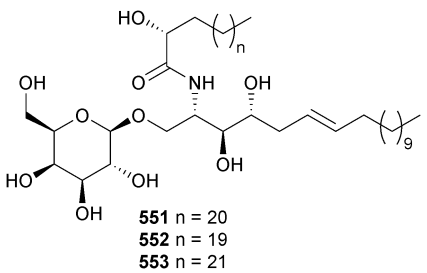
Synthesis of the two proposed diastereomers of prevezol C (*L. obtusa*)[582] showed that neither is the structure of the NP.[583] Parguerenes (*L. filiformis*)[584] were identified as inhibitors of P-glycoprotein (ABCB1) in multidrug resistant human cancer cells.[585] Five known bromophenols from a variety of red algae had inhibitory activity against glucose 6-phosphate dehydrogenase, this being the first report of such inhibitors from red algae.[586] Analysis of the metabolite compositions of seasonal collections of *Graciliaria gracilis* (Lesina Lagoon, S. Adriatic Sea, Italy) led to the proposition for using *G. gracilis* as a multi products source for biotechnological, nutraceutical and pharmaceutical applications.[587] Bioactive metabolites isolated from *Asparagopsis taxiformis* were found to have little potential for therapy services to fish infected with *Streptococcus iniae*.[588]

7 Sponges

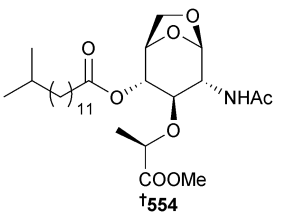
Even with only 243 new compounds reported in 2013, a significant decrease in relation to previous years (19% and 33% down on 2011 and 2012, respectively),[589,2] sponges remain the dominant phylum for the discovery of new marine-derived bioactives (see section 15 Conclusion). The modified sphingoid base halisphingosine B **549** was isolated from *Haliclona tubifera* (Santa Catarina, Brazil)[590] while taurinated fatty acid **550** was isolated from *Axinella* sp. (Hainan Is., S. China Sea).[591]



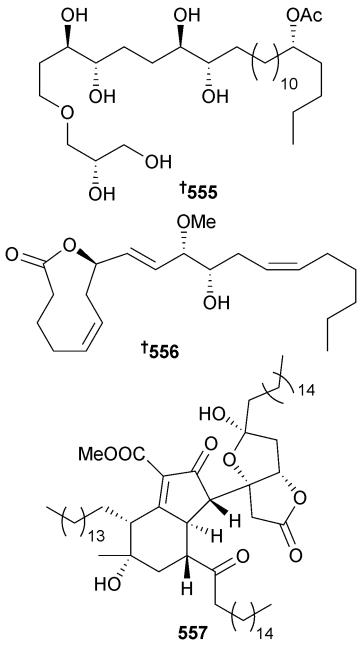
The asymmetric total synthesis of the "two-headed" sphingoid base rhizochalin C (*Rhizochalina incrustata*)[592] has been completed.[593] An *Axinyssa djiferi* found attached to mangrove tree roots (Djifer, Senegal) yielded axidjiferosides A–C **551–553**, a mixture of which inhibited chloroquine-resistant *P. falciparum*.[594]



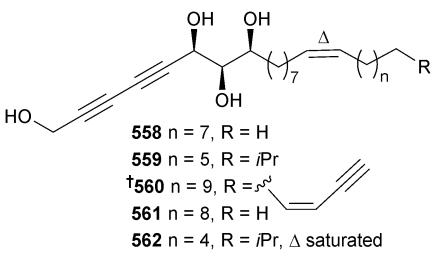
An acetylated nitrogenous glycolipid **554** was isolated from *Plakinastrella clathrata* (Gneerings Reef, Queensland, Australia), with the absolute configuration confirmed by synthesis of lipid-chain analogues. The compound was claimed to be a moderate anti-inflammatory by inhibition of PGE_2 but no data was provided.[595]



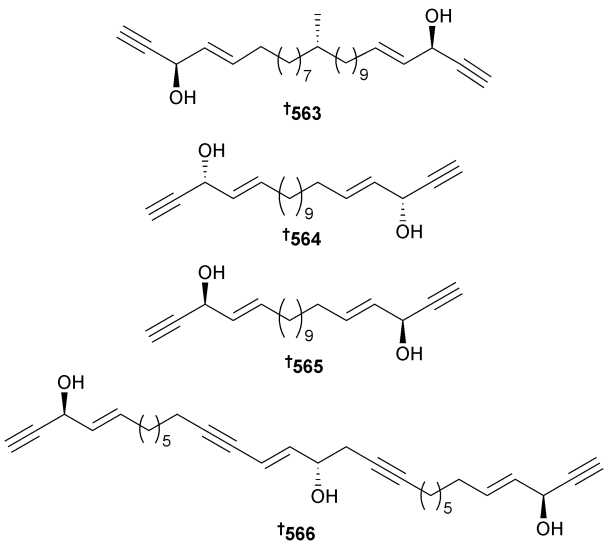
Mycalol **555** is a glycerol ether isolated from *Mycale acerata* (Terra Nova Bay, Antarctica). A combination of chiroptical and Mosher's methods were used to assign the absolute configuration of this specific inhibitor of human anaplastic thyroid carcinomas, the most aggressive and currently untreatable thyroid gland malignancies, but inactive against other solid tumours.[596] The absolute configuration of topsentolide C_2 **556** (*Topsentia* sp.)[597] was established by total synthesis of four possible diastereomers.[598] The moderately antimicrobial fatty acid trimer manzamenone O **557** was isolated from *Plakortis* sp. (Manzamo, Okinawa).[599]



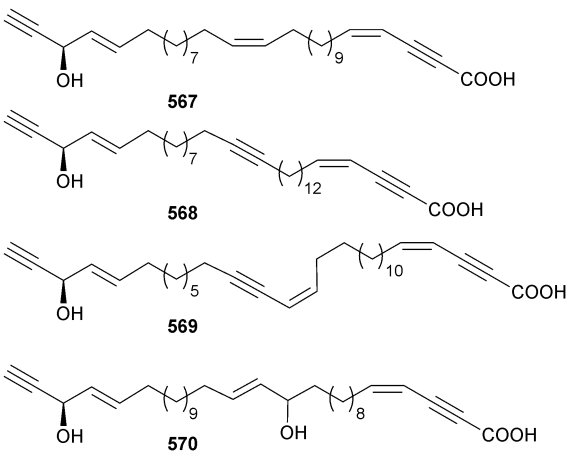
Sponges from the genus *Petrosia* continue to be a rich source of new polyacetylenes. The report of petrosiols A–E **558–562** from *Petrosia strongylata* (Ishigakijima Is., Okinawa) as inducers of nerve growth factor-like neuronal differentiation in PC12 cells was followed rapidly by reports of the total synthesis and absolute configuration of petrosiol D **560**,[600,601] and the discovery that **558** inhibits proliferation and migration of platelet derived growth factor-induced vascular smooth muscle cells and hence could be used as a lead for vascular disorders.[602]



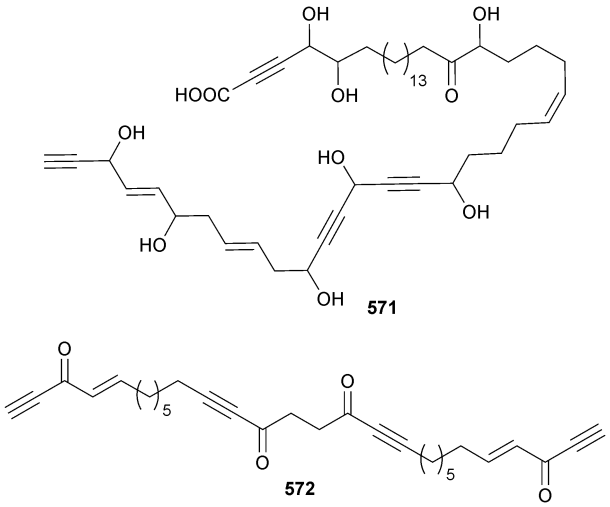
The absolute configuration of the isolated methyl group of miyakosyne A **563** (*Petrosia* sp.)[603] was established by chemical degradation and subsequent esterification with Ohrui's acid,[604] thus correcting an earlier tentative assignment made from an analysis by X-ray crystallography of miyakosyne absorbed in a porous metal complex.[71,605] A racemic mixture of C20 bisacetylenic alcohols **564** and **565** has been isolated from *Callyspongia* sp. (Iriomote Is., Okinawa), and separated by chiral HPLC. Total synthesis of both enantiomers and detailed biological evaluation showed **564** was more active than its enantiomer against HeLa and temperature sensitive rat lymphatic endothelial cells, thus defining the 1-yne-3-ol moiety as an essential pharmacophore.[606] Petrosiacetylene E **566** (*Petrosia* sp. Dokdo Is., S. Korea) was a low μM inhibitor of multiple HTCLs.[607]



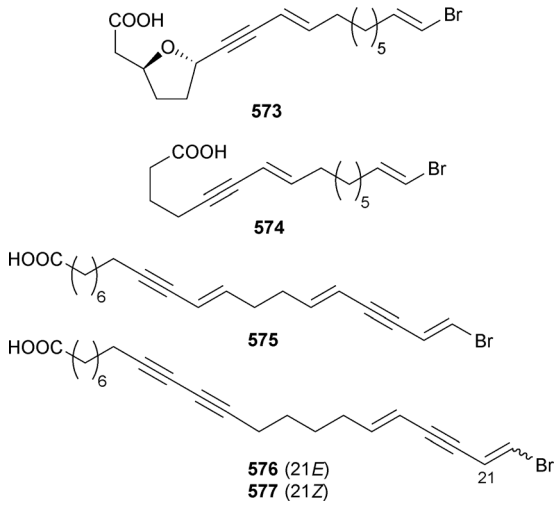
Petrosynic acids A–D **567–570** (*Petrosia* sp., Tutuila, American Samoa) all displayed similar activity *versus* various HTCLs and non-proliferative human fibroblasts and hence no therapeutic window is available.[608]



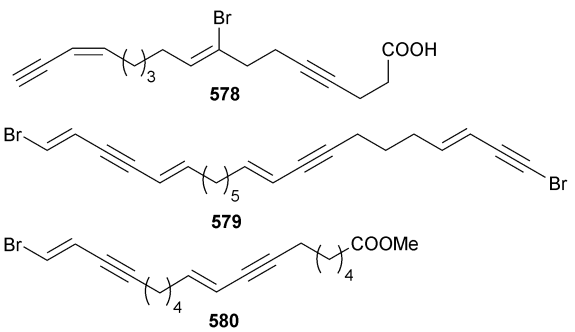
A New Caledonian *Niphates* sp. was the source of nepheliosyne B **571**.[609] Examination of *Petrosia solida* (Amami-Oshima, Japan) yielded petroacetylene **572** that inhibited starfish embryo blastulation.[610]



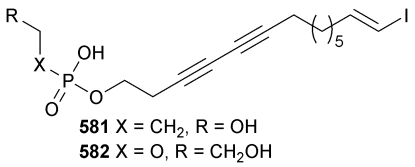
Bromoacetylene testafuran A **573** was isolated from *Xestospongia testudinaria* (Iwo Is., Kagoshima, Japan) along with four other polyacetylenes **574–577**, all five of which induced apidogenesis (stimulation of the differentiation of preadipocytes to adipocytes), and hence may act as leads for treatment of cardiovascular disorders.[611]



An inhibitor of starfish egg maturation, bromotheoynic acid **578**, was reported from *Theonella swinhoei* (Tanegashima, Kagoshima, Japan),[612] while two further bromopolyacetylenes **579** and **580** were obtained from *Haliclona* sp. (Sharm Obhur, Jeddah, Saudi Arabia).[613]

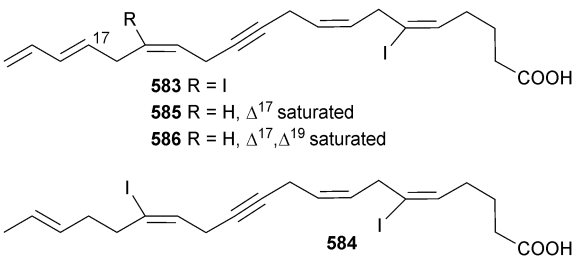


Phosphoiodyns A **581** and B **582** are iodinated and phosphate containing alkynes from *Placospongia* sp. (Tong-Young City, S. Korea). Phosphoiodyn B was inactive, but **581** was a potent inhibitor of human peroxisome proliferator-activated receptor delta (hPPARδ) with 200-fold selectivity over other PPARs, and therefore a potent regulator of lipid and glucose metabolism, and potentially a lead for treating type 2 diabetes or metabolic disorders.[614,615]

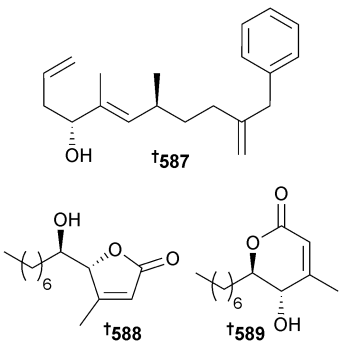


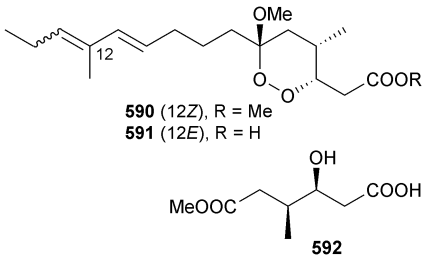
581 X = CH_2, R = OH
582 X = O, R = CH_2OH

Four mono- or di-iodinated polyacetylene acids were isolated from *Suberites mammilaris* (**583** and **584**) and *S. japonicus* (**585** and **586**) (Gageo Is., S. Korea). Anti-inflammatory bioactivity profiling of the methyl esters indicated that pre-treatment with the *S. mammilaris* metabolites inhibited nitrite production in LPS-stimulated RAW 267.4 macrophages while the *S. japonicus* metabolites inhibited NO production in BV2 microglial cells, with each pair being inactive in the other assay.[616]



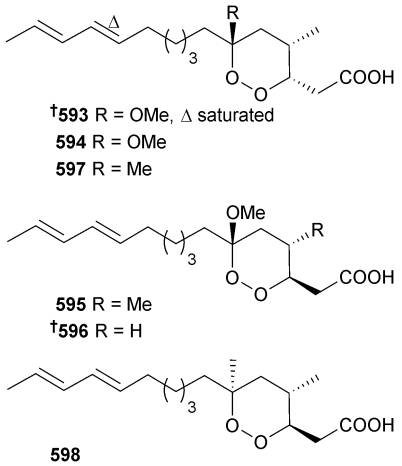
A mixed extract from *Smenospongia aurea*, *S. cerebriformis* and *Verongula rigida* (Key Largo, Florida) yielded a linear phenyl alkene **587** with activity against HL-60 cells. Molecular modelling docking studies suggested that **587** had a pharmacophore similar to that of eribulin and hence potential to interfere with microtubule dynamics.[617] Dysideolides A **588** and B **589** are methyl-branched lactones from *Dysidea cinerea* (Lang Co Beach, Vietnam),[618] while 12-manadoperoxide B **590**, manadoperoxidic acid B **591** and monoester **592** were reported from *Plakortis lita* (Bunaken Is., Manado, Indonesia). Both **591** and the likely oxidative breakdown product **592** showed potent anti-trypanocidal activity against *T. b. rhodesiense*.[619]



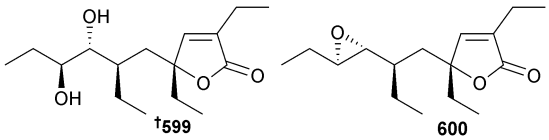


592

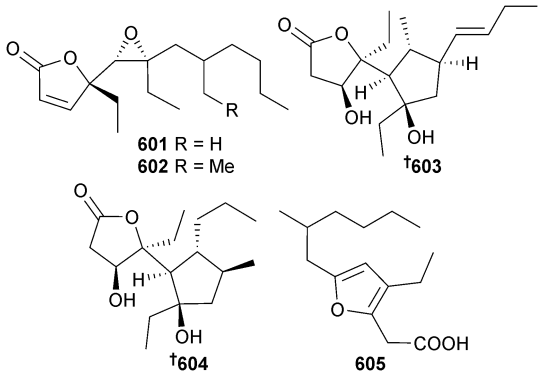
Six new methylated peroxidic acids **593–598** were isolated from *Plakortis simplex* (Keomun Is., West Sea, S. Korea). All showed low moderate cytotoxic activity against RAW264.7 cells.[620]



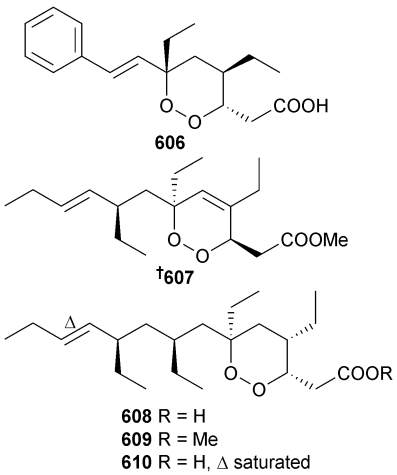
A chemical ecological study of *Discodermia dissoluta* held in Santa Marta, Colombia has shown that <40 kg of sponge could be sufficient to sustainably produce 1 g of discodermolide[621] over six months for clinical trials.[622] A comprehensive study combining computation, chemical derivatisation and NMR studies was used to assign both the relative and absolute configurations of plakilactones G **599** and H **600** from a Fijian *Plakinastrella mamillaris*.[623]



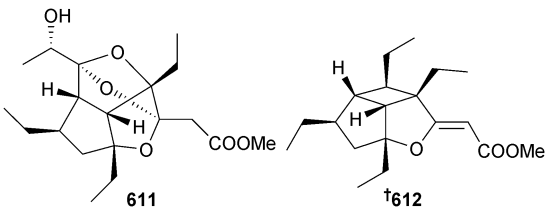
Plakortoxides A **601** and B **602**, simplextones C **603** and D **604** and plakorsin D **605** were all isolated from *Plakortis simplex* (Yongxing Is., S. China Sea) although only **603** showed activity.[624]



A two-sponge association between *Plakortis communis* and *Agelas mauritiana* (Mooloolaba, Queensland, Australia) yielded a new peroxy acid **606.**[625] *Plakinastrella mamillaris* (Fiji Is.) produced plakortides R–U **607–610.** Congener **610** was a potent antimalarial agent against chloroquine-resistant *P. falciparum*. The remaining compounds were less active and none of the compounds were cytotoxic against Vero cells at much higher concentrations.[626]

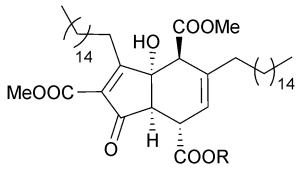


Gracilioether K **611** is a Pregnane X-Receptor (PXR) agonist with no activity against the Farnesoid X-Receptor isolated from *Plakinastrella mamillaris* (Fiji Is.). *In silico* docking studies suggested a similar binding motif to other gracilioether congeners.[627] The sponge *Hippospongia lachne* (Xisha Is., S. China Sea) provided hippolachnin A **612**, a compound with an unprecedented carbon skeleton, that was potently antifungal, but had no activity against three cancer cell lines. The absolute configuration of **612** was determined from comparison of calculated and experimental electronic circular dichroism (ECD) spectra.[628]

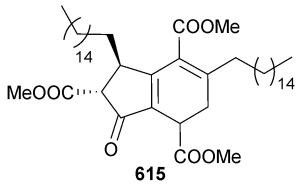


Manzamenones L–N **613–615** were isolated from *Plakortis* sp. (Manzamo, Okinawa). Manzamenones M and N showed some antimicrobial activity against *E. coli*, *S. aureus* and *Cryptococcus neoformans* (*C. neoformans*), while manzamenone L (isolated as a racemate) was inactive.[629]

Callylactam A **616** was isolated from *Callyspongia* sp. (Hainan Is., China),[630] while allos-hemicalyculin **617** was reported from *Discodermia calyx* (Shikine-Jima Is., Japan). Photo-oxidative cleavage of the oxazole moiety of calyculin A was suggested as a route to the formation of **617**.[631] The lipopeptide ciliatamide D **618** was found from a dredged *Stelletta* sp. (170 m, Oshima-shinsone seamount, Japan).[632] This study also reaffirmed the absolute configuration of ciliatamide A (*Aaptos ciliata*) as that

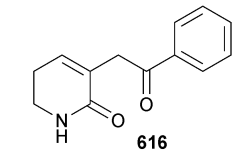


613 R = Me
614 R = H



615

assigned during the original isolation,[633] and subsequently incorrectly reassigned by synthesis.[634]



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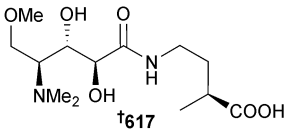
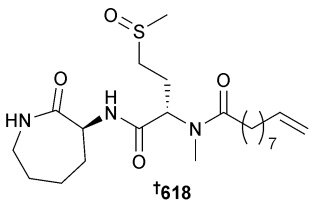
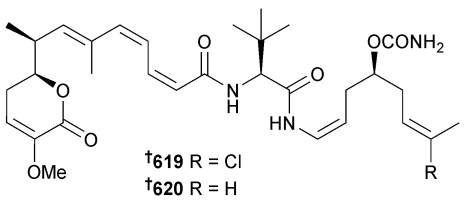


†**617**



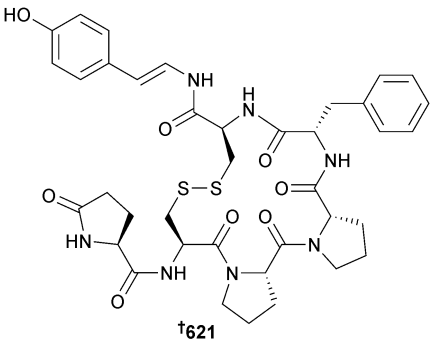
†**618**

The sponge *Lithoplocamia lithistoides* (Madagascar) produced PM050489 **619** and PM060184 **620**, polyketide amides that differ only in the presence of a chlorine atom. Both are active at sub-nanomolar levels against several cancer cell lines. The gram-scale total syntheses of each compound were also reported. PM060184 **620** has undergone a remarkably rapid development from the source sponge collection in 2005 through isolation, characterisation and synthesis in 2006, to the commencement of phase I clinical trials in 2011.[635]

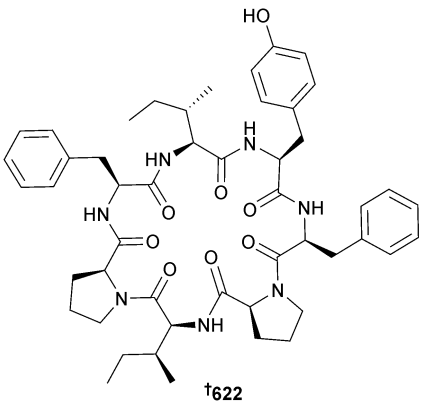


†**619** R = Cl
†**620** R = H

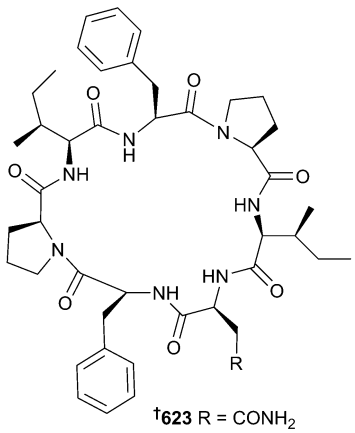
A detailed study of the terrestrial myxobacterial genera *Sorangium* and *Jahnella* has delineated the biosynthesis of the microsclerodermins, unusual peptides isolated from *Microscleroderma* and *Theonella* sponges,[636,637] hence suggesting the likely microbial origin of these NPs.[638] Gombamide A **621**, a disulfide linked hexapeptide, was isolated from *Clathria gombawuiensis* (Gageo-Do, S. Korea).[639] Stylissatin A **622**, a cyclic heptapeptide from *Stylissa massa* (Loloata Is., Papua New Guinea), inhibited NO production in LPS-stimulated macrophages,[640] while euryjanicins E–G **623–625** are phenylalanine- and proline-rich heptapeptides from *Prosuberites laughlini* (Puerto Rico).[641]



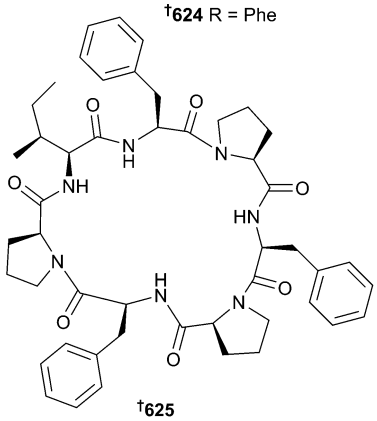
†**621**



†**622**



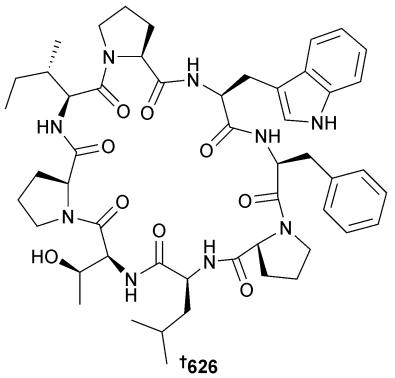
†**623** R = $CONH_2$
†**624** R = Phe



†**625**

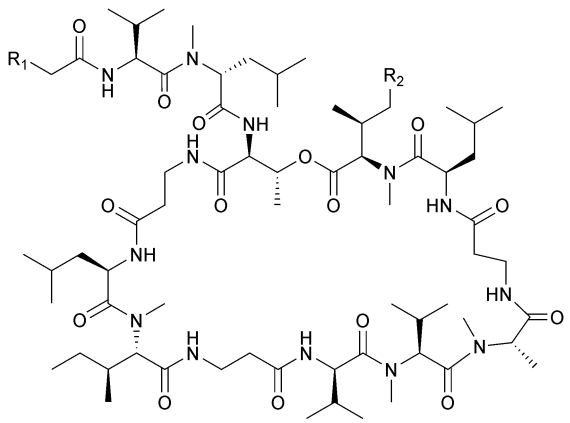
Although the structure of the NP is yet to be reported, the proline-rich octapeptide phakellistatin-19 **626** has been synthesised. Interestingly, the bioactivity of the natural (GI_{50} =

440–515 nM *vs.* three cell lines) and synthetic (not active) versions differ significantly, a puzzling discrepancy that has been noted previously.[642,643]



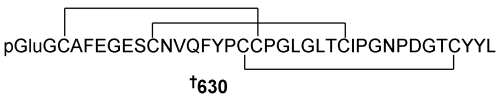
†626

The antifungal activity of the theonellamides (*Theonella* sp.)[644] has been linked to their ability to bind to the 3β-OH of sterols in lipid bilayers. This was established using solid state ^{2}H-NMR and surface plasmon resonance spectroscopies.[645] Sulfinyltheonellapeptolide **627** and theonellapeptolide If **628** were isolated from *Theonella swinhoei* (N. Sulawesi, Indonesia), both with similar activities against HepG2 hepatic carcinoma cells.[646]



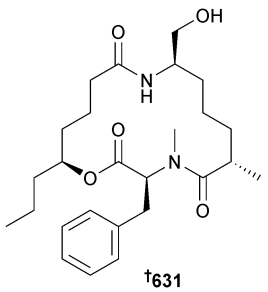
627 R_1 = MeSO, R_2 = Me
628 R_1 = MeO, R_2 = H

The total synthesis of yaku'amide A **629** (*Ceratopsion* sp.)[647] established the configuration of the C-terminal methyl. Altering the configuration of the methyl had no significant effect on bioactivity.[648] Asteropsin A **630** (*Asteropus* sp., Geoje Is., S. Korea) is a cysteine-knot peptide with an unusual *N*-terminal pyroglutamate residue that enhanced neuronal Ca^{2+} influx in murine cerebrocortical neuron cells and therefore may be useful for the treatment of topical pain or hypertension.[649]

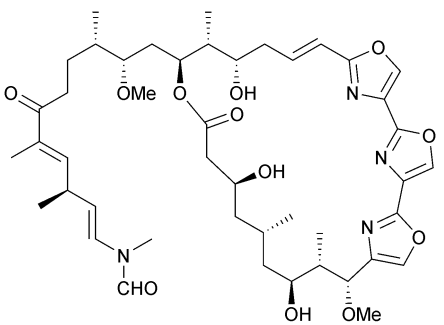


†630

The total syntheses of 18-*epi*-latrunculol A (*Negombata magnifica*)[650] and haliclamide (*Haliclona* sp.)[651] have been achieved, with the latter study determining the absolute configuration **631** of the NP.[652,653] Two separate collections of *Pachastrissa nux* (Koh Tao, Surat Thani Province, and Chumphon Is. National Park, Thailand) yielded the antimalarial trioxazole macrolide kabiramide L **632**.[654]



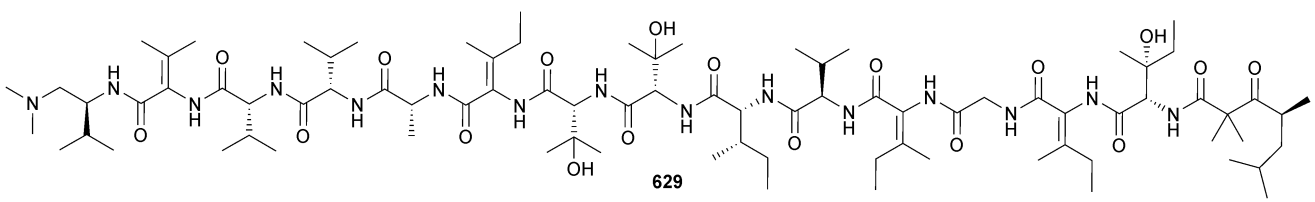
†631



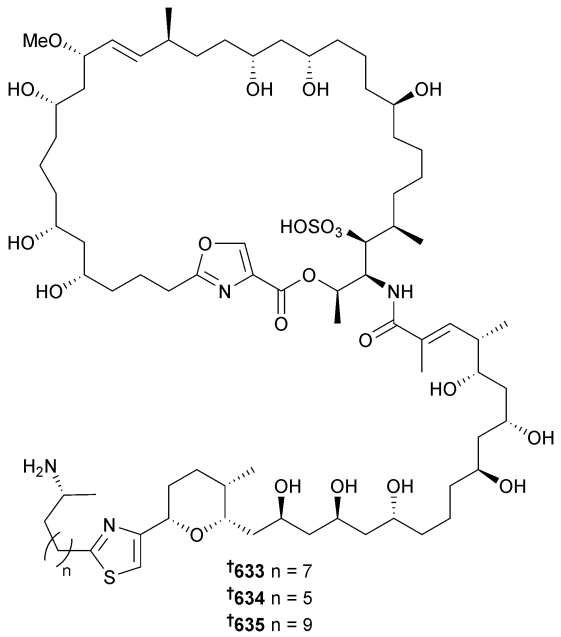
632

A comprehensive study using *J*-based conformational analysis, the universal NMR database and chemical derivatisations, established the absolute configurations of theonezolide A–C **633–635**, originally isolated from a *Theonella* sponge.[655–657]

Theonella swinhoei (Bunaken Marine Park, Manado, Indonesia) provided isoswinholide B **636** and swinholide K **637**.



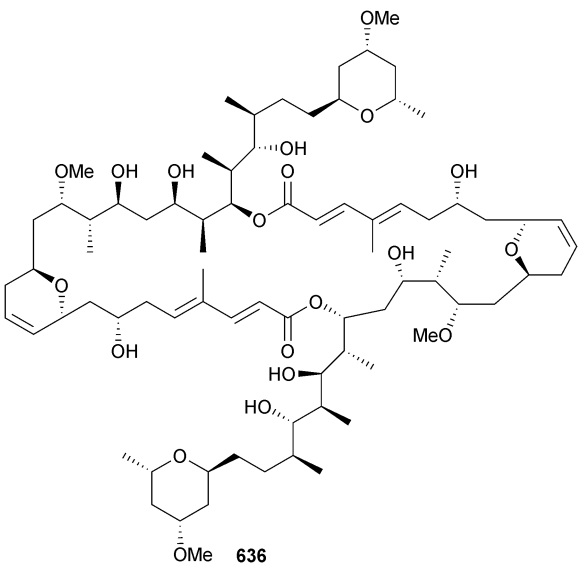
629

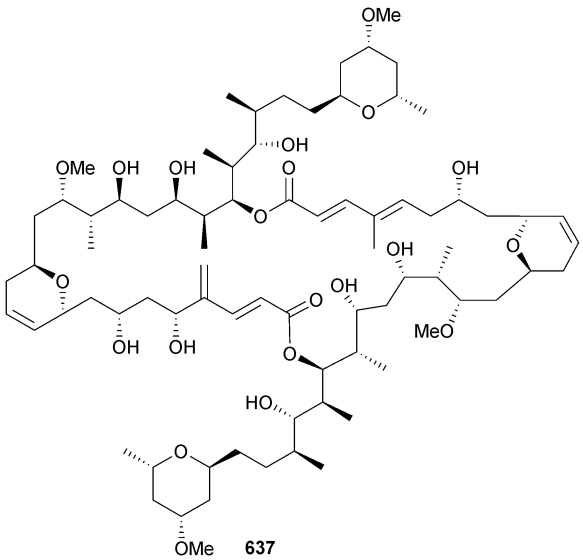


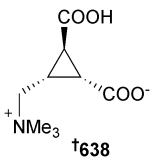
Interestingly **636** was completely inactive while **637** showed significant potency against HepG2 cells consistent with other swinholide congeners.[658]

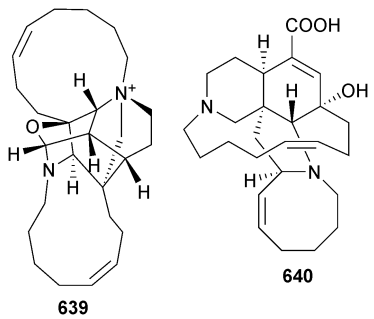
The absolute configuration of (−)-dysibetaine CPa **638** (*Dysidea herbacea*)[659] was established by total synthesis, although the current study incorrectly mentions *Lendenfeldia chondrodes* as the original source.[660]

The synthesis of nakinadine C (*Amphimedon* sp.)[661] confirmed the absolute structure.[662] Synthesis also confirmed the structures of batzellasides A and C (*Batzella* sp.).[663,664] Manzamine A (*Haliclona* sp.)[665] inhibited autophagy, and hence could prevent pancreatic cancer, by uncoupling vacuolar ATPases,[666] as well as suppressing hyperlipidaemia and hence atherosclerosis in apoE-deficient mice.[667] Zamamiphidin A **639** is a moderately antibacterial (*S. aureus*) manzamine-type alkaloid isolated along with ircinic acid 2 **640** from *Amphimedon* sp. (Zamami, Okinawa).[668]



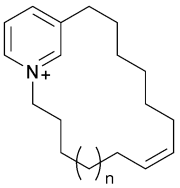




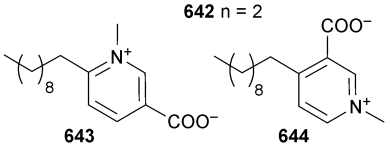


The synthesis of two unstable stereoisomers of 'upenamide (*Echinochalina* sp.)[669] has shown that the putative structure was incorrect, although the constitution of the NP could not be established and given the paucity of remaining compound, structural revision will be difficult.[670] The sponge *Haliclona* sp. (d'Urville Is., New Zealand) yielded dehydrohaliclocyclins C **641** and F **642** but lack of material prevented bioactivity profiling.[671] *Plakortis simplex* (Keomun Is., West Sea, S. Korea) provided two regioisomeric alkylpyridinium carboxylates **643** and **644**.[620] The pyridinium diamine callyimine A **645** was obtained from *Callyspongia* sp. (Hainan Is., China).[630]

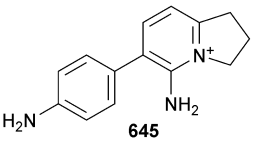
Synthesis confirmed the structures of amphimedosides A–C (*Amphimedon* sp.).[672,673] Pyrinodemins G–I **646–648** are bis-3-alkylpyridinium alkaloids from *Amphimedon* sp. (Okinawa), although the exact positioning of the alkyne functionalities is uncertain and hence the compounds are likely a mixture of related congeners.[674]



641 n = 1
642 n = 2



643 **644**



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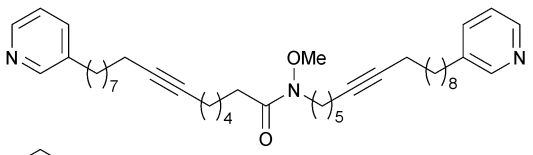

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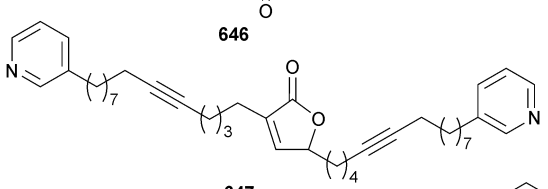

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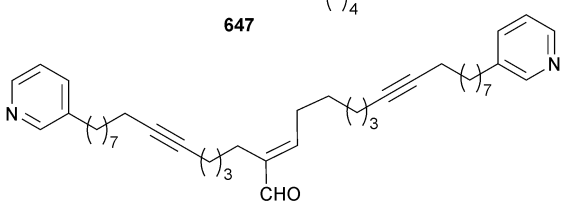
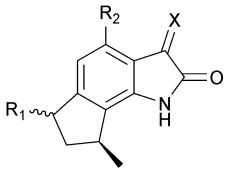


648

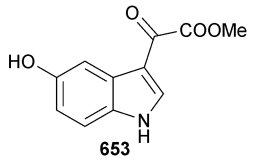
High-level DFT calculations helped confirm the unusually deshielded ^{13}C chemical shifts found in trikentramides A–D **649–652**, isolated using an NMR-guided approach from *Trikentrion flabelliforme* (East Point Bommies, Northern Territory, Australia).[675] The synthesis of igzamide (*Plocamissa igzo*)[676] was achieved.[677] Three 5-hydroxyindole compounds **653–655** were reported from *Scalarispongia* sp. (Dokdo, S. Korea).[678]

Hyrtioreticulin F **656** was obtained from *Hyrtios reticulatus* (N. Sulawesi, Indonesia) and is the likely product of a Pictet–Spengler reaction between tryptophan, alanine and glycine.[679] The bis-indole 6′′-debromohamacanthin A (*Spongosorites* sp.)[680] inhibited angiogenesis by suppressing vascular endothelial growth factor VEGFR2-mediated PI3K/ALT/mTOR signalling in human umbilical vascular endothelial cells and mouse embryonic stem cells.[681]

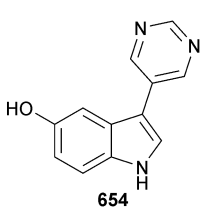
Hyrtioerectines D–F **657–659** are indolo-β-carboline alkaloids from a Red Sea *Hyrtios* species, with all three showing antimicrobial and radical scavenging activity.[682] Two brominated indolo-carbazoles **660** and **661** were isolated from a



649 R_1 = —Me, R_2 = Et, X = O
650 R_1 = ····Me, R_2 = Et, X = O
651 R_1 = —Me, R_2 = Me, X = O
652 R_1 = —Me, R_2 = Me, X = H,H



653



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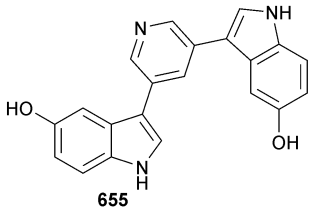

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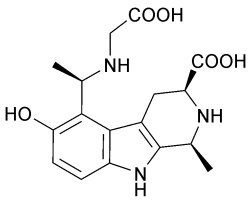
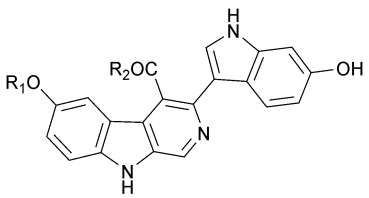
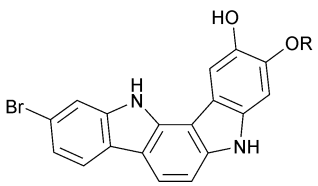


†**656**

deep water *Asteropus* sp. (offshore from Bimini, Ocean Cay, Bahamas). While catechol **660** showed antimicrobial activity (*C. albicans* and MRSA), sulfonate **661** was completely inactive.[683]

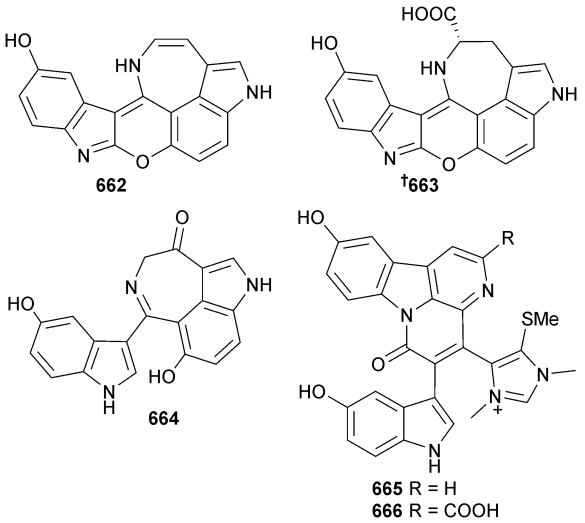


657 R_1 = H, R_2 = OH
658 R_1 = Me, R_2 = OH
659 R_1 = H, R_2 = NH_2

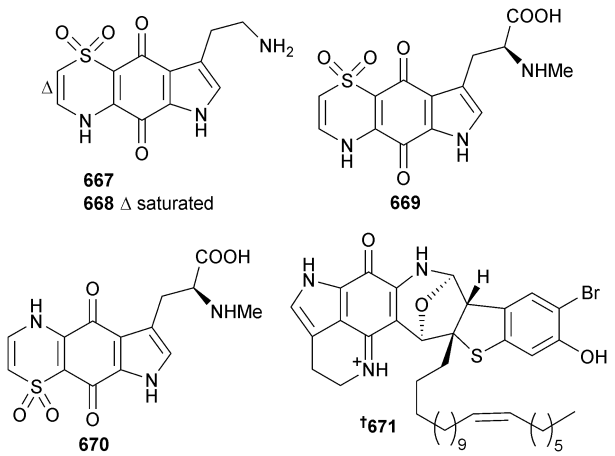


660 R = H
661 R = SO_3Na

Hyrtimomines A–C **662–664** are 5-hydroxyindole alkaloids from *Hyrtios* sp. (Kerama Is., Okinawa), although only **662** showed activity against tumour cells.[684] Hyrtimomines D **665** and E **666** from the same collection are bisindole dimers with some activity against *C. albicans*, *C. neoformans*, *S. aureus* and *Trichophyton mentagrophytes*.[685]

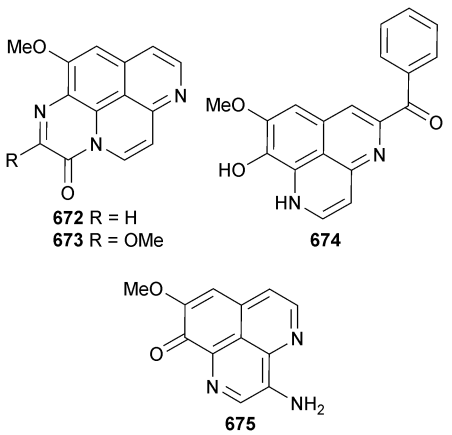


The Australian sponge *Plakortis lita* (Tydeman Reef, Queensland) yielded thiaplakortones A–D **667–670** following HTS of a library of 202 983 fractions from 18 453 extracts. All were potent inhibitors of *P. falciparum* with **667** showing greater than 60-fold selectivity for *Plasmodium* over human embryonic kidney cells.[686] The total syntheses of zyzzyanones A–D (*Zyzzya fuliginosa*)[687,688] have been achieved.[689] Atkamine A **671** is a new pyrroloiminoquinone isolated from a deep water *Latrunculia* sp. (Aleutian Is., Alaska). Olefin metathesis was used to identify the location of the side-chain alkene of this surprisingly inactive metabolite.[690]

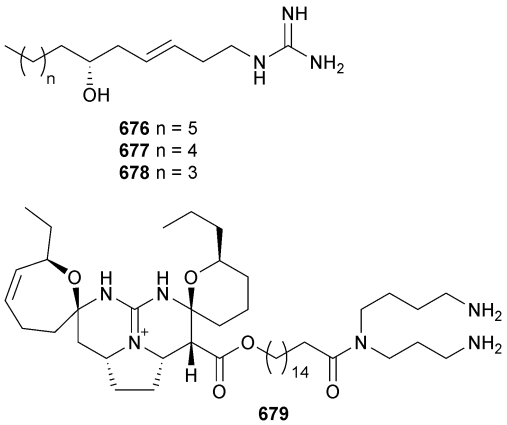


Of four new aaptamine-derivatives **672–675** (*Aaptos suberitoides*, Ambon, Indonesia) only **674** showed any activity against murine lymphoma.[691] The total synthesis of 2-deoxy-2-aminokealiiquinone (*Leucetta chagosensis*)[692] confirmed the structure of the NP.[693]

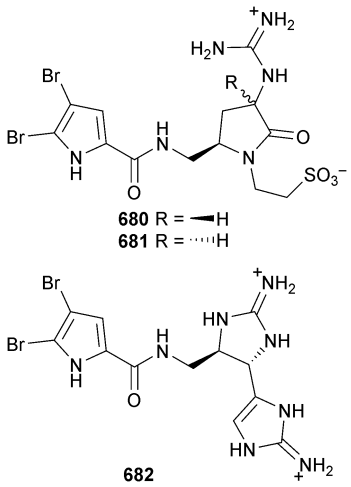
Pulchranins A–C **676–678**, isolated from two dredged *Monachora pulchra* samples (Kuril Is. Chain, Russia), were moderately active inhibitors of the transient receptor potential cationic channel subfamily V (capsaicin receptor), and hence are pain and thermal reception modulators.[694,695] The same sponge that yielded pulchranins B and C also yielded

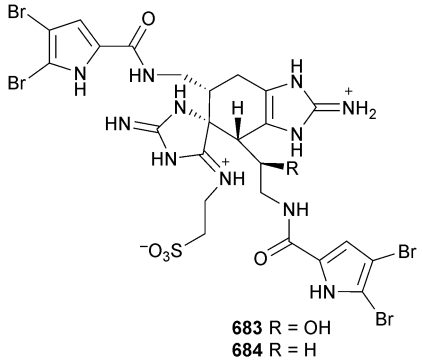


monanchomycalin C **679**, a modest inhibitor of MDA-MB-231 breast cancer cells.[696]

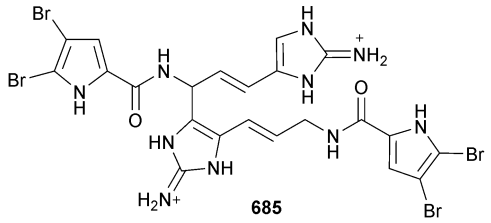


Spongiacidin C (*Stylissa massa*, Indonesia)[697] is the first selective inhibitor of USP-7 over other ubiquitin-specific-processing proteases to be isolated from a natural source, and hence is a new lead as an oncological therapeutic.[698] Nagelamides U–Z **680–685** are bromopyrrole alkaloids from *Agelas* sp. (Kerama Is., Okinawa) with a variety of biological activities, especially the inhibition of the growth of *C. albicans*. Congeners **683** and **684** were isolated as racemates.[699,700]



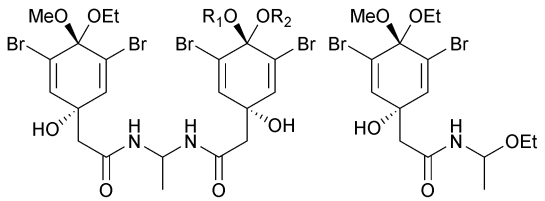


683 R = OH
684 R = H



685

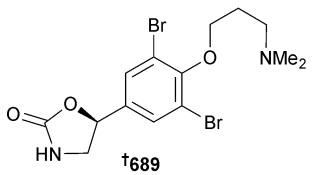
Three new bromotyrosine compounds **686–688** were isolated from *Aplysina* sp. (Ladda Reef, S. China Sea),[701] while the structures of ma'edamines A and B (*Suberea* sp.)[702] have been confirmed by synthesis.[703]



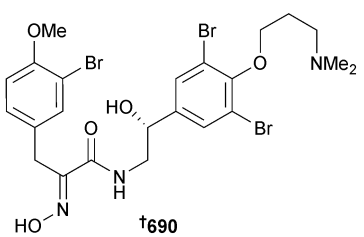
686 R_1 = Me, R_2 = Et
687 R_1 = Et, R_2 = Me

688

Pseudoceratina verrucosa (Hook Reef Lagoon, Queensland, Australia) yielded pseudoceralidinone A **689** and aplysamine 7 **690**, with the absolute configurations established by Mosher's method and by total synthesis, respectively. The latter compound inhibited the growth of PC3 prostate adenocarcinoma cells while the former was inactive.[704]

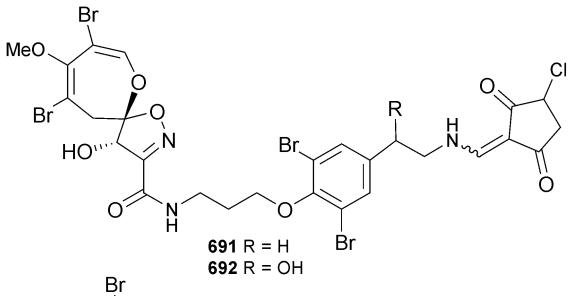


†**689**

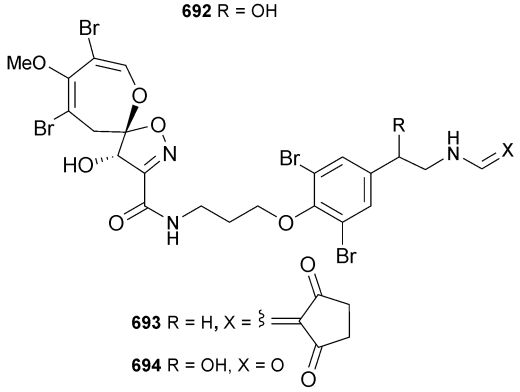


†**690**

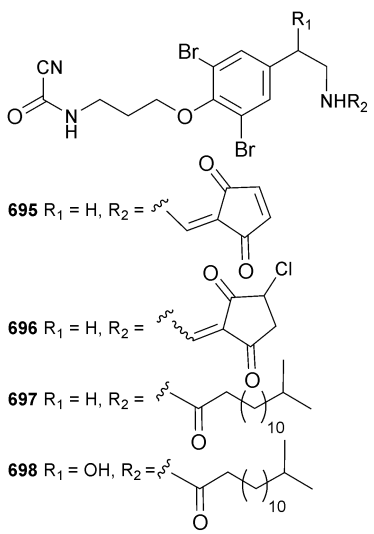
Eight new bromotyrosine derivatives of the psammaplysin **691–693**, ceratinamide **694** and subereamide **695–698** classes were isolated from *Suberea* sp. (Chuuk, Federated States of Micronesia). Only psammaplysin X **691** and the 19-hydroxy derivative **692** showed activity against six HTCLs.[705]



691 R = H
692 R = OH



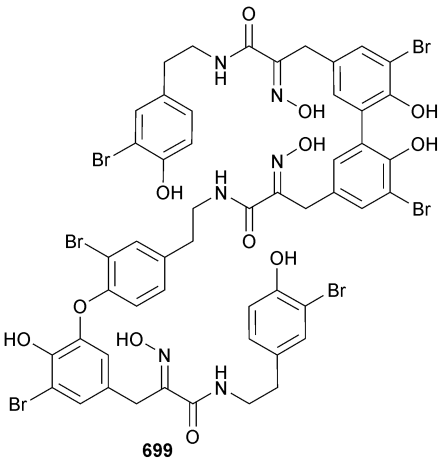
693 R = H, X = ⌇
694 R = OH, X = O



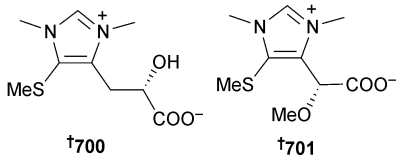
695 R_1 = H, R_2 = ⌇
696 R_1 = H, R_2 = ⌇
697 R_1 = H, R_2 = ⌇
698 R_1 = OH, R_2 = ⌇

Sesquibastadin **699** (*Ianthella basta*, Ambon, Indonesia) is a trimer of hemibastadin that inhibited a variety of protein kinases from a panel of 24 enzymes, but had no effect on the proliferation of murine lymphoma cells (L5178Y).[706]

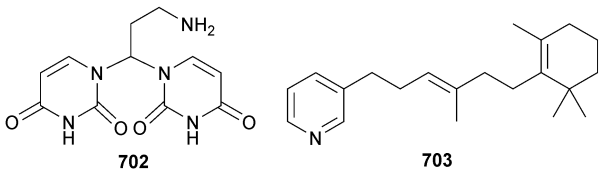
The Verongid sponges *Ianthella basta* and *Aplysina cavernicola* were examined for the presence of brominated skeletal components within their organic and siliceous matrices. The conclusions drawn from this work were that the bastadin and aerothionin compounds found are likely of microbial origin and that the known secondary metabolites are not associated with the sponge skeletons. However, a considerable quantity of brominated mass was found within the skeleton and it is possible that this represents tightly bound sponge-derived

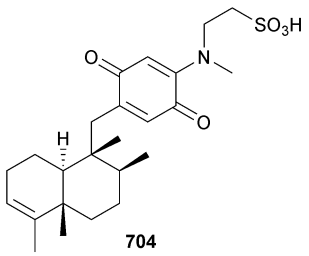

699

secondary metabolites with a defensive role.[707] Reticulatins A **700** and B **701** are dimethylimidazolium cations isolated from *Hyrtios reticulatus* (N. Sulawesi, Indonesia). Surprisingly, they differ in absolute configuration of the side chain carbinol.[679]

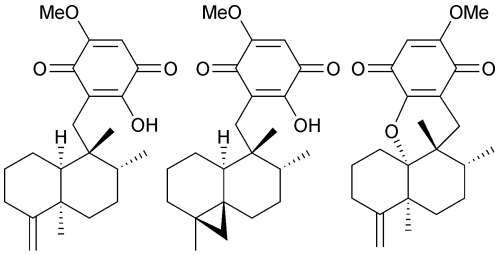

†700 †701

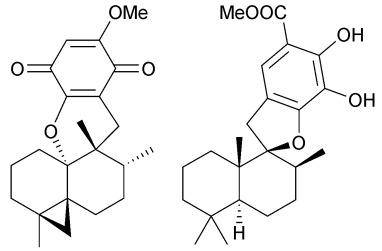
Bis-uracil **702** was isolated from *Agelas clathrodes* (Yongxing Is., S. China Sea).[708] A *Fasciospongia* sp. (Weizhou Is., Guangxi, China) gave the sesquiterpene alkaloid fasciospyrinadine **703**,[709] while *Dysidea avara* (Fethiye, Turkey) yielded the merosesquiterpenoid *N*-methylmelemeleone-A **704**.[710]


702 703

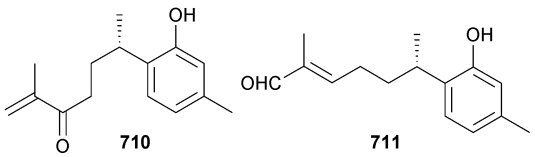

704

Samples of *Dactylospongia elegans* collected in both Malaysia and Palau contained the related 5,8-di-*epi*-ilimaquinone **705**, 4,5-di-*epi*-dactylospongiaquinone **706**, 8-*epi*-dactyloquinone **707**, 10,17-*O*-cyano,4,5-di-*epi*-dactylospongiaquinone **708** and cyclospongiacatechol **709**. All five compounds showed antiproliferative effects at high concentrations while **706** and **707** also activated Hypoxia Inducible Factor-1 (HIF-1), with the 1,4-benzoquinone moiety demonstrated as essential for activity.[711]

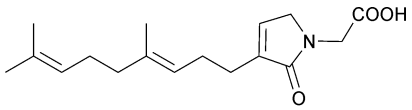

705 706 707


708 709

The asymmetric total synthesis of strongylin A (*Strongylophora hartmani*)[712] confirmed the absolute configuration,[713] while synthesis of dysideavarone A (*Dysidea avara*)[714] confirmed the structure and also provided material to demonstrate the compound's potent antimicrobial activity, especially against Gram-positive bacteria, in particular various *Staphylococci* spp.[715] The bisabolane sesquiterpenoids 3-oxobolene **710** and 1-oxocurcuphenol **711** were isolated from *Myrmekioderma* sp. (Phi-Phi Is., Thailand) and were potent inhibitors of HT-29 cancer cells.[716]


710 711

Ianthellalactams A **712** and B **713** (*Ianthella flabelliformis*, Port Philip Heads, Victoria, Australia) did not inhibit Glycine-gated chloride channel receptors (GlyR) like other related glycinal lactams.[717] Eurysponginsin A–C **714–716** (*Eurysponginsia* sp., Iriomote Is., Okinawa) have rare six- or eight-membered skeletons with either fused furan or γ-lactone rings. The presence of the C-4 hydroxyl group in all three compounds was thought to totally abrogate activity compared with other active analogues.[718]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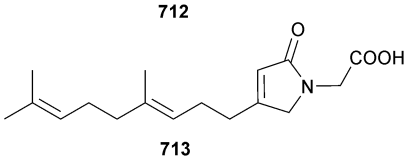
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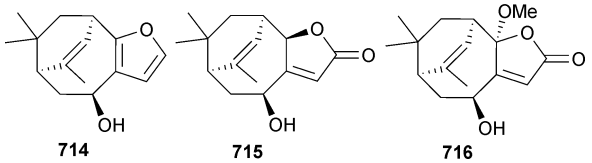
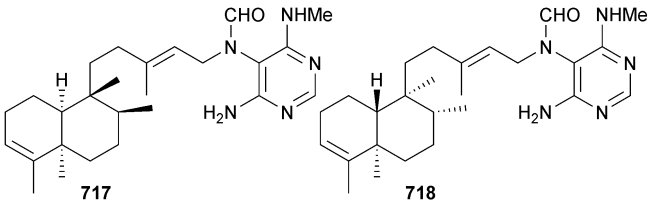
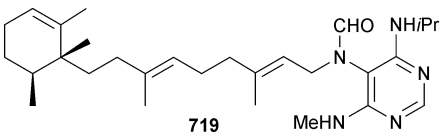

714 715 716

Phorbasin H, originally isolated from *Phorbas gukulensis*[719] but differing from another structure with the same name from *Phorbas* sp.,[720] inhibits the hypha-specific HWP1 and ALS3 mRNAs of *C. albicans*, preventing the yeast-to-hyphae transition and therefore inhibits virulence of the pathogen.[721] Axistatins 1–3 **717–719** are pyrimidine diterpenoids from *Agelas axifera* (Koror, Republic of Palau). All three were low μM inhibitors of various human and murine cancer cell lines, as well as being potent broad-spectrum antibiotics against several Gram-positive and negative bacteria.[722]

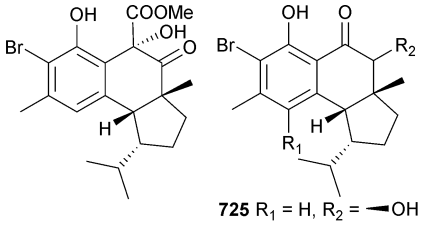


717 **718**



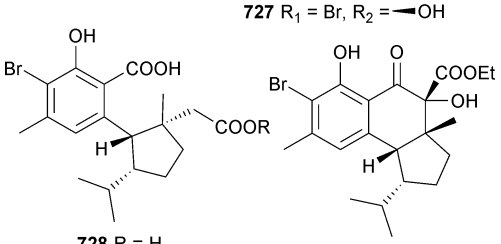
719

Phenotypic screening using zebra fish as a genome-wide eukaryote assay identified kalihinol F (*Acanthella* sp.)[723] as a copper chelator, resulting in abnormal development as indicated by an undulating notochord, and both pigmentation and neural defects. This study exemplifies the use of zebra fish as a viable chemical genetic tool for assessing bioactives in a complex eukaryotic organism.[724] The total syntheses of cyanthiwigins A, C (*Epipolasis reiswigi*)[725] and H (*Myrmekioderma styx*)[726] have been achieved, confirming the absolute structures.[727] *Hamigera tarangaensis* (Cape Karikari, North Is., New Zealand) provided hamigerans F–K **720–725**, 10-*epi*-hamigeran K **726**, 4-bromohamigeran K **727**, hamigeran L **728** and the methyl ester **729**, hamigeran A ethyl ester **730** and an unrelated congener of *epi*-verrucosane **731**. All but the latter compound inhibited the growth of HL-60 cells while chemical genetic screening using yeast as a model organism showed that the mode of action of the antifungal hamigeran G **721** was *via* influence of Golgi function and Golgi vesicle formation.[728]



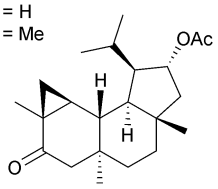
724

725 R_1 = H, R_2 = α-OH
726 R_1 = H, R_2 = β-OH
727 R_1 = Br, R_2 = α-OH



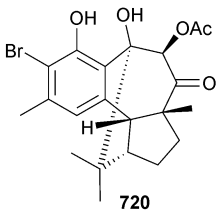
728 R = H
729 R = Me

730

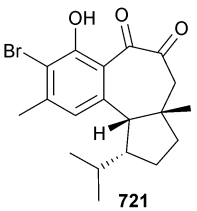


731

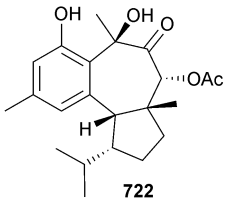
Two new isoneoamphilectane diterpenes **732** and **733** were isolated from *Svenzea flava* (previously described as *Pseudoaxinella flava*) (Great Inagua Is., Bahamas). The absolute configurations of these compounds were secured by comparison of experimental and calculated VCD data. Both compounds inhibited the growth of *Mycobacterium*, but had no effect on mammalian cell lines.[729] Petronigrione **734** is a cembranoid dimer from *Petrosia nigricans* (Haivan, Danang, Vietnam) with moderate activity against HTCLs,[730] while *Phorbas gukhulensis* (Gagu-Do Is., S. Korea) yielded the diterpene pseudo-dimers gukulenin C–F **735–738**. All four were cytotoxic against K562 and A549 cancer cell lines but none showed any activity against various microbes.[731]



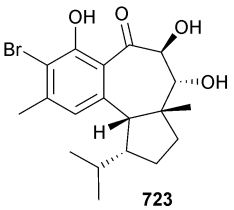
720



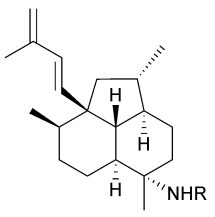
721



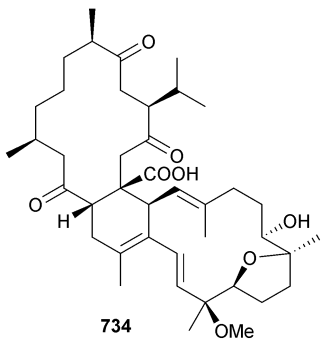
722



723

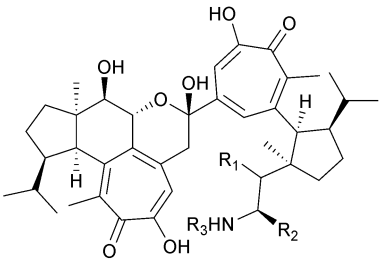


†**732** R = Me
†**733** R = CHO

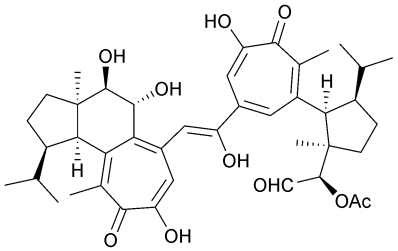


734

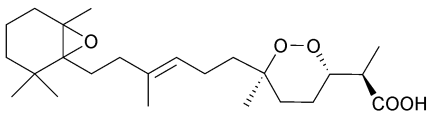
The norsesterterpene cyclic peroxides 13,14-epoxymuqublin A **739** and the 9,10-epoxy isomer **740** were isolated from *Diacarnus erythraeanus* (Elfanadir, Hurghada coast, Egypt). Both were low micromolar inhibitors of various HTCLs.[732]



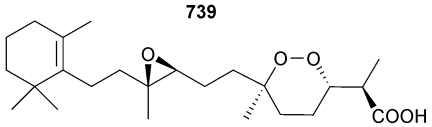
735 R_1 = ····OH, R_2 = OMe, R_3 = Ac
736 R_1 = ····OH, R_2 = OH, R_3 = Ac
737 R_1 = =O, R_2 = H, R_3 = $CH_2CH_2SO_3H$



738

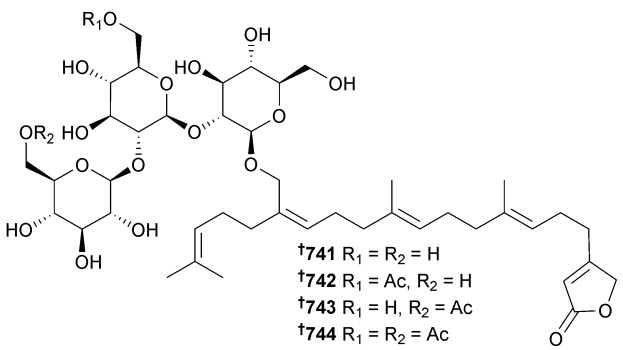


739



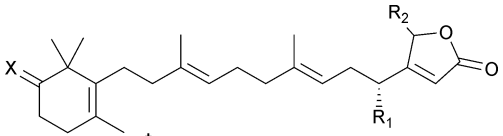
740

Collections of the Homoscleromorpha sponge *Oscarella balibaloi* at two sites near Marseilles (Mediterranean Sea) yielded the glucosidated sesterterpenes balibaloside **741**, 6″-*O*-acetylbalibaloside **742**, 6‴-*O*-acetylbalibaloside **743** and 6″,6‴-*O*-diacetylbalibaloside **744**. These metabolites are the first glycosidated sesterterpenes reported and although tested in a wide variety of assays, proved to be inactive.[733]

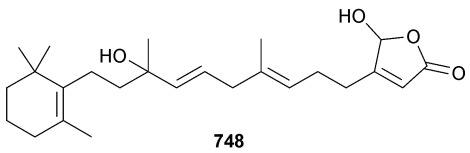


†**741** R_1 = R_2 = H
†**742** R_1 = Ac, R_2 = H
†**743** R_1 = H, R_2 = Ac
†**744** R_1 = R_2 = Ac

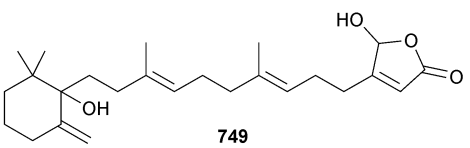
Hyrtios communis (Northern Reef region, Palau) yielded thorectidaeolide A **745**, the 4-acetoxy congener **746**, and thorectidaeolides B–E **747–750**. Compounds **745–747** inhibited HIF-1 yet did not show any antiproliferative effects against the parent T47D or NDA-MB-231 breast cancer cell lines.[734]



†**745** R_1 = OH, R_2 = H, X = O
746 R_1 = OAc, R_2 = H, X = O
747 R_1 = H, R_2 = OH, X = O
750 R_1 = OH, R_2 = H, X = H,H

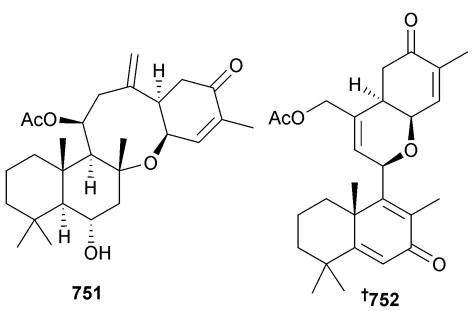


748

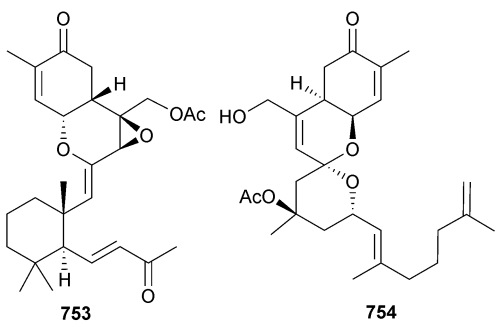


749

A Canadian *Phorbas* sp. (Ansell Point, Howe Sound, British Columbia), provided four distinct sesterterpenes ansellone B **751**, phorbadione **752**, secoepoxyansellone A **753** and alotaketal C **754**. The latter compound showed similar levels of activation of cAMP signalling to the standard probe, forskolin.[735]

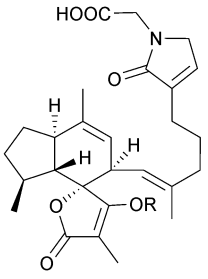


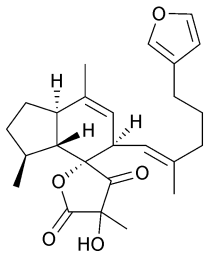
751 †**752**

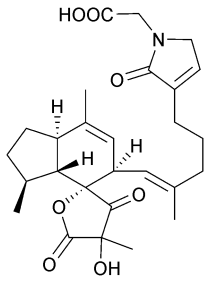


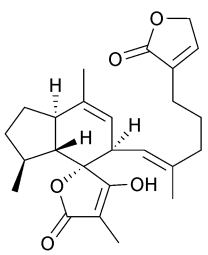
753 **754**

Five new sesterterpenes were reported from three different *Psammocinia* sp. (various locations in New South Wales and Victoria, Australia). Ircinianin lactam A **755**, the sulfate derivative **756**, oxoircinianin **757**, oxoircinianin lactam A **758** and ircinianin lactone A **759** were all assessed for GlyR modulating activity with **755** and **758** being selective and potent potentiators of α3-GlyR and α1-GlyR, respectively, having potential as leads for treatment of inflammatory pain, epilepsy and both breathing or movement disorders.[736]

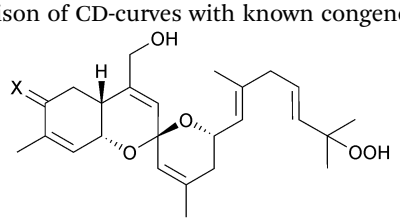


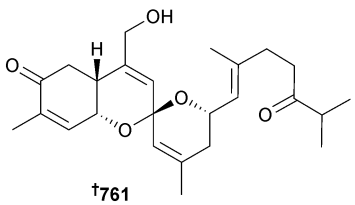


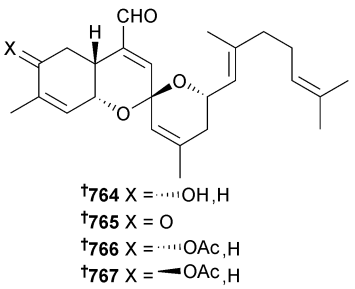


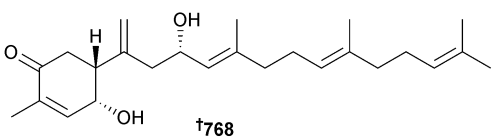


Phorbaketals D–K **760–767** and phorbin A **768** were reported from *Monachora* sp. (Gageo Is., Korea), with **764** and **765** weakly active against A498 cancer cells. The absolute configurations of all the new compounds were established by Mosher's method and comparison of CD-curves with known congeners.[737]

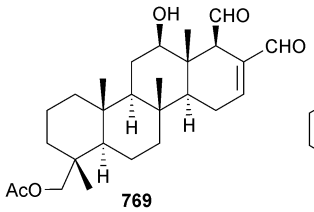


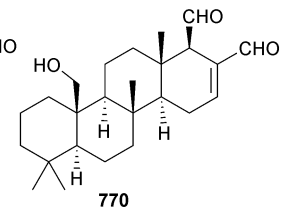


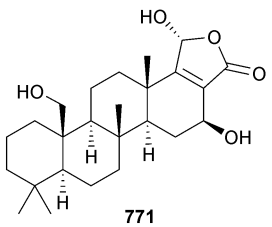


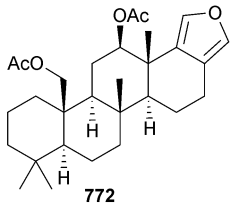


The scalarane sesterterpenoid hippospongide C **769** (*Hippospongia* sp., Tai-Tung, Taiwan) had moderate activity against four HTCLs,[738] while 12-deacetoxy-23-hydroxyscalardial **770**, 12-deacetoxy-23-hydroxyhyrtiolide **771** and 12-*O*-acetyl-16-deacetoxy-23-acetoxyscalarafuran **772** from *Psammocinia* sp. (S. Korea) were inactive in all assays used.[739]

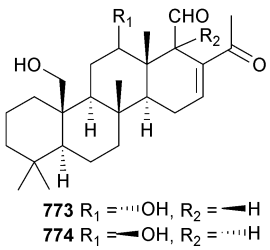


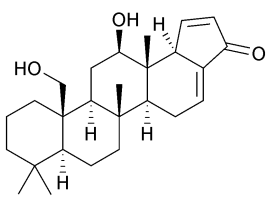


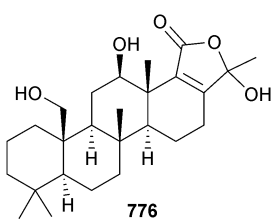




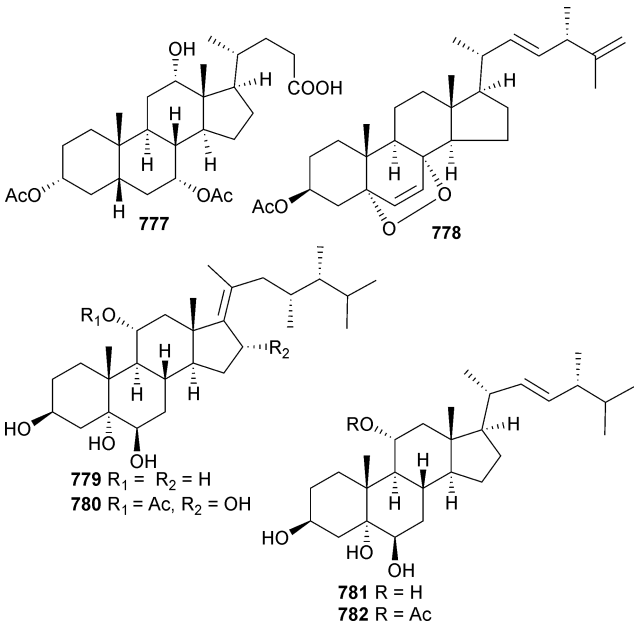
Four new scalaranes **773–776** were reported from *Carteriospongia* sp. (Nosy Be, Madagascar) with **773** and **774** being significantly more active than the other two congeners, indicating the importance of the aldehyde pharmacophore.[740]



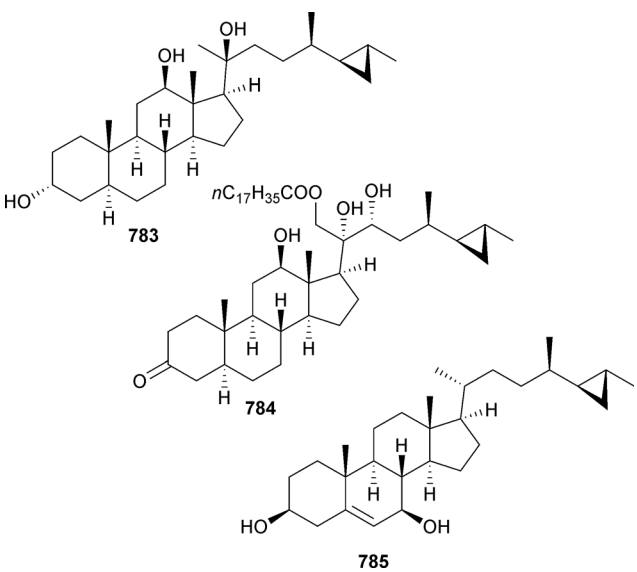




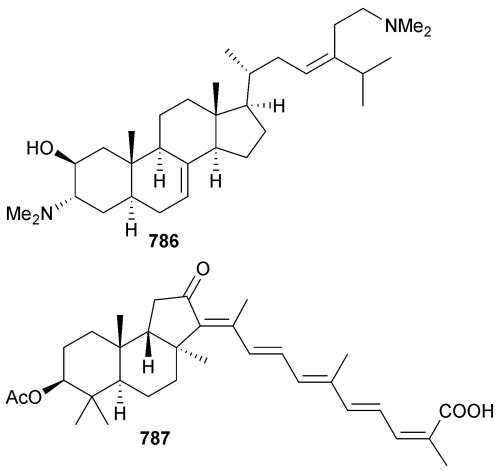
Cholic acid-3,7-diacetate **777** was isolated as an MNP for the first time from *Siphonochalina fortis* (Bahia Bustamante, Chubat, Argentina),[741] while the 5α,8α-epidioxy sterol 3-acetylaxinysterol **778** was isolated from *Axinyssa* sp. (Pingtung, Taiwan).[742] *Haliclona crassiloba* (Dongshan Is., Guangdong, China) yielded halicrasterols A–D **779–782** with moderate activity against various microbial pathogens.[743]



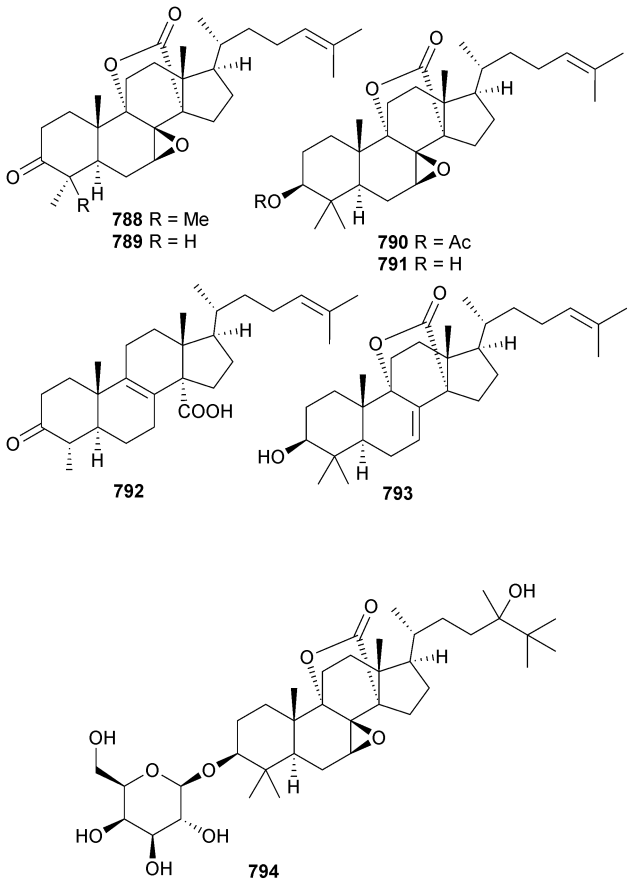
Cyclopropanated sterols aragusterol I **783**, 21-*O*-octadecanoyl-xestokerol A **784** and 7β-hydroxypetrosterol **785** were isolated from *Xestospongia testudinaria* (Truong Sa Archipelago, Khanh Hoa, Vietnam). Both **783** and **784** had antifouling potential (growth inhibition of *Pseudoalteromonas* and *Polaribacter* bacterial species) at similar levels of activity to the now-banned antifoulant marine pollutant tributyltin oxide.[744]



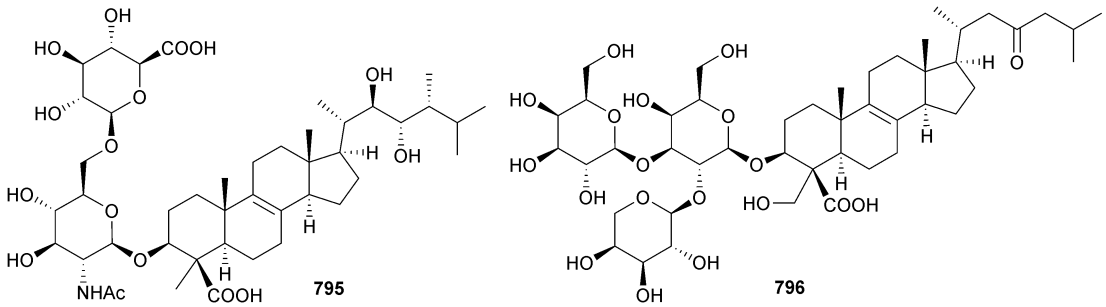
The structure of the unusual autophagy-modulating aminosterol clionamine B (*Cliona celata*)[745] was confirmed by synthesis, which also confirmed the assumed absolute configuration.[746] A *Corticium* sp. (New Britain, Papua New Guinea) yielded the steroidal alkaloid plakinamine M **786**, which displayed antitubercular activity.[747] Stellettin N **787** is an isomalabaricane triterpene acid from *Stelletta* sp. (Lingshui Bay, Hainan, China), which along with the other isolated congeners presented a chemotaxonomic link between three genera within the sponge order Astrophorida.[748]

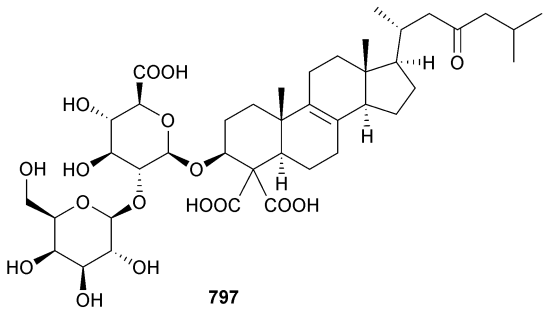


A dredged *Penares* sp. (Vietnam) provided six new lanosterol congeners **788–793**. Only **793** showed any significant activity against HL-60 cells. A combination of CD and X-ray data allowed the assignment of absolute configuration for **789** and also permitted reassignment of the aglycone of eryloside U **794** from 7α,8α to 7β,8β.[749,750]



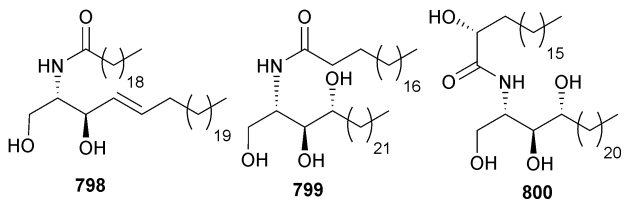
Finally, ulososide F **795**, urabosides A **796** and B **797** are triterpene saponins from *Ectyoplasia ferox* (Caribbean Sea, Colombia), with **797** being the first reported compound with both C-4 methyls elevated to the carboxylic acid oxidation state.[751]



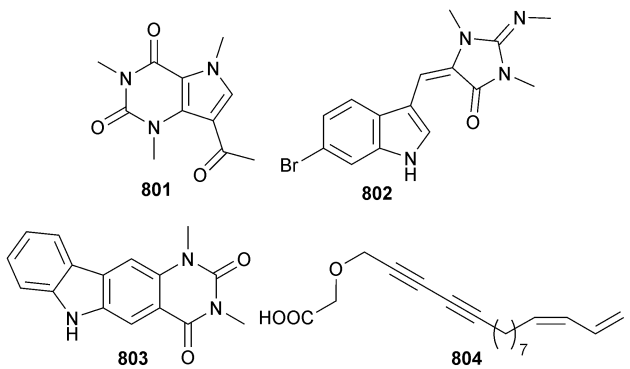


8 Cnidarians

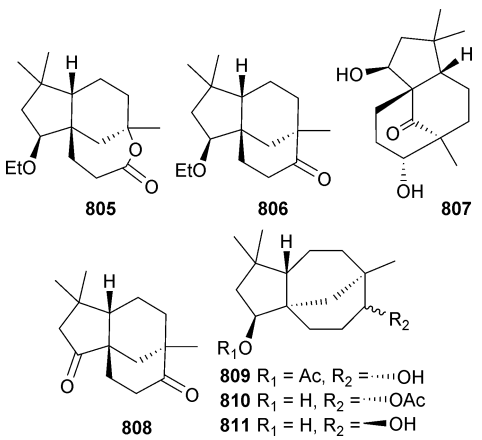
The number of new compounds reported from cnidarians in 2013 (281) has increased by 38% over the average for each of the previous 10 years. In addition to an epidioxysterol (see later), three ceramides **798–800** were isolated from *Sinularia candidula* (Safaga, Egyptian Red Sea).[752] Of the three ceramides, **798** was the most potent anti-H5N1 virus agent.



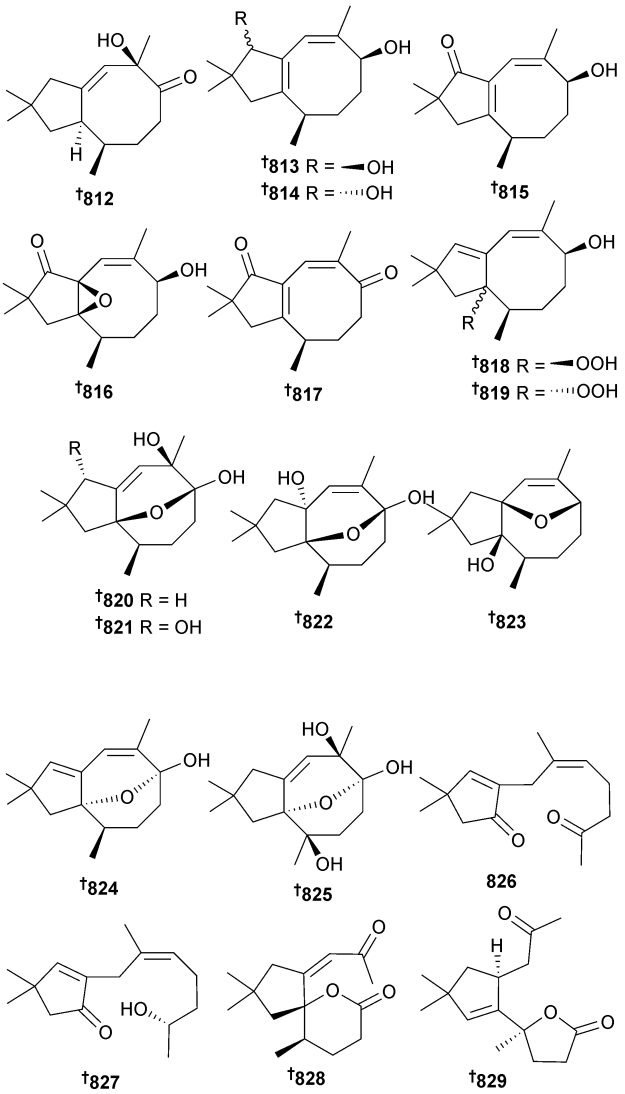
Pyrimidinedione **801** was reported from *Verrucella umbraculum* (Hainan Is., S. China Sea),[753] while Mediterranean specimens of the scleractinian coral *Astroides calycularis* afforded the new aplysinopsin analogue **802**.[754] The highly strained *cyclo*-1,3-carbazole structure originally proposed for antipathine A (*Antipathes dichotoma*)[755,756] has been corrected to the 2,3-carbazole **803** by total synthesis.[757] Polyacetylenic montiporic acid D **804** (*Montipora digitata*, Sesoko Is., Okinawa, Japan) exhibited only mild antibacterial and antioxidant properties.[758]



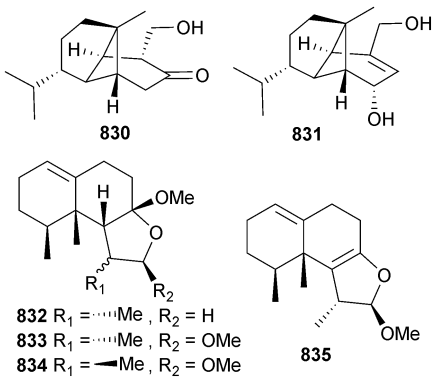
New clovane-type sesquiterpenes rumphellclovane C–E **805–807** and four unnamed variants **808–811** were reported from the same collection of *Rumphella antipathies* (Southern Taiwan).[759,760] The latter four compounds are reported as NPs for the first time. Clovane **808** inhibited superoxide generation and elastase release by stimulated human neutrophils.



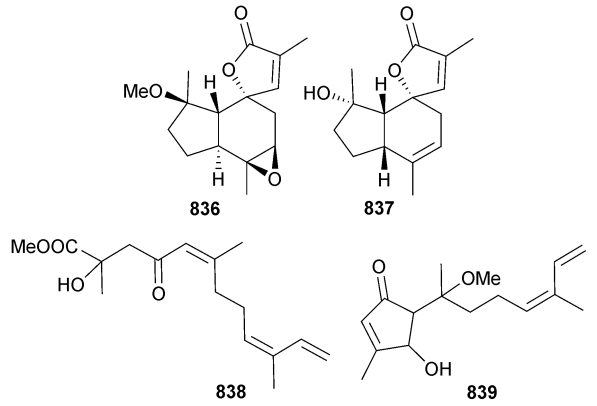
Sesquiterpenes capillosanane A–N **812–825** and *seco*-variants capillosanane O–R **826–829** were isolated from *Sinularia capillosa* (Sanya Bay, Hainan Province, China).[761] Absolute configurations were established by combinations of chemical conversions, Mosher's method, CD analysis and biogenetic reasoning. Capillosanane A exhibited antifouling activity against *B. amphitrite*.



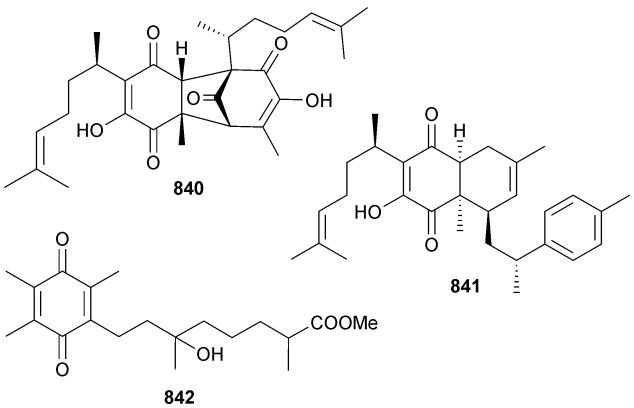
Further examples of tricyclic sesquiterpenes were reported from *Lemnalia philippinensis* (philippinlins A **830** and B **831**) collected at Lanyu, Taiwan[762] and *Paralemnalia thyrsoides* (parathyrsoidins A–D **832–835**) collected at Sansiantai, Taitong County also in Taiwan.[763]



Spiro-butenolides sinularianins C **836** and D **837** and potential biosynthetically-related precursors sinularianins E **838** and F **839** were isolated as mild inhibitors of NF-κB activation from *Sinularia* sp. (Dongluo Is., Hainan Province, China).[764]

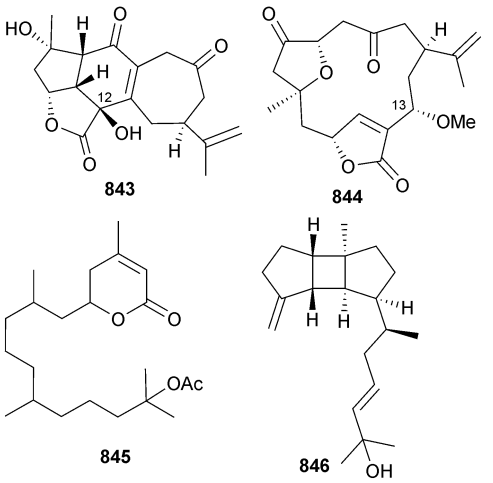


Perezoperezone **840** and curcuperezone **841** (*Pseudopterogorgia rigida*, Caribbean Sea) are envisaged to arise, in the case of **840**, from non-symmetrical dimerisation of known co-metabolite perezone[765] and in the case of **841**, through coupling of perezone and α-curcumene.[766] Flexibilisquinone **842** (cultured specimen of *Sinularia flexibilis*)[767] was claimed to be the enantiomer of sarcophytonone (*Sarcophyton crassocaule*)[768] based upon optical rotation data (**842** $[\alpha]_D$ −19.6, sarcophytonone $[\alpha]_D$ +5.8).

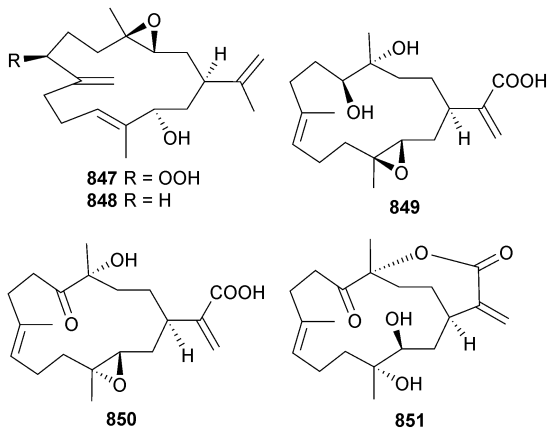


Of two new C_{19}-norditerpenes 12-hydroxy-scabrolide A **843** and 13-*epi*-scabrolide C **844** (*Sinularia maxima*, Nha Trang Bay, Vietnam) the latter was identified as an inhibitor of the production of IL-6 and IL-12 by LPS-stimulated bone marrow-derived dendritic cells.[769] In addition to five sterols (see later), δ-lactone **845** was isolated from *Scleronephthya gracillimum* (Green Is., Taiwan) as a modest inhibitor of expression of iNOS and COX-2 in stimulated macrophages.[770] The weakly cytotoxic spatane diterpene leptoclalin A **846** was reported from cultured specimens of *Sinularia leptoclados*.[771]

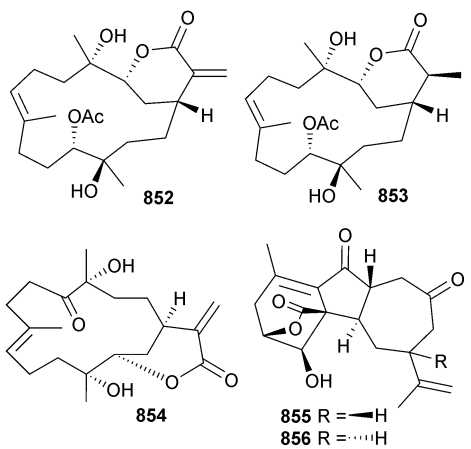
As with most years, a diverse array of cembranoid diterpenes were reported from soft corals in 2013. Arbolides A **847** and B **848**, epoxy-alcohols with the former also containing a hydroperoxide functional group, were obtained from *Sinularia arborea* (southern Taiwan).[772] Similarly functionalised cembranes flexibilins A **849** and B **850** in addition to ε-lactone-



containing flexibilin C **851** were reported from *S. flexibilis* also collected from southern Taiwan.[773]

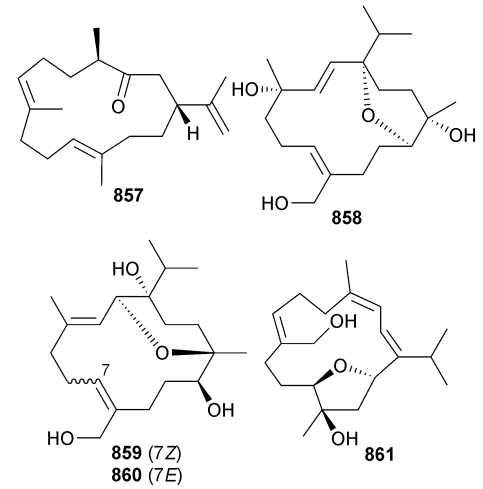


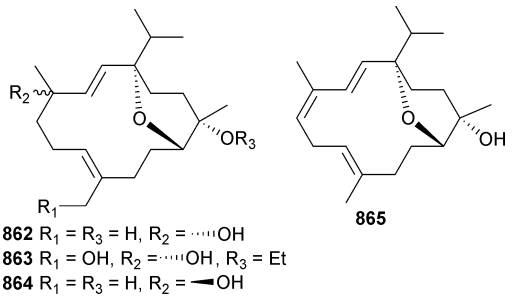
The absolute configuration of co-metabolite (−)-sandensolide (*Dendronephthya* sp.)[774] was confirmed by X-ray crystal analysis. Of the δ-lactones 11-acetylsinuflexolide **852** and dihydro analogue **853** (*S. flexibilis*, Pingtung county, Taiwan), only the former exhibited cytotoxicity as anticipated for an exomethylene-conjugated lactone.[775] *Sinularia flexibilis* (southern Taiwan) was also the source of flexibilin D **854** and of known

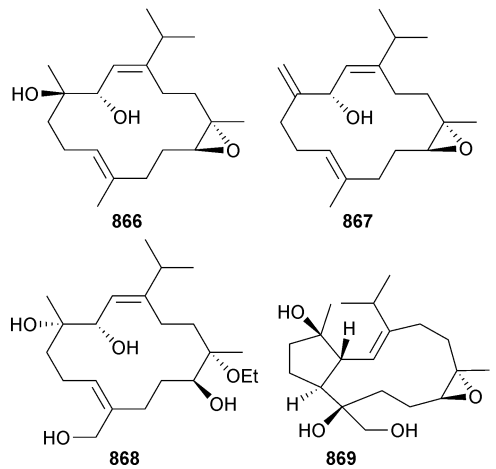


congener 5-dehydrosinulariolide[776] the absolute configuration of which was determined by X-ray crystal analysis.[777] The same publication and a second one[778] also described sinulanorcembranolide A **855** and the 1-*epi*-diastereomer **856** from the same collection of *S. gaweli* (Sansiantai, Taitung county, Taiwan).

While cembranoid cugibberosene A **857** (*S. gibberosa*, Pingtung, Taiwan)[779] was found to be devoid of cytotoxic or antibacterial properties, one of sinulariols T–Z_5 **858–869** (*S. rigida*, Sanya Bay, Hainan Is., S. China Sea), specifically **864**, exhibited effects against the model fouling organisms *B. amphitrite* and *B. neritina*.[780]

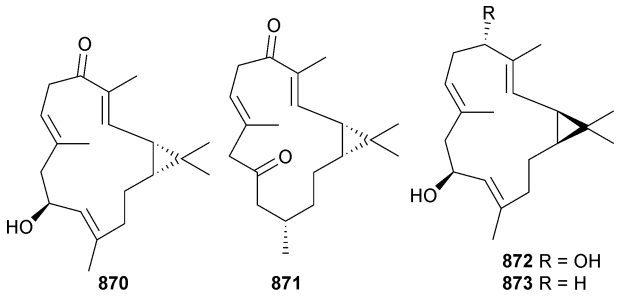


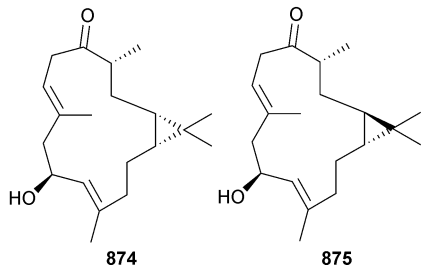




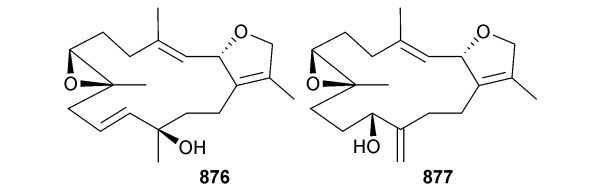
The casbane family of cembranoid diterpenes is characterised by the presence of a fused dimethyl-cyclopropyl ring. Of

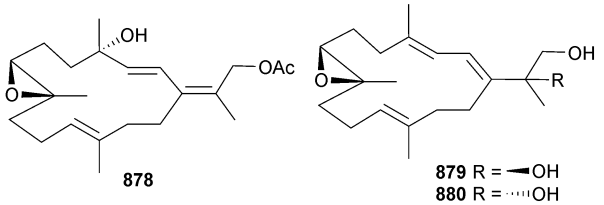
new examples sinularcasbanes A–F **870–875** (*Sinularia* sp., Ximao Is., Hainan, S. China Sea), **871** and **874** exhibited modest ability to inhibit NO production by stimulated macrophages.[781]

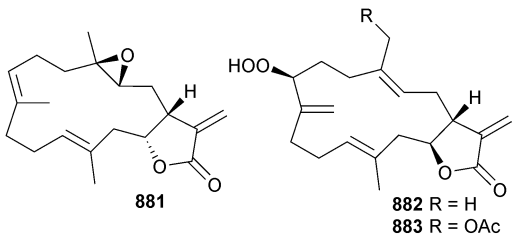




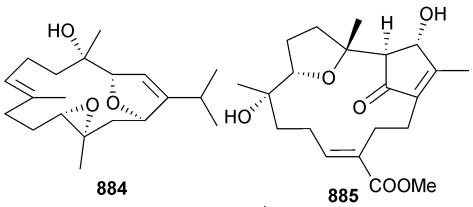
Two separate collections of *Lobophytum* sp. yielded epoxycembranes **876–880** (Ximao Is., Sanya Bay, Hainan, China)[782] and α-methylene-γ-lactones **881–883** (Sanya Bay, Hainan, China).[783] This is the first report **880** as an NP. Epoxycembrane **878** was a modest inhibitor of NO production by stimulated macrophages, while **881–883** were each found to be moderately cytotoxic towards a range of human and murine tumour cell lines.

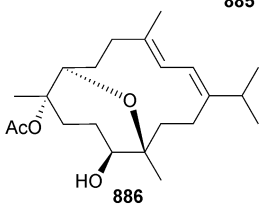




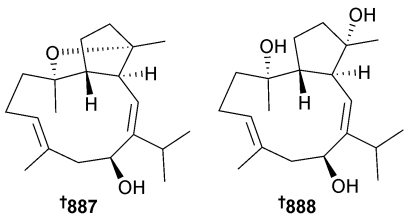


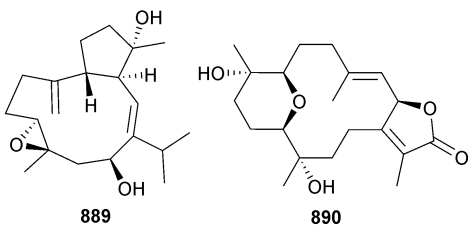
Hydroxycembrane sarcophytol W **884** was isolated from *Sarcophyton* sp. (Xuwen coral reef area, Guangdong Province, China) – absolute configuration was assigned based upon that determined for a previously reported (*Sinularia ovispiculata*)[784] co-metabolite.[785] *Sarcophyton ehrenbergi* (San-hsian-tai, Taitong county, Taiwan) was the source of diterpenes ehrenbergol C **885** and acetylehrenberoxide B **886** which both exhibited mild cytotoxicity (P388) but **886** was more potent as an anti-human cytomegalovirus agent.[786]



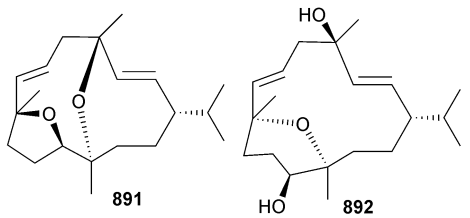


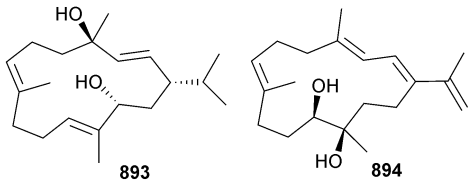
Of the sarcophyolides B–E **887–890** isolated from *S. elegans* (Xidao Is., Hainan, China), the structures and absolute configurations of **887** and **888** were established by X-ray crystal studies.[787]





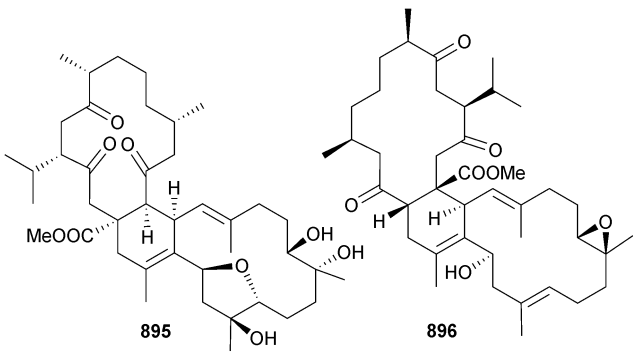
Sarcophyolide B exhibited modest cytotoxicity. Red Sea collections of *S. glaucum* afforded **891–893** with **893** being reported as an NP for the first time.[788] While **891** and **892** were



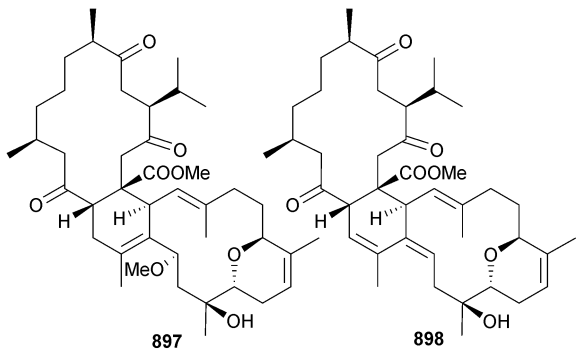


equally cytotoxic towards a melanoma and a mouse kidney cell line, **892** exhibited selectivity towards the tumour cell line. Due to the presence of the conjugated triene functionality in sarglaucol **894** (*S. glaucum*, Sanya Bay, Hainan, China), it can be considered a diene-precursor to biscembranoids typically isolated from soft corals of the genus *Sarcophyton*.[789]

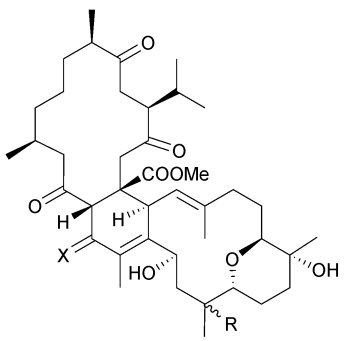
The same collection of *S. elegans* that afforded sarcophyolides B–E (see earlier) also yielded new examples of an isobiscembranoid and biscembranoids, the sarcophytolides G–L **895–900**.[790] These structures represent minor modifications to previously reported biscembranoids, being a dihydroxylated analogue of lobophytone F,[791] a positional isomer of lobophytone S,[792] a methoxylated analogue of lobophytone H,[793] a dehydrated analogue of methyl tortuoate A,[794] an oxidised analogue of lobophytone U[795] and a 31-epimer also of lobophytone U, respectively.



895 **896**

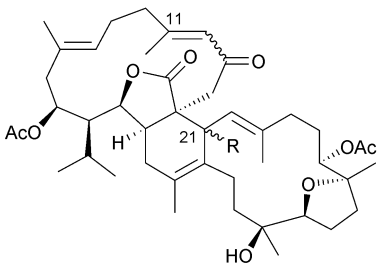


897 **898**

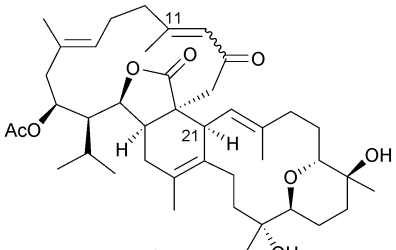


899 X = O, R = ◄OH
900 X = 2H, R = ····OH

Further investigation of *S. latum* (Sanya, Hainan Province), that had previously afforded, amongst other metabolites, biscembranoids bislatumlides A and B,[796] has now yielded four more congeners bislatumlides C–F **901–904**.[797] Detailed examination of the absolute configuration of **901** and **903** by time dependent DFT (TDDFT) calculations of ECD data necessitated reassignment of the C-21 configuration of bislatumlides A **905** and B **906**.

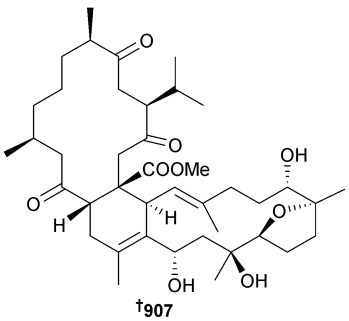


†**901** (11*E*), R = ····H
†**902** (11*Z*), R = ····H
†**903** (11*E*), R = ◄H
†**904** (11*Z*), R = ◄H



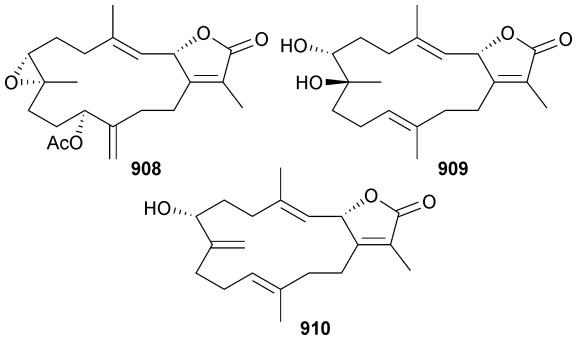
†**905** (11*E*)
†**906** (11*Z*)

Re-isolation of methyl tortuoate D[798] (*Sarcophyton tortuosum*, Yalong Bay, Hainan, China) has led to its structural revision to **907**, with absolute configuration assigned by comparison of ECD data with that of co-metabolite ximaolide A.[799] The study also concluded that the structure previously attributed to lobophytone K (*Lobophytum pauciflorum*)[800] should also be corrected to **907**.

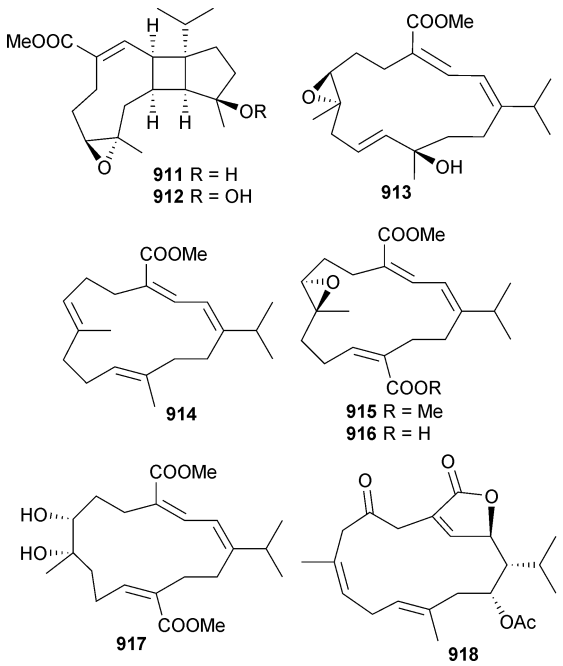


†**907**

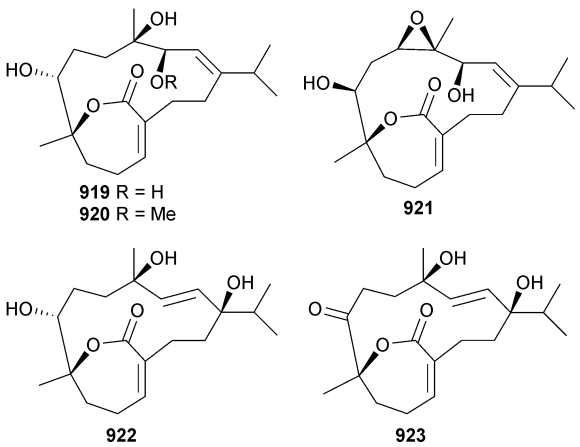
A Red Sea (Hurghada) collection of *S. trocheliophorum* provided trochelioids A **908** and B **909** and 16-oxosarcophytonin E **910**, the latter reported for the first time as an NP.[801]

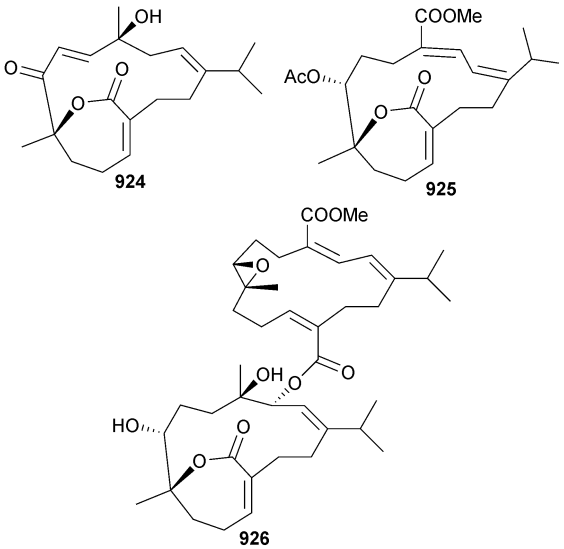


In three separate accounts, sixteen new cembranoids were reported from *S. trocheliophorum* (Yalong Bay, Hainan, China). Of methyl sarcotroates A **911** and B **912**, and sarcophytonolides M–R **913–918**, only hydroperoxide-containing **912** and sarcophytonolide N **914** were found to inhibit human PTP1B.[802,803]

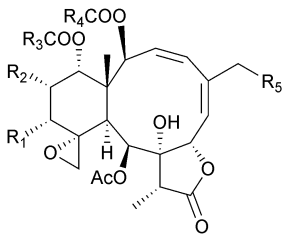


Also isolated were ε-lactone-containing cembranolides sartrolide A–G **919–925** and dimer bissartrolide **926**.[804] The unusual (1*E*,3*Z*)-diene configuration of **925** was supported by X-ray crystal analysis of isomeric co-metabolites sarcrassin D[805] and emblide.[806] Bissartrolide represents a dimer of sartrolide A and a free carboxylic acid analogue of sarcophytonolide B.[807]

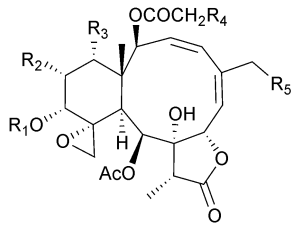




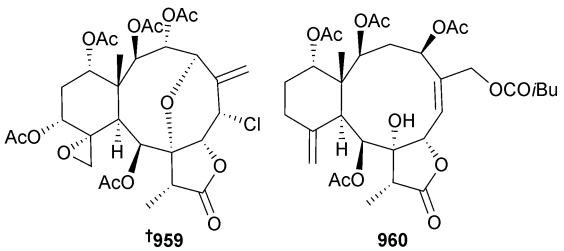
A total of 34 new briarane diterpenes were reported from two collections of *Dichotella gemmacea*: gemmacolides AA–AR **927–944** (S. China Sea)[808] and dichotellides F–U **945–960** (Meishan Is., Hainan, China).[809] The absolute configurations of **927–944** were assigned by comparison of ECD data with those of dichotellide T **941**, the absolute configuration of which was established by X-ray crystal analysis. Modest to moderate levels of cytotoxicity were observed for the gemmacolides while the dichotellides were all poorly cytotoxic with some examples exhibiting strong antifouling activity.



†**927** $R_1 = R_2 = OAc$, $R_3 = Me$, $R_4 = CH_2OH$, $R_5 = OMe$
†**928** $R_1 = OCOiBu$, $R_2 = OAc$, $R_3 = Me$, $R_4 = CH_2OH$, $R_5 = OMe$
†**929** $R_1 = OCOiBu$, $R_2 = OAc$, $R_3 = R_4 = Me$, $R_5 = OMe$
†**930** $R_1 = OCOiBu$, $R_2 = OAc$, $R_3 = iBu$, $R_4 = Me$, $R_5 = OMe$
†**931** $R_1 = R_2 = H$, $R_3 = Me$, $R_4 = CH_2OCOiBu$, $R_5 = OMe$
†**932** $R_1 = R_5 = OCOiBu$, $R_2 = OAc$, $R_3 = R_4 = Me$
†**933** $R_1 = R_2 = OAc$, $R_3 = R_4 = Me$, $R_5 = OCOiBu$
†**934** $R_1 = R_5 = OCOiBu$, $R_2 = OAc$, $R_3 = Me$, $R_4 = CH_2OCOiBu$
†**935** $R_1 = OH$, $R_2 = OAc$, $R_3 = Me$, $R_4 = CH_2OCOiBu$, $R_5 = OCOiBu$
†**936** $R_1 = OCOiBu$, $R_2 = OAc$, $R_3 = Me$, $R_4 = CH_2OCOiBu$, $R_5 = Cl$
†**937** $R_1 = OAc$, $R_2 = OCOiBu$, $R_3 = Me$, $R_4 = CH_2OH$, $R_5 = OMe$
†**938** $R_1 = OAc$, $R_2 = OCOiBu$, $R_3 = Me$, $R_4 = CH_2OCOiBu$, $R_5 = OMe$
†**939** $R_1 = OAc$, $R_2 = OCOiBu$, $R_3 = Me$, $R_4 = CH_2OCOiBu$, $R_5 = Cl$
†**940** $R_1 = OAc$, $R_2 = OCOiBu$, $R_3 = Me$, $R_4 = CH_2OH$, $R_5 = Cl$
†**941** $R_1 = R_2 = R_5 = OCOiBu$, $R_3 = Me$, $R_4 = CH_2OH$
†**942** $R_1 = R_2 = OAc$, $R_3 = iBu$, $R_4 = CH_2OH$, $R_5 = Cl$
†**943** $R_1 = R_2 = OAc$, $R_3 = iBu$, $R_4 = Me$, $R_5 = OH$
†**944** $R_1 = R_2 = R_5 = OAc$, $R_3 = iBu$, $R_4 = Me$

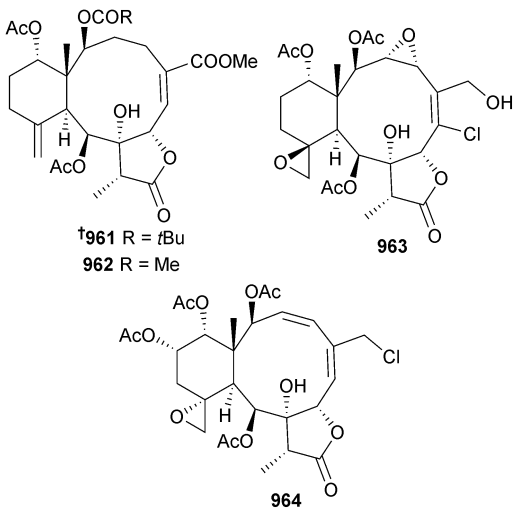


945 R_1 = Ac, R_2 = R_3 = OAc, R_4 = OCO*i*Bu, R_5 = OMe
946 R_1 = Ac, R_2 = R_4 = OCO*i*Bu, R_3 = OAc, R_5 = OMe
947 R_1 = CO*i*Bu, R_2 = R_3 = OAc, R_4 = OCO*i*Bu, R_5 = Cl
948 R_1 = Ac, R_2 = R_3 = OAc, R_4 = R_5 = OCO*i*Bu
949 R_1 = Ac, R_2 = R_3 = R_5 = OAc, R_4 = H
950 R_1 = Ac, R_2 = R_5 = OCO*i*Bu, R_3 = OAc, R_4 = H
951 R_1 = Ac, R_2 = OAc, R_3 = R_5 = OCO*i*Bu, R_4 = H
952 R_1 = CO*i*Bu, R_2 = OCO*i*Bu, R_3 = OAc, R_4 = H, R_5 = OMe
953 R_1 = Ac, R_2 = R_4 = H, R_3 = OCO*i*Bu, R_5 = OMe
954 R_1 = CO*i*Bu, R_2 = R_4 = H, R_3 = OAc, R_5 = OMe
955 R_1 = Ac, R_2 = R_4 = H, R_3 = R_5 = OCO*i*Bu
956 R_1 = R_4 = H, R_2 = OCO*i*Bu, R_3 = OH, R_5 = Cl
957 R_1 = R_4 = H, R_2 = R_5 = OCO*i*Bu, R_3 = OH
958 R_1 = R_4 = H, R_2 = OAc, R_3 = OH, R_5 = OCO*i*Bu



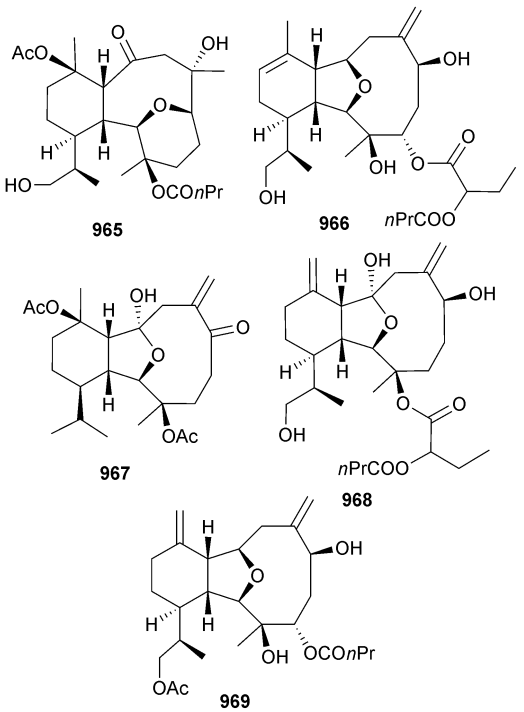
†**959** **960**

Junceella fragilis (Tai-Tong county, Taiwan) was the source of four more briaranes, frajunolide P–S **961–964**.[810] Hirsutalins I–M **965–969** are eunicellin diterpenes isolated from *Cladiella hirsuta* (Sianglu Islet, Penghu Is., Taiwan).[811] Moderate inhibition of NO production by stimulated macrophages for **967** was shown.



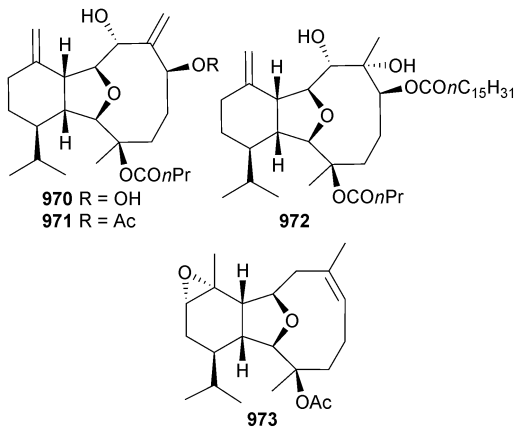
†**961** R = *t*Bu
962 R = Me
963
964

In addition to a number of related metabolites, *C. krempfi* (Weizhou Is., S. China Sea) yielded oxylitophynol **970**, litophynol A acetate **971**, litophynol C **972** and krempfenin **973**.[812]



965 **966** **967** **968** **969**

Reduction of **970** gave a product identical to known co-metabolite litophynol A,[813] subsequent acetylation of which afforded a product identical to **971**.



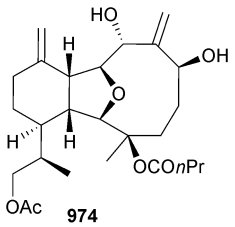
970 R = OH
971 R = Ac
972

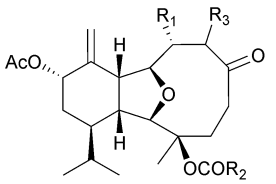
973

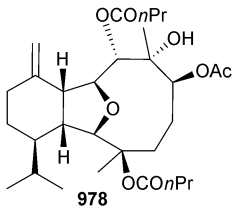
Also isolated from *C. krempfi* (Penghu Is., Taiwan) were krempfielins E–M **974–982**.[814,815] Although **974–977** were inactive in antitumour and anti-inflammatory assays, structurally related co-metabolites did exhibit activity.

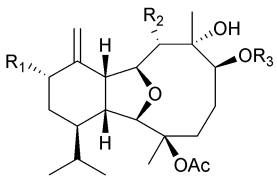
Of four new eunicellins reported from *Cladiella* sp. (Penghu Is., Taiwan), cladieunicellins I **983**, K **984**, and L **985** and litophynin I diacetate **986**, the latter has been previously reported[816] as a semi-synthetic derivative.[817,818] Cladieunicellins I and L exhibited moderate activity towards an HTCL.

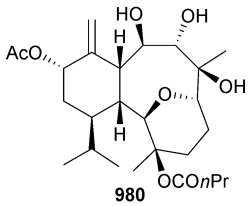
An unusual member of the klymollins I–S **987–997** (*Klyxum molle*, Penghu Is., Taiwan) is the phenylacetate-bearing klymollin M **991**.[819] This same metabolite was the most potent of the set, exhibiting cytotoxicity and the ability to inhibit superoxide generation and elastase release from stimulated human neutrophils.


974


975 R_1 = H, R_2 = Me, R_3 = —Me
976 R_1 = OH, R_2 = *n*Pr, R_3 = —Me
977 R_1 = H, R_2 = Me, R_3 = ····Me


978


979 R_1 = R_2 = H, R_3 = Me
981 R_1 = OH, R_2 = R_3 = H
982 R_1 = OAc, R_2 = R_3 = H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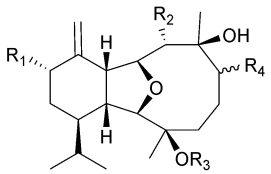
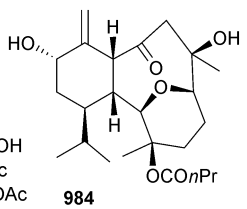
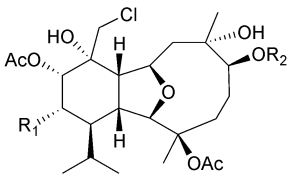
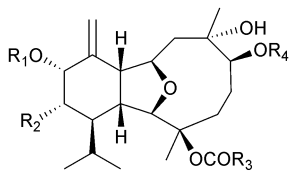
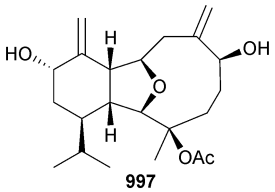

983 R_1 = H, R_2 = OAc, R_3 = CO*n*Pr, R_4 = ····OH
985 R_1 = OAc, R_2 = OH, R_3 = Ac, R_4 = —OAc
986 R_1 = OAc, R_2 = H, R_3 = CO*n*Pr, R_4 = —OAc

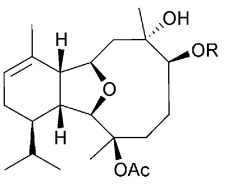

984

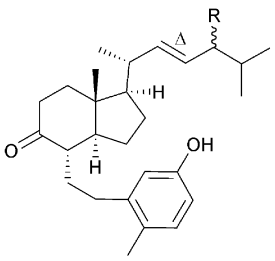

987 R_1 = OAc, R_2 = Ac
988 R_1 = OAc, R_2 = H
989 R_1 = H, R_2 = Ac
990 R_1 = R_2 = H

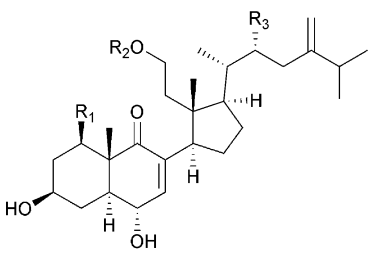

991 R_1 = R_2 = H, R_3 = *n*Pr, R_4 = $COCH_2Ph$
992 R_1 = H, R_2 = OAc, R_3 = *n*Pr, R_4 = Ac
993 R_1 = Ac, R_2 = OH, R_3 = *n*Pr, R_4 = Ac
994 R_1 = R_4 = H, R_2 = OAc, R_3 = *n*Pr
995 R_1 = R_2 = H, R_3 = Me, R_4 = Ac
996 R_1 = R_2 = R_4 = H, R_3 = Me


997

In addition to two eunicellin diterpenes sibogin A **998** and B **999**, investigation of the NPs from *Muricella sibogae* (Weizhou Is., China) also afforded three new *seco*-sterols sibogol A–C **1000–1002**.[820] A further two *seco*-sterols **1003** and **1004** were reported from *Sinularia nanolobata* (Xiao-Liuqiu Is., Pingtung county, Taiwan)[821] and eleven, subergorgol A–J **1005–1014** and **1015**, from *Subergorgia suberosa* (Meishan coast, S. China Sea).[822] The latter unnamed *seco*-sterol is reported as an NP for the first time. Subergorgols C **1007** and D **1008**, and F **1010** and G **1011** were isolated as their respective epimeric pairs but with unassigned configuration. The latter two were considered artefacts of isolation. While **1013** was found to be the most cytotoxic (moderate), **1015** was devoid of activity.


998 R = Ac
999 R = Me

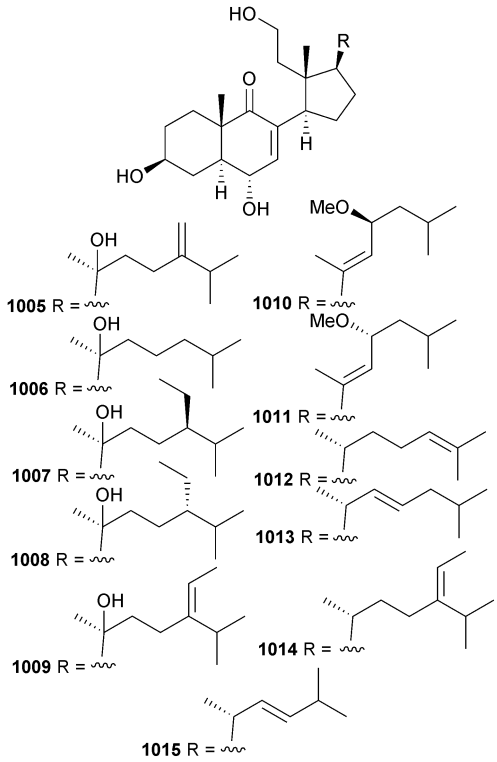

1000 R = —Et, Δ saturated
1001 R = ····Et
1002 R = ····Me, Δ saturated

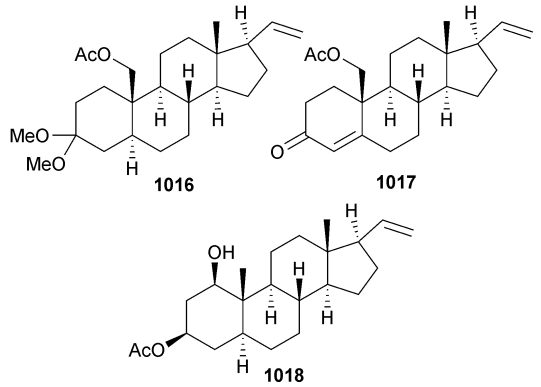

1003 R_1 = R_2 = H, R_3 = OAc
1004 R_1 = OH, R_2 = Ac, R_3 = H

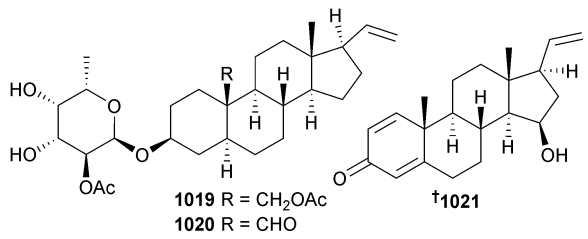
As well as a modestly bioactive δ-lactone noted earlier, an extract of *Scleronephthya gracillimum* (Green Is., Taiwan) also afforded pregnanes sclerosteroid J–N **1016–1020**.[770] Sclerosteroids K and M were more active than the other metabolites at inhibiting expression of iNOS and COX-2 in stimulated macrophages. Pregnane **1021** (*Carijoa* sp., Weizou Is., S. China Sea) exhibited potent antimicrobial properties.[823]

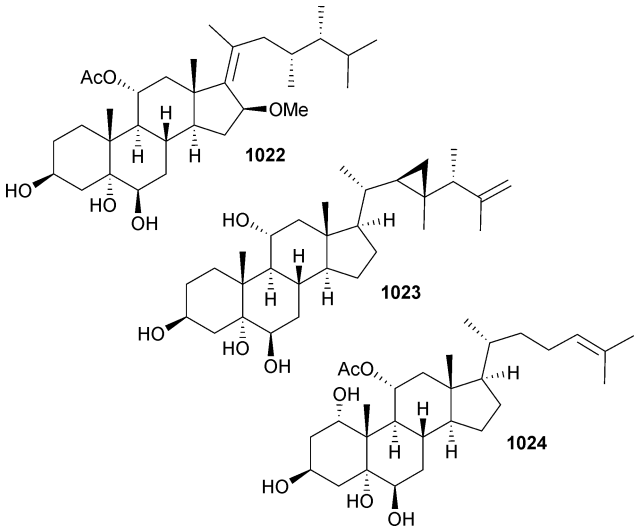
In addition to a number of known congeners, three new mildly cytotoxic polyhydroxylated steroids **1022–1024** were isolated from *Sarcophyton* sp. (Weizhou Is., S. China Sea).[824] The possible artefactual origin of methylether **1022** was noted.

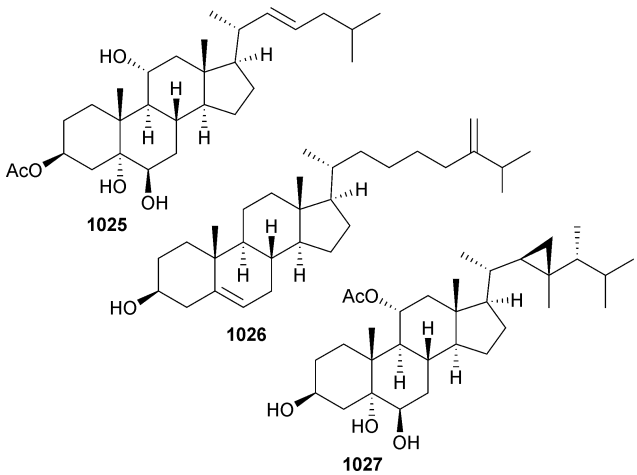
A collection of *Anthogorgia caerulea* from the same general location afforded caerulsteroid A **1025**.[825] Three studies of Red Sea (Hurghada) cnidarians afforded steroids – hurgadacin **1026** was isolated from *Sinularia polydactyla*,[826] gorgostane **1027** (= 11-acetyl-sarcoaldosterol A[827]) from *Heteroxenia ghardaqensis*[828] and zahramycins A **1028** and B **1029** from *Sarcophyton*

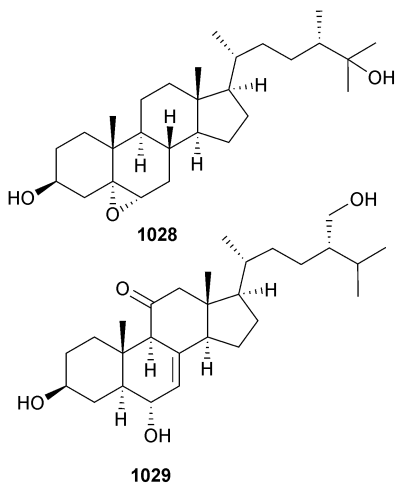








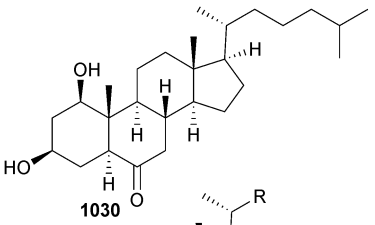




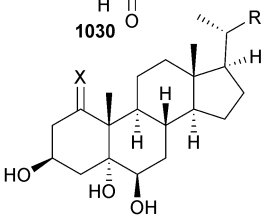
trocheliophorum.[829] Zahramycin B exhibited modest antibacterial activity.

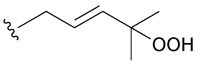
Fourteen new sterols **1030–1043**, plus one **1044** reported as an NP for the first time, were isolated as mildly cytotoxic constituents of *Menella kanisa* (coast of Beihai, Guangxi province, China).[830]

In addition to a number of co-metabolites, muriflasteroids A–C **1045–1047** were identified as weak to moderate cytotoxins (*Muriceopsis flavida*, Beihai, Guangxi province, China).[831] Sterols containing 24(28)-unsaturation were reported from *Sinularia depressa* (**1048** and **1049**, Lingshui Bay, Hainan, S. China Sea)[832]

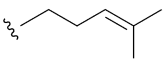


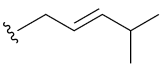
1030

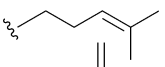


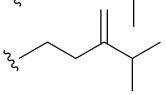
1031 X = H,H, R = 

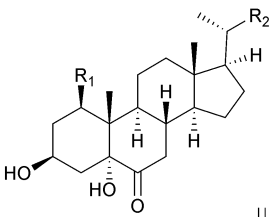
1032 X = 

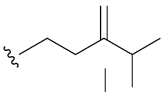
,H, R = 

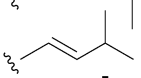
1033 X = O, R = 

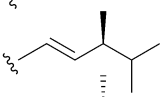
1034 X = O, R = 

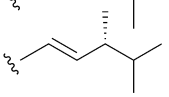
1035 X = O, R = 

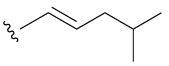


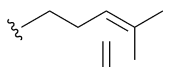
1036 R_1 = H, R_2 = 

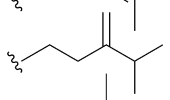
1037 R_1 = H, R_2 = 

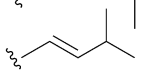
1038 R_1 = H, R_2 = 

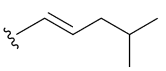
1039 R_1 = H, R_2 = 

1040 R_1 = OH, R_2 = 

1041 R_1 = OH, R_2 = 

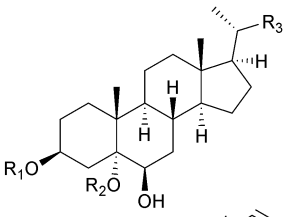
1042 R_1 = OH, R_2 = 

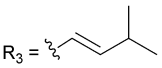
1043 R_1 = OH, R_2 = 

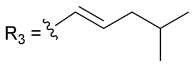
1044 R_1 = H, R_2 = 

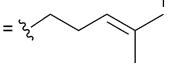
and *Nephthea chabrolii* (nebrosteroids Q–S, **1050–1052**, San-Hsian-Tai coast, Taitong county, Taiwan).[833] The latter three sterols exhibited mild cytotoxicity.

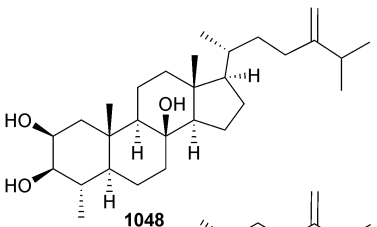
While sterols **1053–1059** (*Sarcophyton* sp., Weizhou Is., S. China Sea)[834] exhibited variable levels of antimicrobial activity, dissesterol **1060** (*Sinularia dissecta*, Hai Van-Son Cha, Hue,



1045 R_1 = Ac, R_2 = H, R_3 = 

1046 R_1 = H, R_2 = Me, R_3 = 

1047 R_1 = R_2 = H, R_3 = 



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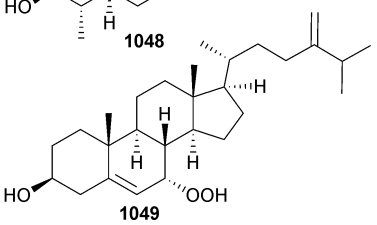

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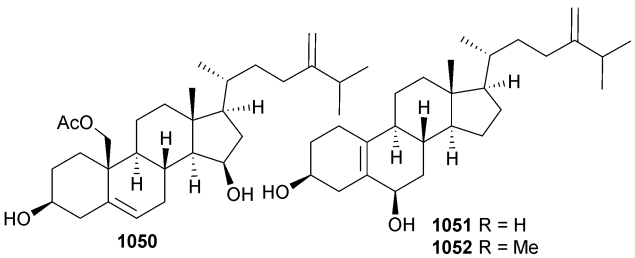
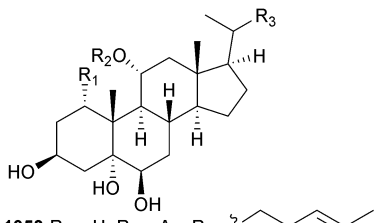


1050 **1051** R = H **1052** R = Me

Vietnam) was a strong inhibitor of IL-12 p40 cytokine production by stimulated bone marrow-derived dendritic cells.[835] One new 18-acetoxy sterol **1061** was isolated from a South China Sea (Xuwen coral reef area) collection of *Sarcophyton* sp.[836]

Two 5α,8α-epidioxysterols were reported: mildly cytotoxic **1062** from *Sinularia gaweli* (Sansiantai, Taitung county, Taiwan)[837] and antiviral (H5N1) **1063** from *S. candidula* (Safaga, Egyptian Red Sea).[752]

A range of ring-A cross-conjugated steroids, including lactone side-chained withanolides, were reported from cnidarians. All five cholestadienones **1064–1068** (*Nepthea* sp., Naozhou Is., S. China Sea)[838] exhibited cytotoxicity towards a panel of HTCLs, while of three carboxylic acid-containing examples, paraminabic acid A–C **1069–1071** (*Paraminabea acronocephala*, Pingtung county, Taiwan), **1071** exhibited the most potent cytotoxicity.[839]

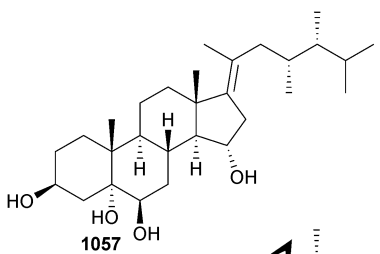


1053 R_1 = H, R_2 = Ac, R_3 =

1054 R_1 = H, R_2 = Ac, R_3 =

1055 R_1 = OH, R_2 = H, R_3 =

1056 R_1 = R_2 = H, R_3 =



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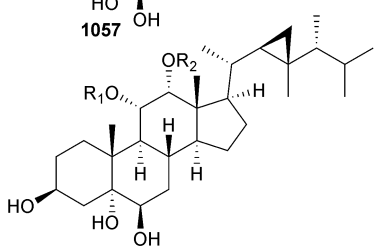
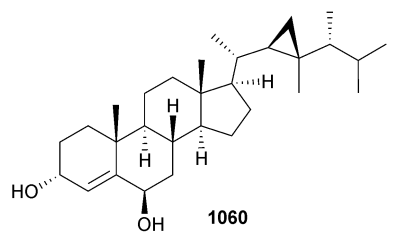


1058 R_1 = Ac, R_2 = H
1059 R_1 = H, R_2 = Ac



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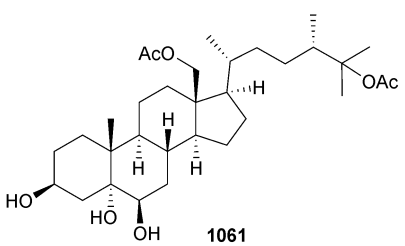
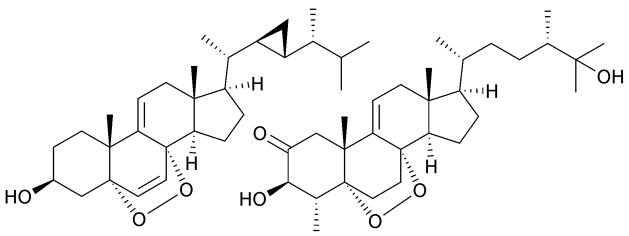
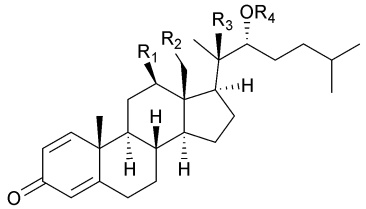


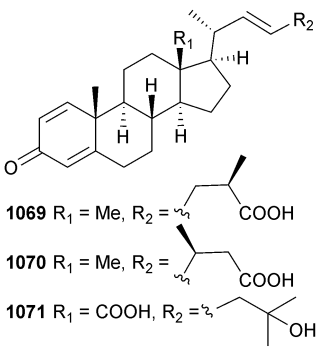
1061



1062 **1063**



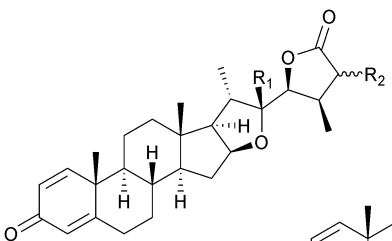
1064 R_1 = OAc, R_2 = R_3 = R_4 = H
1065 R_1 = OH, R_2 = R_3 = H, R_4 = Ac
1066 R_1 = OAc, R_2 = R_3 = H, R_4 = Ac
1067 R_1 = R_3 = H, R_2 = OAc, R_4 = Ac
1068 R_1 = R_2 = H, R_3 = OH, R_4 = Ac



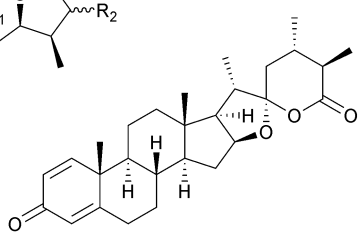
1069 R_1 = Me, R_2 = COOH

1070 R_1 = Me, R_2 = COOH

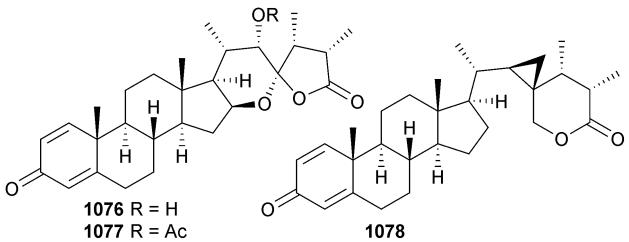
1071 R_1 = COOH, R_2 = OH



†**1072** R_1 = H, R_2 = Me
1073 R_1 = H, R_2 = Me
1074 R_1 = OH, R_2 = Me



1075

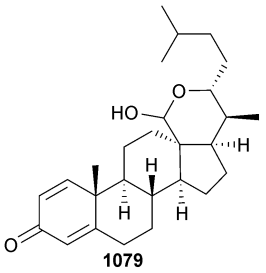


1076 R = H
1077 R = Ac

1078

Sinubrasolides A–G **1072–1078** are withanolide-type steroids isolated from cultured specimens of *Sinularia brassica* (Taiwan) – the structure of **1075** is notable for containing an unusual spiroketal moiety.[840] Mild cytotoxicity was observed for **1072**, **1073** and **1076**.

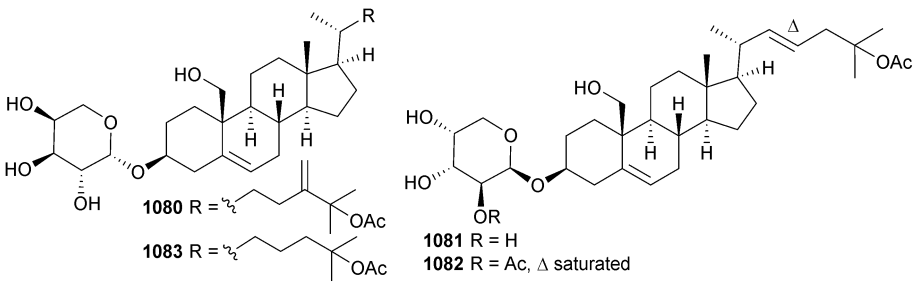
Acetylation of hemiacetal-containing nephthoacetal **1079** (*Nephthea* sp., Naozhou Is., S. China Sea) yielded two acetates.[841] The NP inhibited the settlement of *B. neritina* larvae, an activity not observed for the acetate derivatives, while all three compounds were mildly cytotoxic to HeLa cells.



1079

Finally, new steroidal glycosides junceelloside E–G **1080–1082** were reported from *Dichotella gemmacea* (Beihai, China).[842] Detailed analysis of the nature of the arabinopyranose subunits (thiocarbamoyl-thiazolidine derivative) identified junceelloside E to contain the β-L anomer while junceellosides F and G contained the more standard β-D anomer. The arabinopyranose unit present in co-metabolite junceelloside C (*Junceella juncea*)[843] was corrected from β-D to β-L (**1083**).

unsuccessful – a new model pathway was proposed, acting *via* a (3 + 2) transannular cyclisation reaction.[848] In a related study, the 5,5,6- and 5,5,7-tricyclic ring systems found in the cnidarian metabolites plumarellide and rameswaralide were constructed from linear furanbutenolide precursors under acidic conditions, suggesting a potential biosynthetic mechanism involving two-step carbocation cyclisation sequences.[849] Further investigation of the previously reported anti-inflammatory activity of the sesquiterpene lemnalol (*Lemnalia* sp.)[850] has revealed that intramuscular injection leads to attenuation of inflammation in a monosodium urate model of human gouty arthritis, and that the NP also suppressed neutrophil infiltration and expression of related pro-inflammatory cytokines.[851] While the mechanisms of cytotoxicity of the cembranoid 5-episinuleptolide acetate[852] appear to include inhibition of levels of Hsp90 and induction of apoptosis,[853] 11-episinulariolide acetate[854] targets EGF-mediated cytoplasmic calcium levels and inhibits COX-2 and IL-8 expression.[855] Of a range of exo-methylene lactone-containing cembranoids tested for immunomodulatory effects, lobocrassin B (*Lobophytum crassum*)[856] was the most effective at blocking TNF-α production and attenuating LPS-stimulated dendritic cell maturation and endocytosis.[857] A hydroxypropyl-β-cyclodextrin formulation of pseudopterosin A (*Pseudopterogorgia elisabethae*)[858] was more effective at inducing HUVEC cell proliferation than a DMSO solution of the NP – the change in formulation allowed observation of the decoupling of proliferative and cytotoxic effects.[859] The previously reported ability of hippuristanol (*Isis hippuris*)[860] to inhibit RNA helicase and eukaryotic initiation factor 4A, has

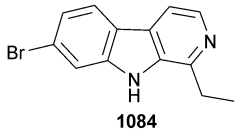


1081 R = H
1082 R = Ac, Δ saturated

The structure of (−)-sinularianin B (*Sinularia* sp.)[844] has been confirmed and absolute configuration established *via* synthesis which made use of sulfone-mediated tandem intramolecular-intermolecular alkylation.[845] Comparison of NMR and chiroptical data for two diastereomers of (+)-sarcophytonolide C (*Sarcophyton* sp.)[807] synthesised *via* a route including macrolactonisation and transannular RCM steps has confirmed the structure and established the absolute configuration of the NP.[846] A general strategy for the synthesis of cladiellin diterpenoid NPs has been exemplified with the synthesis of ten examples.[847] Efforts to mimic the putative carbon-centred radical reactions proposed for the biosynthesis of selected norcembranoids in *Sinularia* sp. were prompted further investigation of the biological properties of the spiroacetal-containing steroid, identifying it as an inhibitor of primary effusion lymphoma cells, inducing G_1 phase arrest, caspase activation and apoptosis.[861] Activity was also observed in an *in vivo* model. Further investigation of anti-inflammatory (15*R*)-prostaglandins from *Plexaura homomalla*[862] has identified the metabolites (15*R*)-PGE_2 and (15*R*)-OAc-PGA_2 as topically active inhibitors of oedema formation, leucocyte degranulation and elastase enzyme activity.[863] As noted in the previous review in this series, simplexin Q (*Klyxum simplex*)[864] is a duplicate of klysimplexin C[865] and simplexin S[864] is identical to cladieunicellin G (*Cladiella* sp.).[866,867]

9 Bryozoans

Only one new metabolite was reported from bryozoans in the last year, continuing the trend of minimal NP research efforts on this phylum. A new alkaloid, 7-bromo-1-ethyl-β-carboline **1084** was isolated from *Pterocella vesiculosa* (Aldermen Islands, New Zealand).[868]

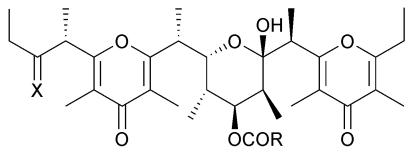


1084

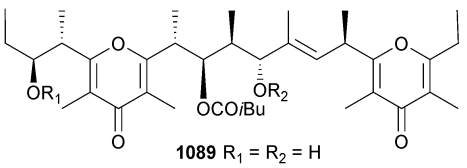
Wilsoniamines A and B, tribrominated alkaloids originally obtained from an Australian collection of *Amathia wilsoni*,[869] have been synthesised in two steps featuring a condensation reaction between (2,4,6-tribromo-3-methoxyphenyl)acetaldehyde and (*S*)-*N*-methylpyrrolidine-2-carboxamide as a key step.[870] Convolutamydine A, a dibrominated oxindole originally obtained from *Amathia convoluta*,[871] (along with two synthetic analogues) has/have been shown to possess antinociceptive effects comparable to those of morphine.[872]

10 Molluscs

The number of new metabolites reported from molluscs (15) is just over half the yearly average number reported over the past decade. The previously noted ability of molluscs to acylate dinoflagellate-produced toxin okadaic acid has been confirmed with acylating activity located in the digestive gland of various molluscs.[873] A range of unusual Δ^8 unsaturated 4-methyl and 4,4-dimethyl sterols was identified in extracts of the gonads of the Japanese limpet *Cellana grata* and *C. toreuma*.[874] Matrix solid-phase dispersion combined with GC-MS was demonstrated as a useful technique to detect the presence of brominated diphenyl ethers and newer halogenated flame retardants in mussel, cockle and clam extracts.[875] New onchidione analogues **1085–1088** and ilikonapyrone esters **1089–1094** were reported from different *Onchidium* sp. molluscs.[876] Acylation of **1086** gave **1087** and **1088**, while reduction of co-metabolite onchidione afforded two diastereomers, one of which was identical to onchidionol **1086**. The configurational relationships between **1089–1094** were identified by methanolysis of each, affording a product identical to co-metabolite ilikonapyrone.[877] Mild cytotoxicity was observed for some of the compounds.

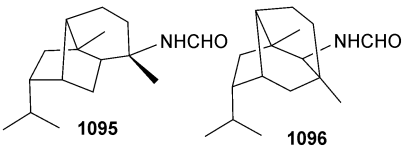


1085 R = Et, X = O
1086 R = *i*Bu, X = OH,H
1087 R = *i*Bu, X = OAc,H
1088 R = *i*Bu, X = OCOEt,H



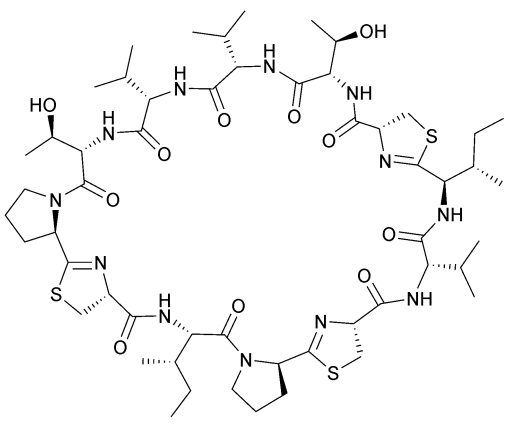
1089 $R_1 = R_2 = H$
1090 $R_1 = H$, $R_2 = Ac$
1091 $R_1 = R_2 = Ac$
1092 $R_1 = H$, $R_2 = COEt$
1093 $R_1 = Ac$, $R_2 = COEt$
1094 $R_1 = R_2 = COEt$

Two formamide-containing pupukeanane sesquiterpenoid congeners **1095** and **1096**, the latter previously known as a synthetic derivative, were reported from the tubercle nudibranch *Phyllidia coelestis* (Koh-Ha Islet, Krabi province, Thailand).[878] Moderate to strong cytotoxicity towards tumour cell lines was observed.



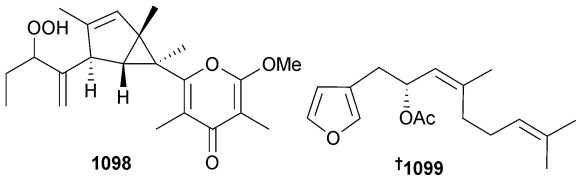
1095 **1096**

The absolute configuration of the mildly cytotoxic cyclic dodecapeptide cycloforskamide **1097** (*Pleurobranchus forskalii*, Ishigaki Is., Okinawa) was established by combinations of ozonolysis and acid hydrolysis.[879] In addition to this peptide, the ergot alkaloid ergosinine[880] was also isolated, an unusual finding as ergot alkaloids are usually only isolated from terrestrial higher plants and fungi.[881]



†**1097**

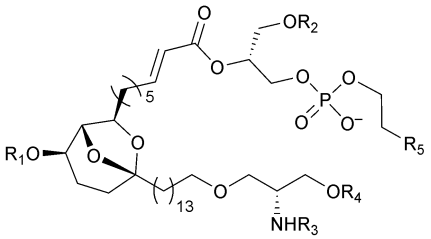
A potentially artefactual hydroperoxide, phototridachiapyrone J **1098** was isolated from the sacoglossan mollusc *Elysia patagonica* (San Jorge Gulf, Patagonia, Argentina).[882] The search for new leads for the treatment of leishmaniasis has identified the known 5α,8α-epidioxycholest-6-en-3β-ol (*Dolabrifera dolabrifera*) as mildly active against the amastigote form with nearly sixty-fold selectivity *versus* Vero cells.[883] The structure of furan **1099** (*Hypselodoris jacksoni*, S. E. Queensland) was confirmed and absolute configuration established by a thorough study using combinations of synthesis, chiral HPLC and MPA derivatisation.[884]



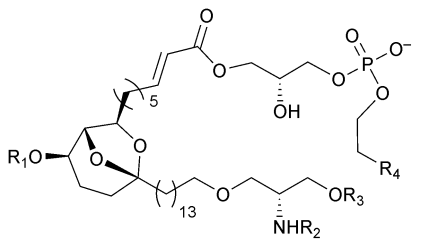
A new enantioselective route to oxazinin alkaloids (*Mytilus galloprovincialis*)[885,886] has helped confirm the absolute configuration of amongst others, oxazinin-1 and -2.[887] Synthesis of a library of analogues of cytotoxic depsipeptide kulokekahilide-2 (*Philinopsis speciosa*)[888,889] has revealed requirements of conformation, ring formation and ring size for biological potency.[890] Aplysiatoxin (*Stylocheilus longicauda*)[891] is a potent PKC binding tumour promoter – synthesis and evaluation of simplified debromo analogues suggest that activation of PKCδ might play a role in the observed antiproliferative activity.[892] Following the synthesis of sanguinamide B (*Hexabranchus sanguineus*),[893] the same group has reported that the use of biotinylated analogues of two cytotoxic D-Phe analogues in combination with pull-down assays have identified cellular targets that include eukaryotic ribosomal subunits.[894] Close investigation of the mechanisms of cell death induced by the compounds indicates that the exact mechanism depends on the position of the D-Phe group. The results of a dose-escalating phase I study of kahalalide F (originally mollusc *Elysia rufescens* and green alga *Bryopsis pennata*)[895] have been reported,[896] while evaluation of a kahalalide F analogue, elisidepsin, against a panel of tumour cell lines suggests that cell lines that exhibit high E-cadherin, ErbB3 and Muc1 gene expression can be regarded as being sensitive to the clinical candidate.[897] Drug resistance was associated with the presence of KRAS activating mutations. Using constrained NOESY NMR data, a conformational search has helped assign the configuration (3*S*) in the 9-methyl-3-decanol subunit of kahalalide Y (*Elysia rufescens*):[898] unfortunately the study made use of the enantiomer of the NP and so the configuration should in fact be (3*R*).[899,900] Investigation of the mechanism of cytotoxic action of aplyronine A (*Aplysia kurodai*)[901] using photoaffinity biotinylated derivatives has identified aplyronine A to synergistically bind to tubulin in association with actin in a 1 : 1 : 1 ratio, leading to inhibition of tubulin polymerisation, and ultimately prevention of spindle formation and mitosis.[902] Similar experiments using aplyronine C[902] (lacks the trimethylserine sidechain of aplyronine A;[903] three orders of magnitude less cytotoxic) showed it to bind to actin, as previously reported, but it did not bind to tubulin in this present study. Model compounds of the *N*-methylformamide sidechain of aplyronine A exhibit cytotoxicity towards tumour cell lines which is strongly correlated with their ability to induce the disruption of actin filaments.[904]

11 Tunicates (ascidians)

The 35 new tunicate-derived NPs presented in this review is average for the number reported per annum over the last decade. The sulfonated serinol lipids siladenoserinol A–L **1100–1111** (Didemnidae, North Sulawesi, Indonesia) inhibited the interaction of tumour suppressor p53 with Hdm2, potentially leading to reactivation of p53 and induction of apoptosis in cancer cells.[905] The absolute configuration of **1100** was established by a combination of degradation, modified Mosher's analysis and comparison with similar fragments of defined configuration.

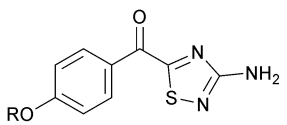


†**1100** $R_1 = R_2 = Ac$, $R_3 = SO_3H$, $R_4 = H$, $R_5 = N^+Me_3$
1101 $R_1 = R_2 = Ac$, $R_3 = SO_3H$, $R_4 = H$, $R_5 = N^+H_3$
1102 $R_1 = R_3 = H$, $R_2 = Ac$, $R_4 = SO_3H$, $R_5 = N^+H_3$
1103 $R_1 = Ac$, $R_2 = R_4 = H$, $R_3 = SO_3H$, $R_5 = N^+Me_3$
1104 $R_1 = R_3 = H$, $R_2 = Ac$, $R_4 = SO_3H$, $R_5 = N^+Me_3$
1105 $R_1 = R_4 = H$, $R_2 = Ac$, $R_3 = SO_3H$, $R_5 = N^+Me_3$
1106 $R_1 = R_2 = Ac$, $R_3 = H$, $R_4 = SO_3H$, $R_5 = N^+Me_3$



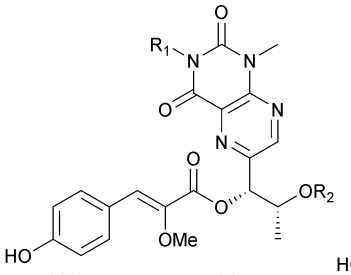
1107 $R_1 = Ac$, $R_2 = SO_3H$, $R_3 = H$, $R_4 = N^+Me_3$
1108 $R_1 = Ac$, $R_2 = H$, $R_3 = SO_3H$, $R_4 = N^+Me_3$
1109 $R_1 = R_2 = H$, $R_3 = SO_3H$, $R_4 = N^+H_3$
1110 $R_1 = R_3 = H$, $R_2 = SO_3H$, $R_4 = N^+Me_3$
1111 $R_1 = R_2 = H$, $R_3 = SO_3H$, $R_4 = N^+Me_3$

Two new examples of the rare 1,2,4-thiadiazole ring system, polycarpathiamine A **1112** and B **1113**, were isolated from *Polycarpa aurata* (Ambon, Indonesia). While **1112** exhibited submicromolar cytotoxicity (L5178Y), **1113** was inactive.[906] The regiochemistry of the 1,2,4-thiadiazole ring was established by analysis of ^1H–^{15}N HMBC data and by synthesis of a model compound.

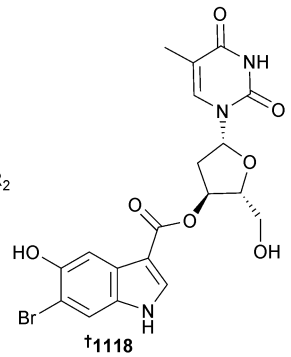


1112 R = H
1113 R = Me

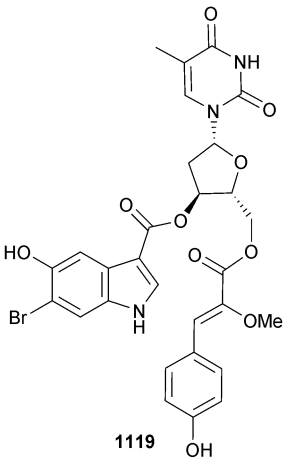
A diverse range of pteridine (duramidines A–D **1114–1117**), thymidine (leptoclinidines A **1118** and B **1119**), choline (durabetaines A **1120** and B **1121**) and imidazole (leptoclinidamines D–F **1122–1124**) analogues was isolated from *Leptoclinides durus* (Swains Reef, Great Barrier Reef).[907]



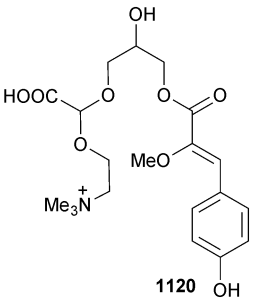
1114 R_1 = Me, R_2 = SO_3H
1115 R_1 = Me, R_2 = H
1116 R_1 = H, R_2 = SO_3H
1117 R_1 = R_2 = H



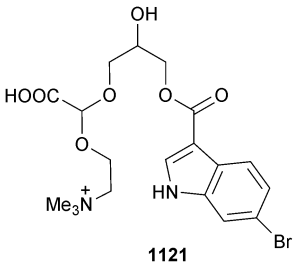
†**1118**



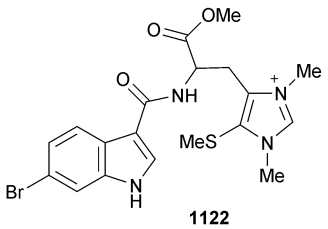
1119



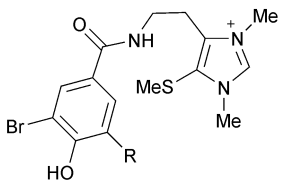
1120



1121

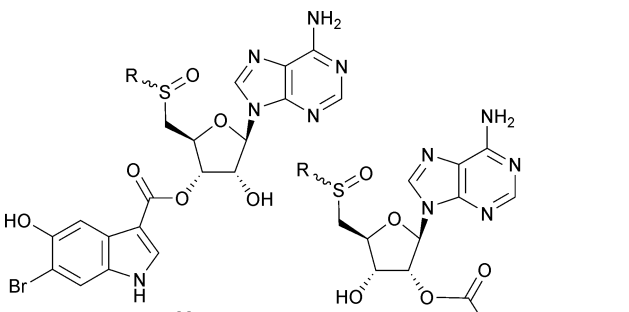


1122



1123 R = Br
1124 R = H

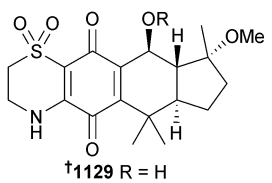
Four methylsulfinyladenosine derivatives, momusine A–D **1125–1128**, isolated as pairs of interconverting isomers, were reported from extracts of *Herdmania momus* (Jeju Is., S. Korea).[908]



1125 R = ◄Me
1127 R = ····Me

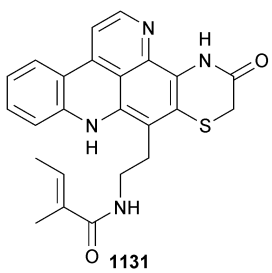
1126 R = ◄Me
1128 R = ····Me

The structures of the modestly cytotoxic dioxothiazinomeroterpenes conthiaquinone A **1129** and B **1130** (*Aplidium conicum*, Porto Cesareo, Lecce, Italy) were established by interpretation of NMR data in combination with DP4 calculated chemical shifts.[909] The absolute configuration of **1129** was proposed from TDDFT calculated ECD data.

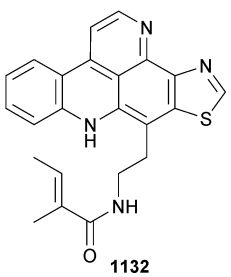


†**1129** R = H
1130 R = Me

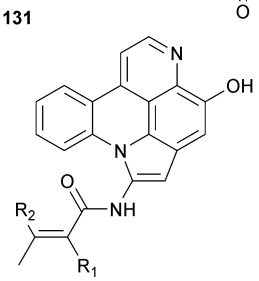
Four new examples of pyridoacridine alkaloids, shermilamine F **1131**, dehydrokuanoniamine F **1132** arnoamine C **1133** and D **1134** (*Cystodytes violatinctus*, Solomon Is.) exhibited modest cytotoxicity towards a panel of HTCLs.[910] A variant biosynthetic pathway to address the formation of arnoamines C and D was proposed. New analogues of the structurally related



1131



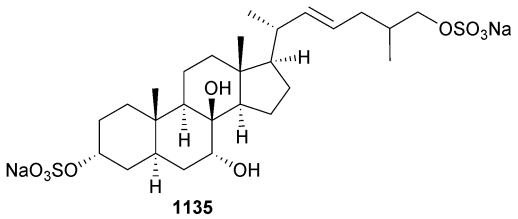
1132



1133 R_1 = Me, R_2 = H
1134 R_1 = H, R_2 = Me

styelsamines[911] were prepared and assessed for DNA binding ability and cytotoxicity.[912]

A sperm activation and attractant **1135** was isolated from egg seawater of *Ascidia sydneiensis*; structure elucidation by NMR and MS was performed on 2.6 μg (4 nmol) of material.[913] The proposed planar and stereo structure of **1135** was supported by the synthesis of model compounds. The structure of this sperm attractant is very similar to that previously reported from *Ciona intestinalis* and *C. savignyi*.[914]

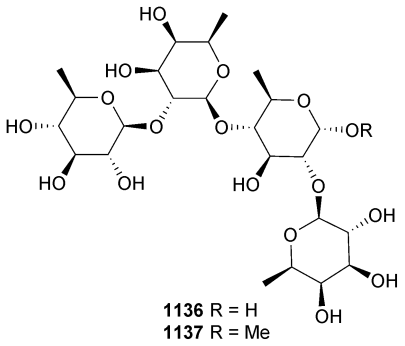


1135

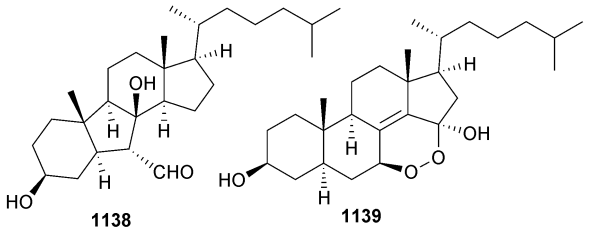
Synthesis and cytotoxic evaluation of aminol lipids clavaminol G[915] (*Clavelina phlegrea*)[916] and crucigasterins A, B and D[917,918] (*Pseudodistoma crucigaster*)[919] have been reported; mild activity was observed. First syntheses of kottamide E[920] (*Pycnoclavella kottae*),[921] lukianol B[922] (unidentified tunicate)[923] and eudistomin Y_7[924–926] (*Eudistoma* sp.)[927] have been published. Syntheses of an isomer of didemnaketal A[928] and the proposed structure of didemnaketal B[929] (*Didemnum* sp.)[930] provide further evidence that the NPs require revision of configurational assignments. Synthesis and structure–activity relationship studies on orthidine F[931] (antimalarial),[932] ascidiathiazone[933] (antimalarial),[934] meridianin G[935] (antimalarial),[936] perspicamide A[937] (antileishmanial),[938] rigidin[939] (antitumour),[940] and ningalin B[941] (P-glycoprotein modulator)[942] have been reported. Further investigation of recently reported ascidian metabolites of the cadiolide and synoilide families of furanones (*Synoicum* sp.)[943] has identified cadiolides E, H and I as being potent inhibitors of *C. albicans* isocitrate lyase, an enzyme associated with microorganism virulence.[944] Semi-synthetic *N*-acyl derivatives of ecteinascidin 770 (*Ecteinascidia thurstoni*)[945] has identified quinoline- and fluorocinnamoyl-containing examples that exhibit 50–70 fold increased cytotoxicity towards the HCT-116 cell line *versus* the parent NP.[946] Minor corrections to manuscripts describing the mandelalides (*Lissoclinum* sp.)[947] and herdmanine K (*Herdmania momus*)[948] have been noted.

12 Echinoderms

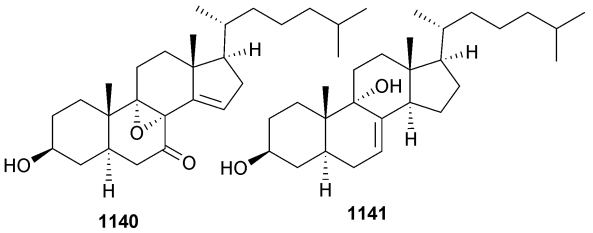
The 33 new metabolites reported from echinoderms in this review is lower than the average number reported per annum over the last decade. A commercially available specimen of the starfish *Asterias rollestoni* (Xiamen food market, China) afforded the tetraosides **1136** and **1137** (ref. 949) while *Astropecten polyacanthus* (Cat Ba, Haiphong, Vietnam) contained the inactive or mildly cytotoxic sterols astropectenol A–D **1138–1141**.[950] The latter set of compounds was also reported to inhibit the expression of pro-inflammatory cytokines in bone marrow-derived dendritic cells.[951]



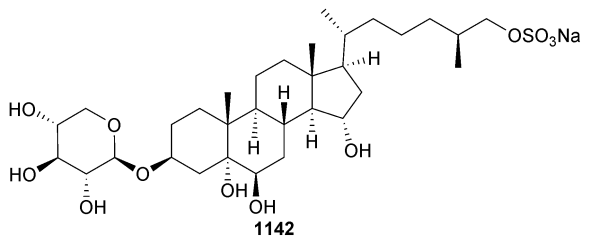
1136 R = H
1137 R = Me



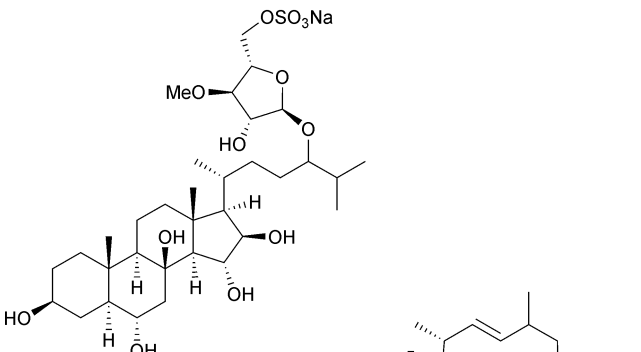
1138 **1139**



1140 **1141**



1142



1143

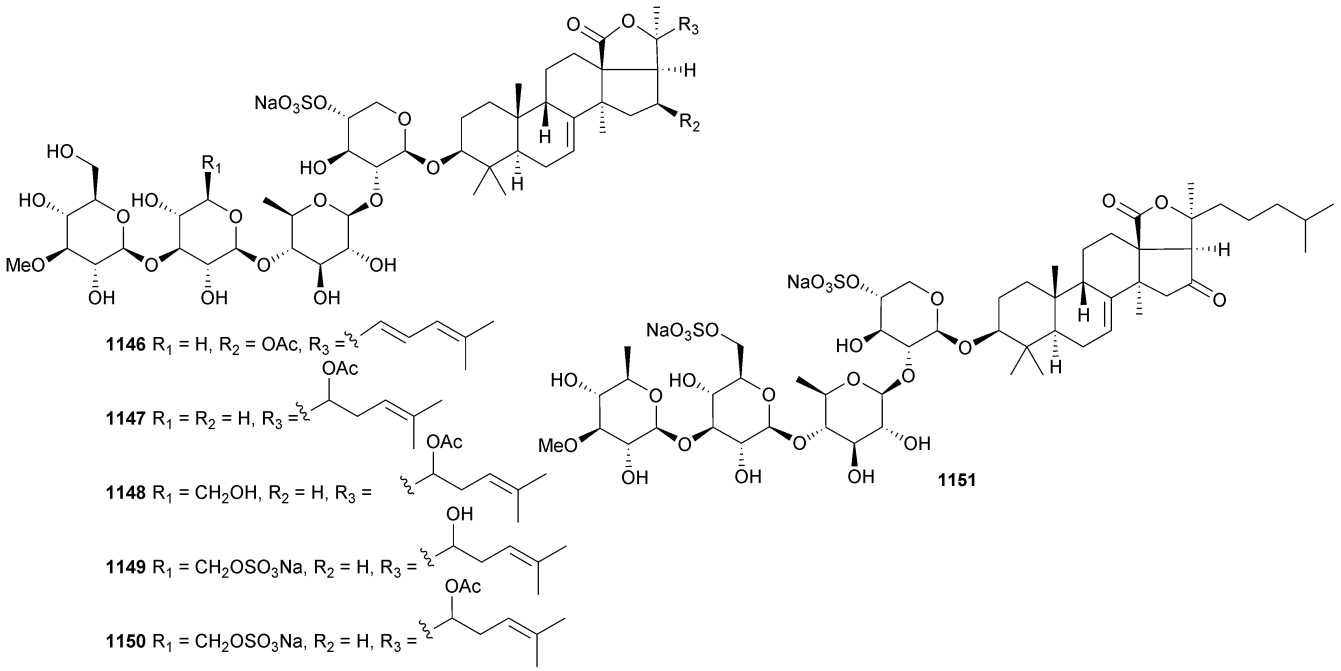
1144 R_1 = H, R_2 = SO_3Na
1145 R_1 = SO_3Na, R_2 = H

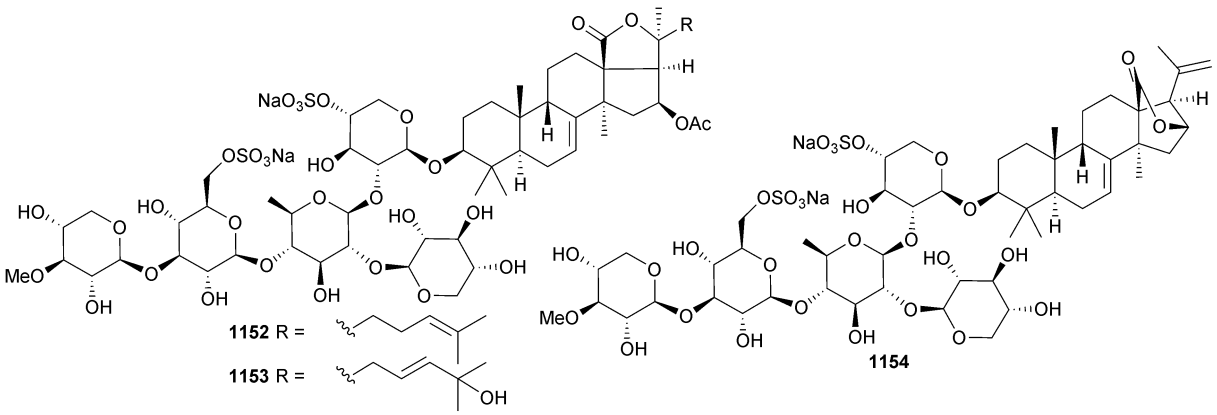
Aphelasteroside E **1142**, which contains the rare sulfation at C-26, was isolated from *Aphelasterias japonica* (Poset Bay, Sea of Japan)[952] and the C-24-arabinosides pectinioside H–J **1143–1145** were identified in extracts of *Asterina pectinifera* (Dalian coast, Yellow Sea, China).[953]

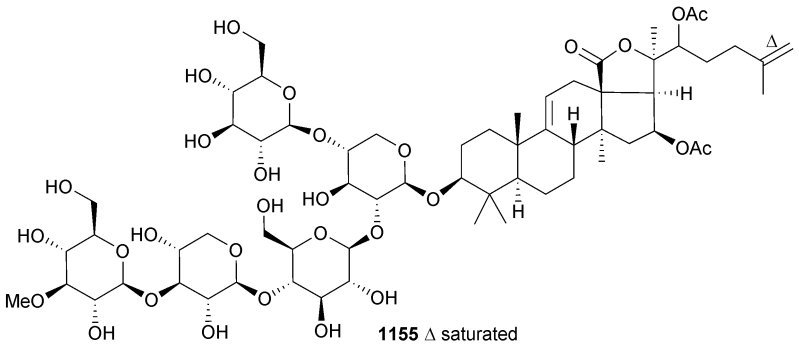
Tetraosides typicoside A_1 **1146** (the 24*E* isomer of previously reported intercedenside A (*Mensamaria intercedens*)[954]), A_2, B_1, C_1 and C_2 **1147–1150** are minor metabolites isolated from the sea cucumber *Actinocucumis typica* (Vizhinjam coast, Arabian Sea, India).[955] Antifungal, haemolytic and cytotoxic evaluations of the five NPs identified widespread activity, with typicoside C_1 being markedly less active in all assays. The presence of disulfated tetraoside turquetoside A **1151**, which contains the rare 3-*O*-methyl-D-quinovose sugar unit, in both *Staurocucumis turqueti* and *S. liouvillei* suggests the sugar is a taxonomic character of this particular genus of Antarctic sea cucumber.[956]

Of the disulfated pentaosides cucumarioside I_1, I_3 and I_4 **1152–1154** (*Eupentacta fraudatrix*, Peter the Great Gulf, Sea of Japan), only **1152** exhibited biological activity including cytotoxicity (weak) and haemolytic activity (strong).[957] Pentaosides cladoloside B_1 **1155** and B_2 **1156** and hexaosides cladoloside C, C_1, C_2 and D **1157–1160** (*Cladolabes schmeltzii*, Nha Trang Gulf, S. China Sea) all exhibited similar levels of strong cytotoxicity and haemolytic activity.[958]

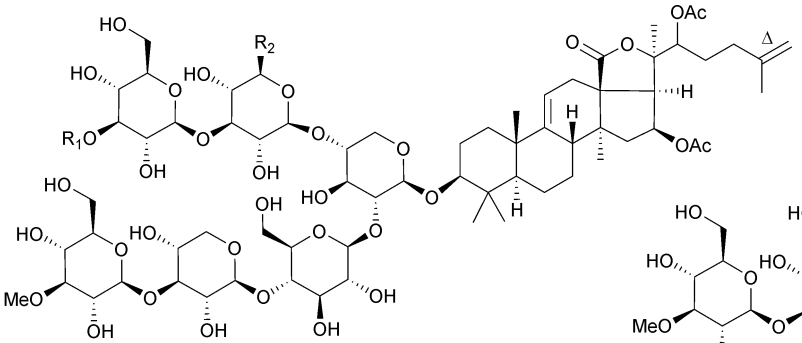
Extracts of the starfish *Astropecten monacanthus* (Cat Ba, Haiphong, Vietnam) afforded the hexaosides astrosterioside A–C **1161–1163** and pentaoside astrosterioside D **1164**.[959] While **1161** and **1163** exhibited mild inhibition of IL-6 production by stimulated bone marrow-derived dendritic cells, diketo-containing **1164** exhibited potent inhibition of production of IL-6, IL-12 p40 and TNF-α.



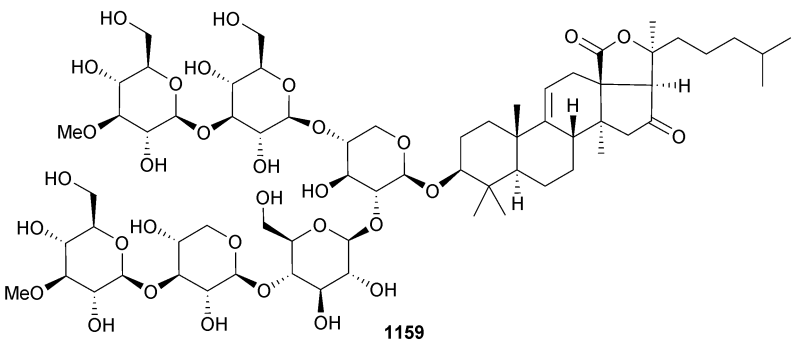




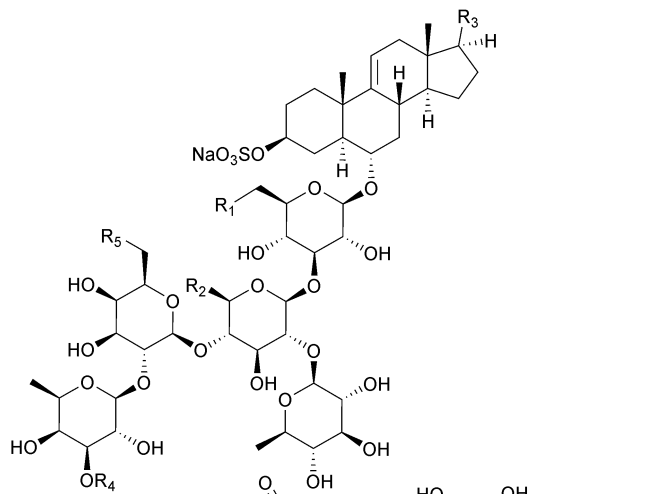
1155 Δ saturated
1156

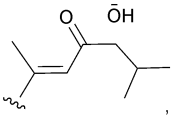
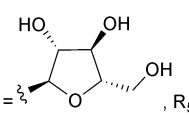


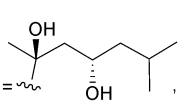
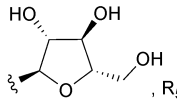
1157 R_1 = Me, R_2 = CH_2OH
1158 R_1 = Me, R_2 = CH_2OH, Δ saturated
1160 R_1 = R_2 = H

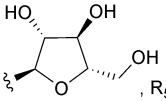


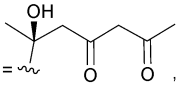
1159

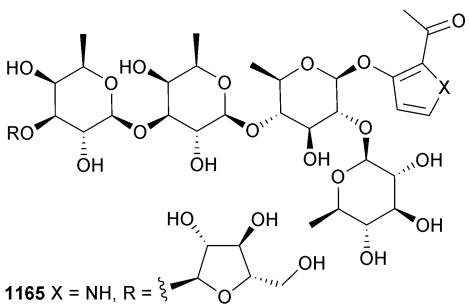


1161 R_1 = R_2 = H, R_3 =  , R_4 =  , R_5 = OH

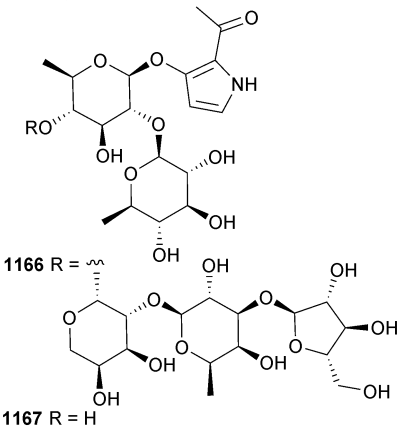
1162 R_1 = R_2 = H, R_3 =  , R_4 =  , R_5 = OH

1163 R_1 = R_2 = H, R_3 = Ac, R_4 =  , R_5 = OH

1164 R_1 = OH, R_2 = Me, R_3 =  , R_4 = R_5 = H



1165 X = NH, R =
1168 X = O, R = H



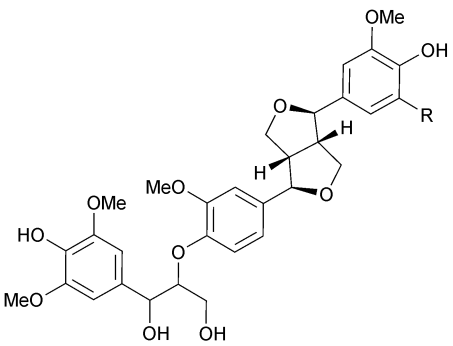
1166 R =
1167 R = H

The pyrrole and furan oligoglycosides astebatherioside A–D **1165–1168** were reported from the starfish *Asterina batheri* (Catba, Haiphong, Vietnam).[960] While **1165** was either inactive or weakly active, **1166–1168** demonstrated inhibition of IL-12 p40 production, and to a lesser extent of IL-6 production, in LPS-stimulated bone marrow-derived dendritic cells.

The synthesis of goniopectenoside B (starfish *Goniopecten demonstrans*)[961] has been reported.[962] Purified polar steroids previously reported from the starfish *Patiria pectinifera* and *Distolasterias nipon* are potent enhancers of neurite outgrowth and acted as neuroprotectors against damage caused by oxygen-glucose deprivation.[963] Crude preparations of cerebrosides from the sea cucumber *Acaudina molpadioides* and the starfish *Asterias amurensis* were found to protect PC12 cells from oxidative damage due to exposure to H_2O_2 or *tert*-butyl hydroperoxide.[964] In both cases the neuroprotection appeared to be conferred by upregulation of superoxide dismutase activity and modulation of components of the mitochondrial apoptotic pathway. High-energy CID tandem mass analysis has been used to determine the structures of ceramides and cerebrosides isolated from *Distolasterias nipon*.[965] Stable isotope biosynthesis feeding experiments have determined that dietary cholesterol and cholesterol 3-sulfate are elaborated into polyhydroxylated sterols in the starfish *Patiria* (= *Asterina*) *pectinifera*.[966]

13 Mangroves

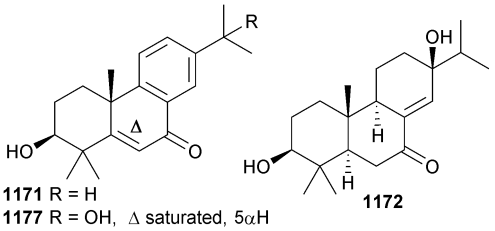
Aerial parts of the mangrove plant *Kandelia obovata* (Ximen Is., Zhejiang Province, China) afforded two new furofuran lignans kandelisesquilignan A **1169** and B **1170**.[967] Similar levels of antioxidant activity (DPPH assay) were observed for **1169** and **1170** *versus* ascorbic acid.



1169 R = H
1170 R = OMe

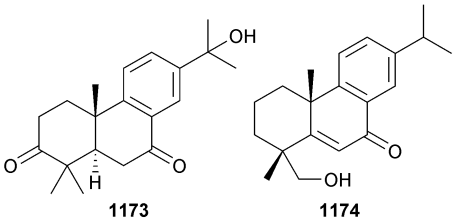
Ethanolic extracts of the bark of *Ceriops decandra* (Godavari estuary, Andhra Pradesh, India) afforded diterpenes decandrin A–K **1171–1181**, the structures of which encompass abietane and podocarpane skeletons,[968] while the wood of *Excoecaria agallocha* (Corangi forest, Godavari estuary) afforded *ent*-isopimarane diterpenoids agallochaexcoerin D–F **1182–1184**.[969]

Two triterpenes tiliacol A **1185** and B **1186** were isolated from the semi-mangrove plant *Hibiscus tiliaceus* (Hainan Is., China).[970]

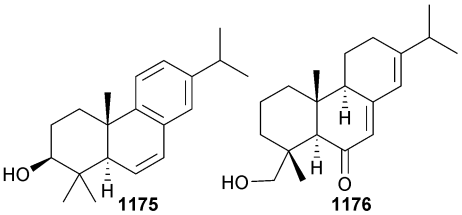


1171 R = H
1177 R = OH, Δ saturated, 5αH

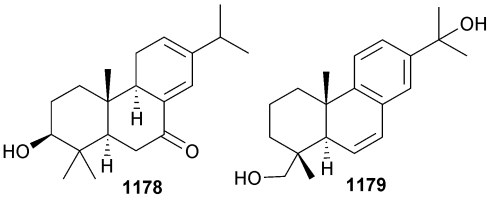
1172



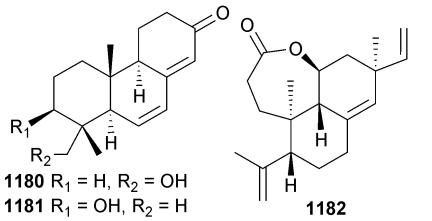
1173 **1174**



1175 **1176**

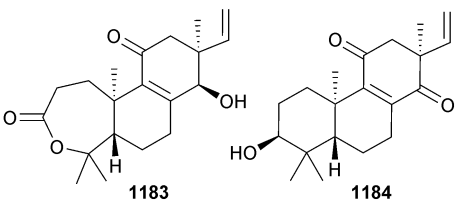


1178 **1179**

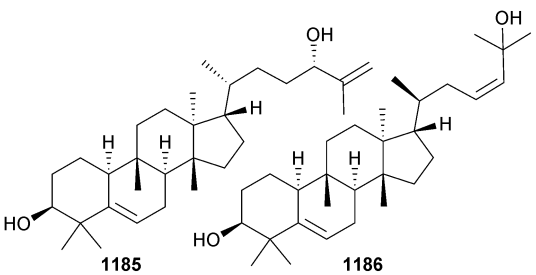


1180 R_1 = H, R_2 = OH
1181 R_1 = OH, R_2 = H

1182



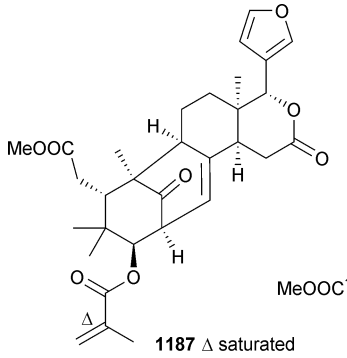
1183 **1184**



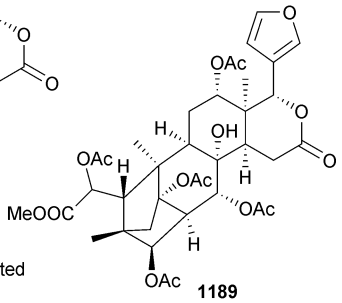
1185 **1186**

A diverse range of liminoids were reported from extracts of *Xylocarpus granatum*: granatumins H–K **1187–1190** (seeds, Krishna estuary, Andhra Pradesh),[971] xylomexicanins C **1191**

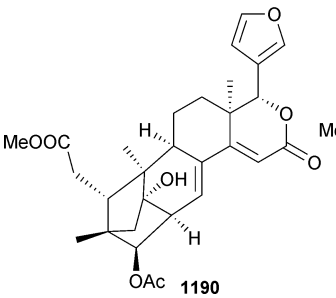
and D **1192** (seeds, Hainan Province, China),[972] and xylogranins A **1193** and B **1194** (leaves, Sundarbans Mangrove Forest, Bangladesh).[973] Xylomexicanin C **1191** exhibited modest cytotoxicity towards a breast tumour cell line, while xylogranin B **1194** and co-metabolite swietephragmin were potent inhibitors of the Wnt signalling pathway and exhibited sub-micromolar cytotoxicity towards two human colorectal tumour cell lines.



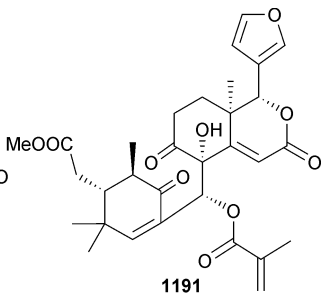
1187 Δ saturated
1188



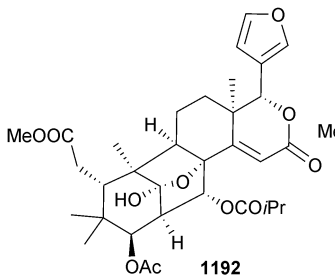
1189



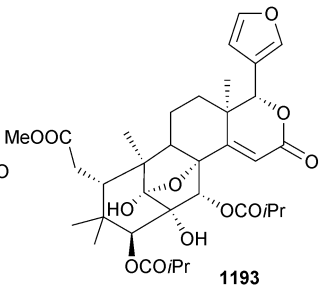
1190



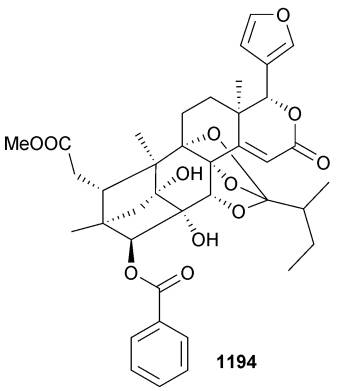
1191



1192

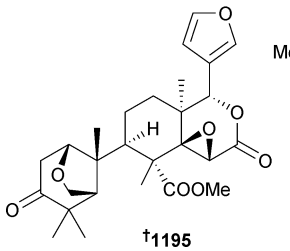


1193

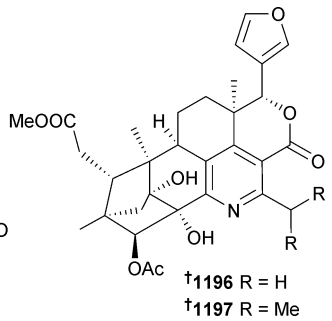


1194

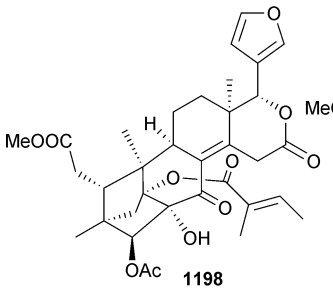
Extracts of the seeds of *X. moluccensis* (Trang province, Thailand) afforded thaixylomolins A–F **1195–1200**.[974,975] The structure of **1195** was secured by X-ray diffraction analysis and TDDFT calculations were used to establish the absolute configurations of **1196** and **1197**, while **1198** was assigned by comparison of ECD data. The 4-hydro-dithiosulfonate, bruguiesulfurol (*Bruguiera gymnorhiza*)[976] was detected as a modest inhibitor of PTP1B, prompting its synthesis and preparation of a library of analogues, some of which exhibited more potent activity.[977]



†**1195**



†**1196** R = H
†**1197** R = Me



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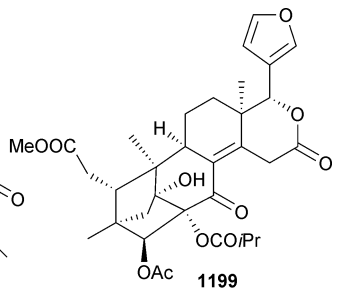
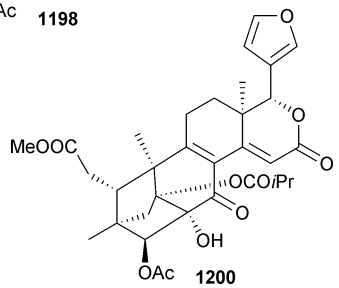


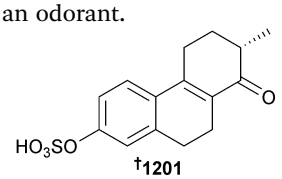
1199



1200

14 Miscellaneous

Investigation of water conditioned with sea lamprey (*Petromyzon marinus*) larvae afforded the hexahydrophenanthrene sulfate petromyzonin **1201**.[978] Absolute configuration was assigned by ECD analysis. Petromyzonin elicited potent (10^{-11} M) response in electro-olfactogram recordings using olfactory epithelia of adult male sea lamprey, indicating a likely ecological role as an odorant.



†**1201**

The detection of 5,11-dideoxytetrodotoxin,[979] isolated as an NP for the first time, in the pufferfish *Takifugu poecilonotus* and the flatworm *Planocerid* sp. 1 (Guam) prompted speculation on the putative biosynthetic pathways for the biosynthesis and metabolism of tetrodotoxins.[980] A new method involving sonication, SPE and LC-MS/MS has been reported to allow simultaneous quantification of Pacific ciguatoxins-1, -2 and -3 in the whole blood of fish.[981]

15 Conclusion

Fifty years ago in 1963 just four papers were published on MNPs with only one paper containing new compounds. At that time MNPs was becoming established as a field of interest. In this Conclusion the phylum-preferences of the MNP community across the subsequent 50 years period are examined. These preferences are presented (Fig. 1) as the annual number of publications reporting the isolation of new compounds for each phylum that has been sampled over this period. The most aggressively selected phylum has been the Porifera, but the popularity of this target has diminished somewhat since the mid 1990s coinciding with the very rapid rise in popularity of the Ascomycota, Actinobacteria and the Cyanobacteria. The Cnidaria have steadily increased in popularity across the years and while the phyla Rhodophyta, Ochrophyta, Echinodermata and Mollusca were as popular as the Porifera in the early years, interest waned in later years. The popularity of these phyla in earlier years may have been a reflection of the relative ease of collection by snorkeling and shore-wading as in the 1960s and 1970s SCUBA diving was more of a specialist technique. The numeric totals for the 50 years of collection are given in Table 1 along with the percentage contribution of each phylum to the marine literature. For the 50 years period from 1963 9220 papers have reported the isolation of 24 662 new compounds. These 9220 papers constitute 37% of the total papers in MarinLit.[77] The other 17 284 papers are associated with topics such as reviews, syntheses, stereochemistry, corrections of structure or stereochemistry, bioactivities, and ecological surveys. Other data shown in Table 1 include the numbers of compounds reported/phylum over the 50 years period as well as the % contributions each phylum has made to the number of papers reporting new compounds or the number of compounds. These relative proportions are comparable as the number of isolated compounds reported/paper is 2–3 across most of the phyla. Also included are the *recognised* totals of species/phylum from the World Register of Marine Species (WORMS),[982] allowing comparison of the numbers of samples of each phylum collected with the actual number of recognised species. This comparison should be used carefully as multiple collections of the *same* species have been made, or the sample may have only been identified to the genus level. However the comparison does offer insights into the coverage of each phylum. This point is emphasised by considering the various contributions the most studied genus for each phylum has made. For example, for

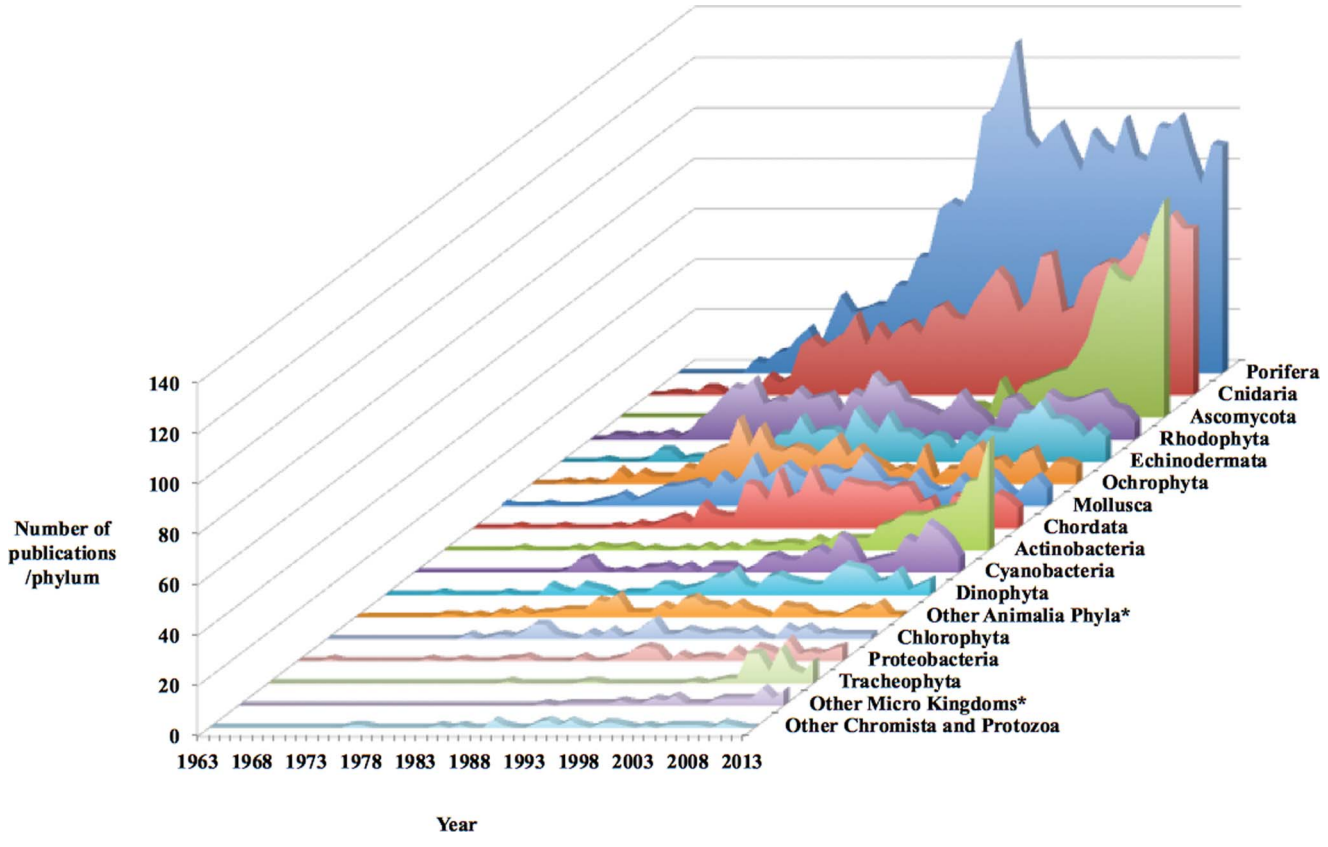


Fig. 1 The phylum-preferences of the marine natural product research community across a 50-year period from 1963.

Table 1 The numeric totals and percentage contribution of each phylum to the marine literature over a 50 years period from 1963. Also included are the numbers of compounds reported/phylum, the % contributions each phylum has made and the recognised totals of species/phylum from the World Register of Marine Species[a]

	Kingdom	Number of genera	Most studied genus	Number of papers and compounds from the most studied genus	Papers/phylum	% MLit papers with new compounds	Compounds/phylum	% of MLit	Compounds	Compounds/paper	Number of recognised species
Animalia	Annelida	13	*Odontosyllis*	5	12	24	0.3%	46	0.2%	1.9	2640
	Arthropoda	8	*Megabalanus*	2	2	9	0.1%	10	0.0%	1.1	6216
	Bryozoa	24	*Bugula*	19	33	86	0.9%	199	0.8%	2.3	6036
	Chordata	66	*Didemnum*	54	144	434	4.7%	1102	4.5%	2.5	1898
	Cnidaria	161	*Sinularia*	234	678	1589	17.2%	4949	20.1%	3.1	10 839
	Echinodermata	136	*Asterias*	35	69	493	5.3%	1335	5.4%	2.7	295
	Hemichordata	3	*Cephalodiscus*	9	19	11	0.1%	27	0.1%	2.5	30
	Mollusca	116	*Aplysia*	87	184	468	5.1%	1095	4.4%	2.3	44 233
	Nematoda	2	*Amphiporus*	1	1	2	0.0%	2	0.0%	1.0	6997
	Platyhelminthes	3	*Amphiscolops*	2	2	3	0.0%	6	0.0%	2.0	11 836
	Porifera	285	*Dysidea*	163	418	2991	32.4%	8152	33.1%	2.7	8320
Archaea	Euryarchaeota	1	*Thermococcus*	2	24	2	0.0%	24	0.1%	12.0	98
Bacteria	Actinobacteria	28	*Streptomyces*	201	465	322	3.5%	778	3.2%	2.4	72
	Bacteroidetes	9	*Rapidithrix*	3	4	12	0.1%	24	0.1%	2.0	235
	Cyanobacteria	28	*Lyngbya*	140	283	234	2.5%	484	2.0%	2.1	436
	Firmicutes	5	*Bacillus*	43	94	47	0.5%	101	0.4%	2.1	96
	Proteobacteria	38	*Pseudomonas*	16	33	110	1.2%	225	0.9%	2.0	772
Chromista	Bacillariophyta	7	*Rhizosolenia*	2	7	10	0.1%	24	0.1%	2.4	2675
	Ciliophora	4	*Euplotes*	8	24	12	0.1%	37	0.2%	3.1	2676
	Cryptophyta	1	*Chrysophaeum*	2	9	2	0.0%	9	0.0%	4.5	91
	Dinophyta	26	*Prorocentrum*	20	27	194	2.1%	297	1.2%	1.5	2194
	Haptophyta	6	*Coccolithus*	2	3	8	0.1%	11	0.0%	1.4	260
	Ochrophyta	57	*Dictyota*	94	249	460	5.0%	1247	5.1%	2.7	5009
Fungi	Ascomycota	129	*Aspergillus*	187	545	783	8.5%	2165	8.8%	2.8	966
Plantae	Chlorophyta	29	*Caulerpa*	30	90	116	1.3%	272	1.1%	2.3	1810
	Rhodophyta	84	*Laurencia*	369	824	672	7.3%	1668	6.8%	2.5	6399
	Tracheophyta	23	*Xylocarpus*	27	119	75	0.8%	253	1.0%	3.4	432
Protozoa	Euglenozoa	1	*Euglena*	1	3	1	0.0%	3	0.0%	3.0	231
	Totals/Averages	1300		1758	4361	9220	100%	24 662	100%	2.7	

[a] In the 28 phyla sampled by MNP chemists WORMS lists 210 892 species. Across all Kingdoms WORMS lists 226 070 marine species.

the Rhodophyta the most studied genus has been *Laurencia*. Even though *Laurencia* is only one of 84 genera studied, this one genus contributed 369 out of the total 672 papers from the Rhodophyta describing new MNPs and was the source of 824 of the 1668 new compounds from this phylum. The important consideration is that even though multiple collections of the same genus/species may have been made, the same genus or species at different locations is giving rise to a different suite of metabolites. Apart from Porifera and Cyanobacteria, the coverage of most phyla is very limited, although the credibility of the numbers of species recognised by WORMS[982] for the Ascomycota and Actinobacteria is probably suspect as much of the micro-world has yet to be fully recognised. Over the past 50 years MNP chemists have studied samples collected from 1300 genera across 28 phyla. These 28 phyla represent an estimated (WORMS) 210 892 marine species out of an estimated total of 224 070 for all marine phyla.[982] In other words MNP chemists have collected widely, but perhaps thinly across the Kingdoms. The Kingdom Virus (119 representatives) has not been sampled at all by MNP chemists and so has been excluded from consideration. As chemists we have published 9220 papers over the past 50 years describing new compounds from these 28 phyla. But, in fact, the 9220 papers describe compounds elicited from just 2657 *named* species with another 2485 occurrences across 484 genera that are only described as sp. So, the number of distinct species studied is a long way short of 9220. This nicely emphasises the point that there is still an enormous MNP resource waiting to be explored; probably in excess of 200 000 species still to be evaluated.

16 Acknowledgements

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17 References

1 J. W. Blunt, B. R. Copp, R. A. Keyzers, M. H. G. Munro and M. R. Prinsep, *Nat. Prod. Rep.*, 2014, **31**, 160–258.
2 J. W. Blunt, B. R. Copp, R. A. Keyzers, M. H. G. Munro and M. R. Prinsep, *Nat. Prod. Rep.*, 2013, **30**, 237–323.
3 R. A. Hill, *Annu. Rep. Prog. Chem., Sect. B: Org. Chem.*, 2013, **109**, 146–166.
4 A. M. S. Mayer, A. D. Rodríguez, O. Taglialatela-Scafati and N. Fusetani, *Mar. Drugs*, 2013, **11**, 2510–2573.
5 G. M. Cragg and D. J. Newman, *Biochim. Biophys. Acta*, 2013, **1830**, 3670–3695.
6 J. Khazir, B. A. Mir, S. A. Mir and D. Cowan, *J. Asian Nat. Prod. Res.*, 2013, **15**, 764–788.
7 S. Vinothkumar and P. S. Parameswaran, *Biotechnol. Adv.*, 2013, **31**, 1826–1845.
8 P. M. Murray, S. Moane, C. Collins, T. Beletskaya, O. P. Thomas, A. W. F. Duarte, F. S. Nobre, I. O. Owoyemi, F. C. Pagnocca, L. D. Sette, E. McHugh, E. Causse, P. Pérez-López, G. Feijoo, M. T. Moreira, J. Rubiolo, M. Leirós, L. M. Botana, S. Pinteus, C. Alves, A. Horta, R. Pedrosa, C. Jeffryes, S. N. Agathos, C. Allewaert, A. Verween, W. Vyverman, I. Laptev, S. Sineoky, A. Bisio, R. Manconi, F. Ledda, M. Marchi, R. Pronzato and D. J. Walsh, *New Biotechnol.*, 2013, **30**, 839–850.
9 Y.-X. Li, S. W. A. Himaya and S.-K. Kim, *Molecules*, 2013, **18**, 7886–7909.
10 C. Gao, X. Yi, R. Huang, F. Yan, B. He and B. Chen, *Chem. Biodiversity*, 2013, **10**, 1435–1447.
11 M. Menna, C. Imperatore, F. D'Aniello and A. Aiello, *Mar. Drugs*, 2013, **11**, 1602–1643.
12 M. Pelay-Gimeno, J. Tulla-Puche and F. Albericio, *Mar. Drugs*, 2013, **11**, 1693–1717.
13 N. E. Golantsov, A. A. Festa, A. V. Karchava and M. A. Yurovskaya, *Chem. Heterocycl. Compd.*, 2013, **49**, 203–225.
14 A. Lorente, J. Lamariano-Merketegi, F. Albericio and M. Álvarez, *Chem. Rev.*, 2013, **113**, 4567–4610.
15 Y. Li, L. Liang, W. Xiao, J. Liang and Y. Guo, *Chin. J. Org. Chem.*, 2013, **33**, 1157–1166.
16 L.-F. Liang and Y.-W. Guo, *Chem. Biodiversity*, 2013, **10**, 2161–2195.
17 F. Desriac, C. Jégou, E. Balnois, B. Brillet, P. Le Chevalier and Y. Fleury, *Mar. Drugs*, 2013, **11**, 3632–3660.
18 V. L. Trainer, L. Moore, B. D. Bill, N. G. Adams, N. Harrington, J. Borchert, D. A. M. da Silva and B.-T. L. Eberhart, *Mar. Drugs*, 2013, **11**, 1815–1835.
19 V. Gouveia, A. M. L. Seca, M. C. Barreto and D. C. G. A. Pinto, *Mini-Rev. Med. Chem.*, 2013, **13**, 1150–1159.
20 B.-G. Wang, J. B. Gloer, N.-Y. Ji and J.-C. Zhao, *Chem. Rev.*, 2013, **113**, 3632–3685.
21 J. A. R. Salvador, J. F. S. Carvalho, M. A. C. Neves, S. M. Silvestre, A. J. Leitão, M. M. C. Silva and M. L. Sá e Melo, *Nat. Prod. Rep.*, 2013, **30**, 324–374.
22 L. Wang, B. Yang, X.-P. Lin, X.-F. Zhou and Y. Liu, *Nat. Prod. Rep.*, 2013, **30**, 455–473.
23 L. M. Blair and J. Sperry, *J. Nat. Prod.*, 2013, **76**, 794–812.
24 Z. Jin, *Nat. Prod. Rep.*, 2013, **30**, 869–915.
25 A. Wang, Z. Zhao, X. Zheng and H. Cao, *Chin. J. Org. Chem.*, 2013, **33**, 483–491.
26 K. D. Cusick and G. S. Sayler, *Mar. Drugs*, 2013, **11**, 991–1018.
27 A. ElMarrouni, A. Kolleth, R. Lebeuf, J. Gebauer, S. Prevost, M. Heras, S. Arseniyadis and J. Cossy, *Nat. Prod. Commun.*, 2013, **8**, 965–972.
28 Z. Qin, S. Huang, Y. Yu and H. Deng, *Mar. Drugs*, 2013, **11**, 3970–3997.
29 V. Valdiglesias, M. V. Prego-Faraldo, E. Pásaro, J. Méndez and B. Laffon, *Mar. Drugs*, 2013, **11**, 4328–4349.
30 D. L. J. Clive and P. Cheng, *Tetrahedron*, 2013, **69**, 5067–5078.
31 H. Abida, S. Ruchaud, L. Rios, A. Humeau, I. Probert, C. De Vargas, S. Bach and C. Bowler, *Mar. Drugs*, 4594, **11**, 4594–4611.
32 R. Subramani and W. Aalbersberg, *Appl. Microbiol. Biotechnol.*, 2013, **97**, 9291–9321.
33 J. Vicente, A. Stewart, B. Song, R. T. Hill and J. L. Wright, *Mar. Biotechnol.*, 2013, **15**, 413–424.

34 J.-R. Wang, W.-F. He and Y.-W. Guo, *J. Asian Nat. Prod. Res.*, 2013, **15**, 185–197.
35 P. Manivasagan, J. Venkatesan, K. Sivakumar and S.-K. Kim, *Microbiol. Res.*, 2013, **168**, 311–332.
36 Y. K. Ng, A. K. Hewavitharana, R. Webb, P. N. Shaw and J. A. Fuerst, *Appl. Microbiol. Biotechnol.*, 2013, **97**, 3097–3108.
37 L. T. Tan, *Drug Discovery Today*, 2013, **18**, 863–871.
38 C. Zhao, T. Zhu and W. Zhu, *Chin. J. Org. Chem.*, 2013, **33**, 1195–1234.
39 Z.-Q. Xiong, J.-F. Wang, Y.-Y. Hao and Y. Wang, *Mar. Drugs*, 2013, **11**, 700–717.
40 W. H. Gerwick and A. M. Fenner, *Microb. Ecol.*, 2013, **65**, 800–806.
41 K. Benkendorff, *Mar. Drugs*, 2013, **11**, 1370–1398.
42 K. Osako and V. L. Teixeira, *Nat. Prod. Commun.*, 2013, **8**, 533–538.
43 Y. M. Lee, M. J. Kim, H. Li, P. Zhang, B. Bao, K. J. Lee and J. H. Jung, *Mar. Biotechnol.*, 2013, **15**, 499–519.
44 M. A. M. Mondol, H. J. Shin and M. T. Islam, *Mar. Drugs*, 2013, **11**, 2846–2872.
45 W.-C. Wei, P.-J. Sung, C.-Y. Duh, B.-W. Chen, J.-H. Sheu and N.-S. Yang, *Mar. Drugs*, 2013, **11**, 4083–4126.
46 J.-A. Kim and S.-K. Kim, *Curr. Protein Pept. Sci.*, 2013, **14**, 177–182.
47 A. J. Jones, T. Grkovic, M. L. Sykes and V. M. Avery, *Mar. Drugs*, 2013, **11**, 4058–4082.
48 R. Pangestuti and S.-K. Kim, *Food Sci. Biotechnol.*, 2013, **22**, 1175–1186.
49 S. Indumathy and C. R. Dass, *J. Pharm. Pharmacol.*, 2013, **65**, 1280–1301.
50 K. Petit and J. F. Biard, *Anti-Cancer Agents Med. Chem.*, 2013, **13**, 603–631.
51 W. R. Sawadogo, M. Schumacher, M. H. Teiten, C. Cerella, M. Dicato and M. Diederich, *Molecules*, 2013, **18**, 3641–3673.
52 B. Pejin, K. K. Jovanovic, M. Mojovic and A. G. Savic, *Curr. Top. Med. Chem.*, 2013, **13**, 2745–2766.
53 S. B. Bharate, S. D. Sawant, P. P. Singh and R. A. Vishwakarma, *Chem. Rev.*, 2013, **113**, 6761–6815.
54 M.-G. Zhong, Y.-F. Xiang, X.-X. Qiu, Z. Liu, K. Kitazato and Y.-F. Wang, *RSC Adv.*, 2013, **3**, 313–328.
55 X. Zhou, J. Liu, B. Yang, X. Lin, X.-W. Yang and Y. Liu, *Curr. Med. Chem.*, 2013, **20**, 953–973.
56 Y.-Q. Wang and Z.-H. Miao, *Mar. Drugs*, 2013, **11**, 903–933.
57 P. A. Harnedy and R. J. FitzGerald, *Curr. Protein Pept. Sci.*, 2013, **14**, 162–172.
58 R. Nasri and M. Nasri, *Curr. Protein Pept. Sci.*, 2013, **14**, 199–204.
59 V. L. T. Hoang and S.-K. Kim, *Curr. Protein Pept. Sci.*, 2013, **14**, 205–211.
60 T. Solov'eva, V. Davydova, I. Krasikova and I. Yermak, *Mar. Drugs*, 2013, **11**, 2216–2229.
61 J.-T. Liu, X.-L. Lu, X.-Y. Liu, Y. Gao, B. Hu, B.-H. Jiao and H. Zheng, *Mini-Rev. Med. Chem.*, 2013, **13**, 617–626.
62 J. S. Roy, K. L. Poulson-Ellestad, R. D. Sieg, R. X. Poulin and J. Kubanek, *Nat. Prod. Rep.*, 2013, **30**, 1364–1379.
63 A. Holland and S. Kinnear, *Mar. Drugs*, 2013, **11**, 2239–2258.
64 J. C. Morris, *Nat. Prod. Rep.*, 2013, **30**, 783–805.
65 M. Gordaliza and P. G. Baraldi, *Curr. Med. Chem.*, 2013, **20**, 2798–2811.
66 T. Nishikawa and M. Isobe, *Chem. Rec.*, 2013, **13**, 286–302.
67 I. Paterson, P. Maltas and E. A. Anderson, *Pure Appl. Chem.*, 2013, **85**, 1133–1147.
68 W. P. Unsworth and R. J. K. Taylor, *Org. Biomol. Chem.*, 2013, **11**, 7250–7261.
69 S. U. Kadam, B. K. Tiwari and C. P. O'Donnell, *J. Agric. Food Chem.*, 2013, **61**, 4667–4675.
70 D. Forner, F. Berrué, H. Correa, K. Duncan and R. G. Kerr, *Anal. Chim. Acta*, 2013, **805**, 70–79.
71 Y. Inokuma, S. Yoshioka, J. Ariyoshi, T. Arai, Y. Hitora, K. Takada, S. Matsunaga, K. Rissanen and M. Fujita, *Nature*, 2013, **495**, 461–466.
72 Y. Inokuma, S. Yoshioka, J. Ariyoshi, T. Arai, Y. Hitora, K. Takada, S. Matsunaga, K. Rissanen and M. Fujita, *Nature*, 2013, **501**, 262.
73 Y. Zhang, S. Xiao, L. Sun, Z. Ge, F. Fang, W. Zhang, Y. Wang and Y. Cheng, *Anal. Chim. Acta*, 2013, **777**, 49–56.
74 J. Y. Yang, L. M. Sanchez, C. M. Rath, X. Liu, P. D. Boudreau, N. Bruns, E. Glukhov, A. Wodtke, R. de Felicio, A. Fenner, W. R. Wong, R. G. Linington, L. Zhang, H. M. Debonsi, W. H. Gerwick and P. C. Dorrestein, *J. Nat. Prod.*, 2013, **76**, 1686–1699.
75 V. Gupta, R. S. Thakur, C. R. K. Reddy and B. Jha, *RSC Adv.*, 2013, **3**, 7037–7047.
76 M. C. Leal, M. H. G. Munro, J. W. Blunt, J. Puga, B. Jesus, R. Calado, R. Rosa and C. Madeira, *Nat. Prod. Rep.*, 2013, **30**, 1380–1390.
77 M. C. Leal, R. Calado, C. Sheridan, A. Alimonti and R. Osinga, *Trends Biotechnol.*, 2013, **31**, 555–561.
78 http://pubs.rsc.org/marinlit.
79 T. P. Wyche, M. Standiford, Y. Hou, D. Braun, D. A. Johnson, J. A. Johnson and T. S. Bugni, *Mar. Drugs*, 2013, **11**, 5089–5099.
80 Y. Hu, M. B. Potts, D. Colosimo, M. L. Herrera-Herrera, A. G. Legako, M. Yousufuddin, M. A. White and J. B. MacMillan, *J. Am. Chem. Soc.*, 2013, **135**, 13387–13392.
81 H. J. Shin, F. S. Tareq, J. H. Kim, M. A. Lee, H.-S. Lee, Y.-J. Lee and J.-S. Lee, *Heterocycles*, 2013, **87**, 307–318.
82 R. W. Phelan, M. Barret, P. D. Cotter, P. M. O'Connor, R. Chen, J. P. Morrissey, A. D. W. Dobson, F. O'Gara and T. M. Barbosa, *Mar. Drugs*, 2013, **11**, 1878–1898.
83 M. A. M. Mondol, F. S. Tareq, J. H. Kim, M. A. Lee, H.-S. Lee, Y.-J. Lee, J. S. Lee and H. J. Shin, *J. Nat. Prod.*, 2011, **74**, 2582–2587.
84 M. A. M. Mondol, F. S. Tareq, J. H. Kim, M. A. Lee, H.-S. Lee, J. S. Lee, Y.-J. Lee and H. J. Shin, *J. Antibiot.*, 2013, **66**, 89–95.
85 T. A. Mansoor, J. Hong, C.-O. Lee, S.-J. Bae, K. S. Im and J. H. Jung, *J. Nat. Prod.*, 2005, **68**, 331–336.
86 X. Yang, Y. Shimizu, J. R. Steiner and J. Clardy, *Tetrahedron Lett.*, 1993, **34**, 761–764.
87 S. Felder, S. Kehraus, E. Neu, G. Bierbaum, T. F. Schäberle and G. M. König, *ChemBioChem*, 2013, **14**, 1363–1371.

88 S. Felder, S. Dreisigacker, S. Kehraus, E. Neu, G. Bierbaum, P. R. Wright, D. Menche, T. F. Schäberle and G. M. König, *Chem.–Eur. J.*, 2013, **19**, 9319–9324.
89 N. F. Montalvo, N. M. Mohamed, J. J. Enticknap and R. T. Hill, *Antonie van Leeuwenhoek*, 2005, **87**, 29–36.
90 J. Martín, T. d. S. Sousa, G. Crespo, S. Palomo, I. González, J. R. Tormo, M. de la Cruz, M. Anderson, R. T. Hill, F. Vicente, O. Genilloud and F. Reyes, *Mar. Drugs*, 2013, **11**, 387–398.
91 C. Hernandez, M. Librada, F. Romero Millan, A. Fernandez Medarde, R. I. Fernandez Chimeno and J. C. Hidalgo Villar, PCT Int. Appl., WO 2012062906 A1 20120518, 2012.
92 G. B. Mahajan, S. D. George, P. V. Ranadive, P. D. S. Mishra, S. S. Eyyammadichiyil, R. M. Panshikar, S. N. Sawant, S. Krishna, M. Sivakumar, K. Pari, B. M. Thomas, Z. E. Patel, R. Vishwakarma, C. G. Naik, L. D'Souza and P. Devi, PCT Int. Appl., WO 2007119201, A2 20071025, 2007.
93 S. Palomo, I. Gonzalez, M. de la Cruz, J. Martín, J. R. Tormo, M. Anderson, R. T. Hill, F. Vicente, F. Reyes and O. Genilloud, *Mar. Drugs*, 2013, **11**, 1071–1086.
94 X. Just-Baringo, P. Bruno, L. K. Ottesen, L. M. Cañedo, F. Albericio and M. Álvarez, *Angew. Chem., Int. Ed.*, 2013, **52**, 7818–7821.
95 S. Carlson, L. Marler, S.-J. Nam, B. D. Santarsiero, J. M. Pezzuto and B. T. Murphy, *Mar. Drugs*, 2013, **11**, 1152–1161.
96 F. Peng, C. Wang, Y. Xie, H. Jiang, L. Chen, P. Uribe, A. T. Bull, M. Goodfellow, H. Jiang and Y. Lian, *Nat. Prod. Res.*, 2013, **27**, 1366–1371.
97 D. W. Udwary, L. Zeigler, R. N. Asolkar, V. Singan, A. Lapidus, W. Fenical, P. R. Jensen and B. S. Moore, *Proc. Natl. Acad. Sci. U. S. A.*, 2007, **104**, 10376–10381.
98 E. J. Skellam, A. K. Stewart, W. K. Strangman and J. L. C. Wright, *J. Antibiot.*, 2013, **66**, 431–441.
99 K. W. Blake and P. G. Sammes, *J. Chem. Soc. C*, 1970, 980–984.
100 Y. Macherla, poster, *3rd Europ. Conf. Marine Nat. Prod.*, Elmau Castle, Germany, 2002.
101 J. Bryans, P. Charlton, I. Chicarelli-Robinson, M. Collins, R. Faint, C. Latham, I. Shaw and S. Trew, *J. Antibiot.*, 1996, **49**, 1014–1021.
102 Q. Zhang, S. Li, Y. Chen, X. Tian, H. Zhang, G. Zhang, Y. Zhu, S. Zhang, W. Zhang and C. Zhang, *J. Antibiot.*, 2013, **66**, 31–36.
103 I. Schneemann, B. Ohlendorf, H. Zinecker, K. Nagel, J. Wiese and J. F. Imhoff, *J. Nat. Prod.*, 2010, **73**, 1444–1447.
104 Z. Lin, J. P. Torres, M. A. Ammon, L. Marett, R. W. Teichert, C. A. Reilly, J. C. Kwan, R. W. Hughen, M. Flores, M. D. Tianero, O. Peraud, J. E. Cox, A. R. Light, A. J. L. Villaraza, M. G. Haygood, G. P. Concepcion, B. M. Olivera and E. W. Schmidt, *Chem. Biol.*, 2013, **20**, 73–81.
105 M. C. Kim, O.-W. Kwon, J.-S. Park, S. Y. Kim and H. C. Kwon, *Chem. Pharm. Bull.*, 2013, **61**, 511–515.
106 P. Fu, P. Liu, Q. Gong, Y. Wang, P. Wang and W. Zhu, *RSC Adv.*, 2013, **3**, 20726–20731.
107 R. Raju, A. M. Piggott, X.-C. Huang and R. J. Capon, *Org. Lett.*, 2011, **13**, 2770–2773.
108 R. Raju, A. M. Piggott, M. Conte, Z. Tnimov, K. Alexandrov and R. J. Capon, *Chem.–Eur. J.*, 2010, **16**, 3194–3200.
109 R. Raju, A. M. Piggott, M. Quezada and R. J. Capon, *Tetrahedron*, 2013, **69**, 692–698.
110 Z. Wang, P. Fu, P. Liu, P. Wang, J. Hou, W. Li and W. Zhu, *Chem. Biodiversity*, 2013, **10**, 281–287.
111 Z.-C. Wu, S. Li, S.-J. Nam, Z. Liu and C. Zhang, *J. Nat. Prod.*, 2013, **76**, 694–701.
112 N. I. Kalinovskaya, L. A. Romanenko, A. I. Kalinovsky, P. S. Dmitrenok and S. A. Dyshlovoy, *Nat. Prod. Commun.*, 2013, **8**, 381–384.
113 L. Kjaerulff, A. Nielsen, M. Mansson, L. Gram, T. O. Larsen, H. Ingmer and C. H. Gotfredsen, *Mar. Drugs*, 2013, **11**, 5051–5062.
114 H. K. Zane and A. Butler, *J. Nat. Prod.*, 2013, **76**, 648–654.
115 D.-C. Oh, P. G. Williams, C. A. Kauffman, P. R. Jensen and W. Fenical, *Org. Lett.*, 2006, **8**, 1021–1024.
116 A. L. Lane, S.-J. Nam, T. Fukuda, K. Yamanaka, C. A. Kauffman, P. R. Jensen, W. Fenical and B. S. Moore, *J. Am. Chem. Soc.*, 2013, **135**, 4171–4174.
117 C. M. Woo, N. E. Beizer, J. E. Janso and S. B. Herzon, *J. Am. Chem. Soc.*, 2012, **134**, 15285–15288.
118 C. M. Woo, S. L. Gholap and S. B. Herzon, *J. Nat. Prod.*, 2013, **76**, 1238–1241.
119 X.-W. Yang, G.-Y. Zhang, J.-X. Ying, B. Yang, X.-F. Zhou, A. Steinmetz, Y.-H. Liu and N. Wang, *Mar. Drugs*, 2013, **11**, 33–39.
120 A. I. M. Khedr, I. Kouno, T. Tanaka and K. Yamada, *Heterocycles*, 2013, **87**, 1029–1037.
121 X.-Y. Lian and Z. Zhang, *Nat. Prod. Res.*, 2013, **27**, 2161–2167.
122 A. Yang, L. Si, Z. Shi, L. Tian, D. Liu, D. Zhou, P. Proksch and W. Lin, *Org. Lett.*, 2013, **15**, 5366–5369.
123 Y. Song, H. Huang, Y. Chen, J. Ding, Y. Zhang, A. Sun, W. Zhang and J. Ju, *J. Nat. Prod.*, 2013, **76**, 2263–2268.
124 N. Liu, F. Shang, L. Xi and Y. Huang, *Mar. Drugs*, 2013, **11**, 1524–1533.
125 A. D. Batcho and W. Leimgruber, U.S. Pat., US 3524849 A 19700818, 1970.
126 M. R. Pena and J. K. Stille, *J. Am. Chem. Soc.*, 1989, **111**, 5417–5424.
127 R. H. Jiao, H. Xu, J. T. Cui, H. M. Ge and R. X. Tan, *J. Appl. Microbiol.*, 2013, **114**, 1046–1053.
128 I. Djinni, A. Defant, M. Kecha and I. Mancini, *Mar. Drugs*, 2013, **11**, 124–135.
129 S. T. Khan, H. Komaki, K. Motohashi, I. Kozone, A. Mukai, M. Takagi and K. Shin-ya, *Environ. Microbiol.*, 2011, **13**, 391–403.
130 M. Izumikawa, T. Kawahara, J.-H. Hwang, M. Takagi and K. Shin-Ya, *Biosci., Biotechnol., Biochem.*, 2013, **77**, 663–665.
131 S. Imai, A. Shimazu, K. Furihata, K. Furihata, Y. Hayakawa and H. Seto, *J. Antibiot.*, 1990, **43**, 1606–1607.
132 P. B. Gomes, M. Nett, H.-M. Dahse and C. Hertweck, *J. Nat. Prod.*, 2010, **73**, 1461–1464.

133 A. Zeeck, S. Breiding-Mack, S. Grabley, H. Voelskow and G. Seibert, Eur. Pat. Appl., EP 260486 A1 19880323, 1998.
134 J. Ren, D. Liu, L. Tian, Y. Wei, P. Proksch, J. Zeng and W. Lin, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 301–304.
135 Z.-Y. You, Y.-H. Wang, Z.-G. Zhang, M.-J. Xu, S.-J. Xie, T.-S. Han, L. Feng, X.-G. Li and J. Xu, *Mar. Drugs*, 2013, **11**, 4035–4049.
136 P. Fu, F. Kong, Y. Wang, Y. Wang, P. Liu, G. Zuo and W. Zhu, *Chin. J. Chem.*, 2013, **31**, 100–104.
137 X. Alvarez–Mico, P. R. Jensen, W. Fenical and C. C. Hughes, *Org. Lett.*, 2013, **15**, 988–991.
138 S. M. Mantovani and B. S. Moore, *J. Am. Chem. Soc.*, 2013, **135**, 18032–18035.
139 H. Kanzaki, S. Yanagisawa and T. Nitoda, *J. Antibiot.*, 2000, **53**, 1257–1264.
140 R. Brown, C. Kelley and S. E. Wiberley, *J. Org. Chem.*, 1965, **30**, 277–280.
141 P. Wang, L. Xi, P. Liu, Y. Wang, W. Wang, Y. Huang and W. Zhu, *Mar. Drugs*, 2013, **11**, 1035–1049.
142 C. Chen, J. Wang, H. Guo, W. Hou, N. Yang, B. Ren, M. Liu, H. Dai, X. Liu, F. Song and L. Zhang, *Appl. Microbiol. Biotechnol.*, 2013, **97**, 3885–3892.
143 T. A. Knappe, U. Linne, S. Zirah, S. Rebuffat, X. Xie and M. A. Marahiel, *J. Am. Chem. Soc.*, 2008, **130**, 11446–11454.
144 S. Um, Y.-J. Kim, H. Kwon, H. wen, S.-H. Kim, H. C. Kwon, S. Park, J. Shin and D.-C. Oh, *J. Nat. Prod.*, 2013, **76**, 873–879.
145 K. Shiomi, H. Iinuma, M. Hamada, H. Naganawa, M. Manabe, C. Matsuki, T. Takeuchi and H. Umezawa, *J. Antibiot.*, 1986, **39**, 487–493.
146 K. Shiomi, H. Nakamura, H. Iinuma, H. Naganawa, T. Takeuchi, H. Umezawa and Y. Iitaka, *J. Antibiot.*, 1987, **40**, 1213–1219.
147 Y.-B. Cheng, P. R. Jensen and W. Fenical, *Eur. J. Org. Chem.*, 2013, **18**, 3751–3757.
148 Z. Wu, S. Li, J. Li, Y. Chen, K. Saurav, Q. Zhang, H. Zhang, W. Zhang, W. Zhang, S. Zhang and C. Zhang, *Mar. Drugs*, 2013, **11**, 2113–2125.
149 Y. Igarashi, T. Iida, K. Miyanochi and Y. Sudo, Jpn. Kokai Tokkyo Koho, JP 2011010586 A 20110120, 2011.
150 K. H. Jang, S.-J. Nam, J. B. Locke, C. A. Kauffman, D. S. Beatty, L. A. Paul and W. Fenical, *Angew. Chem., Int. Ed.*, 2013, **52**, 7822–7824.
151 K. Takada, A. Ninomiya, M. Naruse, Y. Sun, M. Miyazaki, Y. Nogi, S. Okada and S. Matsunaga, *J. Org. Chem.*, 2013, **78**, 6746–6750.
152 A. Pesic, H. I. Baumann, K. Kleinschmidt, P. Ensle, J. Wiese, R. D. Süssmuth and J. F. Imhoff, *Mar. Drugs*, 2013, **11**, 4834–4857.
153 Y. Zhang, X. Zhou, H. Huang, X. Tian, Y. Song, S. Zhang and J. Ju, *J. Antibiot.*, 2013, **66**, 327–331.
154 D. E. Williams, D. S. Dalisay, F. Li, J. Amphlett, W. Maneerat, M. A. G. Chavez, Y. A. Wang, T. Matainaho, W. Yu, P. J. Brown, C. H. Arrowsmith, M. Vedadi and R. J. Andersen, *Org. Lett.*, 2013, **15**, 414–417.
155 S.-J. Nam, C. A. Kauffman, P. R. Jensen and W. Fenical, *Tetrahedron*, 2011, **67**, 6707–6712.
156 S.-J. Nam, C. A. Kauffman, L. A. Paul, P. R. Jensen and W. Fenical, *Org. Lett.*, 2013, **15**, 5400–5403.
157 M. S. Abdelfattah, *Nat. Prod. Res.*, 2013, **27**, 2126–2131.
158 E. Z. Ilan, M. R. Torres, J. Prudhomme, K. Le Roch, P. R. Jensen and W. Fenical, *J. Nat. Prod.*, 2013, **76**, 1815–1818.
159 C. Wu, Y. Tan, M. Gan, Y. Wang, Y. Guan, X. Hu, H. Zhou, X. Shang, X. You, Z. Yang and C. Xiao, *J. Nat. Prod.*, 2013, **76**, 2153–2157.
160 S. Um, T. J. Choi, H. Kim, B. Y. Kim, S.-H. Kim, S. K. Lee, K.-B. Oh, J. Shin and D.-C. Oh, *J. Org. Chem.*, 2013, **78**, 12321–12329.
161 M. Bae, H. Kim, Y. Shin, B. Y. Kim, S. K. Lee, K.-B. Oh, J. Shin and D.-C. Oh, *Mar. Drugs*, 2013, **11**, 2882–2893.
162 H.-Q. Pan, S.-Y. Zhang, N. Wang, Z.-L. Li, H.-M. Hua, J.-C. Hu and S.-J. Wang, *Mar. Drugs*, 2013, **11**, 3891–3901.
163 Y. Igarashi, T. Zhou, S. Sato, T. Matsumoto, L. Yu and N. Oku, *Org. Lett.*, 2013, **15**, 5678–5681.
164 X.-W. Yang, K. Peng, Z. Liu, G.-Y. Zhang, J. Li, N. Wang, A. Steinmetz and Y. Liu, *J. Nat. Prod.*, 2013, **76**, 2360–2363.
165 X. Xu, L. Yin, S. Wang, H. Liu, J. Gao and S. Zhao, *Rec. Nat. Prod.*, 2013, **7**, 292–295.
166 D.-C. Oh, W. K. Strangman, C. A. Kauffman, P. R. Jensen and W. Fenical, *Org. Lett.*, 2007, **9**, 1525–1528.
167 Y. Xu, R. D. Kersten, S.-J. Nam, L. Lu, A. M. Al-Suwailem, H. Zheng, W. Fenical, P. C. Dorrestein, B. S. Moore and P.-Y. Qian, *J. Am. Chem. Soc.*, 2012, **134**, 8625–8632.
168 I. Kaneko, H. Minekura, Y. Takeuchi, K. Kodama, T. Nakamura, H. Haruyama and Y. Sakaida, Japanese Patent, JP 06298796 A 1994.
169 A. C. Ross, Y. Xu, L. Lu, R. D. Kersten, Z. Shao, A. M. Al-Suwailem, P. C. Dorrestein, P.-Y. Qian and B. S. Moore, *J. Am. Chem. Soc.*, 2013, **135**, 1155–1162.
170 S. Um, Y. Pyee, E.-H. Kim, S. K. Lee, J. Shin and D.-C. Oh, *Mar. Drugs*, 2013, **11**, 611–622.
171 X. Li, S. Vanner, W. Wang, Y. Li, V. A. Gallardo and N. A. Magarvey, *J. Antibiot.*, 2013, **66**, 443–446.
172 J. Riedlinger, A. Reicke, H. Zaehner, B. Krismer, A. T. Bull, L. A. Maldonado, A. C. Ward, M. Goodfellow, B. Bister, D. Bischoff, R. D. Süssmuth and H.-P. Fiedler, *J. Antibiot.*, 2004, **57**, 271–279.
173 S. Keller, G. Nicholson, C. Drahl, E. Sorensen, H.-P. Fiedler and R. D. Süssmuth, *J. Antibiot.*, 2007, **60**, 391–394.
174 Q. Wang, F. Song, X. Xiao, P. Huang, L. Li, A. Monte, W. M. Abdel-Mageed, J. Wang, H. Guo, W. He, F. Xie, H. Dai, M. Liu, C. Chen, H. Xu, M. Liu, A. M. Piggott, X. Liu, R. J. Capon and L. Zhang, *Angew. Chem., Int. Ed.*, 2013, **52**, 1231–1234.
175 R. Raju, A. M. Piggott, M. M. Conte and R. J. Capon, *Org. Biomol. Chem.*, 2010, **8**, 4682–4689.
176 R. Sugiyama, S. Nishimura and H. Kakeya, *Tetrahedron Lett.*, 2013, **54**, 1531–1533.
177 K. Motohashi, M. Takagi and K. Shin-ya, *J. Nat. Prod.*, 2010, **73**, 226–228.
178 T. Hosoya, T. Hirokawa, M. Takagi and K. Shin-ya, *J. Nat. Prod.*, 2012, **75**, 285–289.

179 K. Motohashi, M. Takagi and K. Shin-ya, *J. Nat. Prod.*, 2013, **76**, 1230.
180 T. Hosoya, T. Hirokawa, M. Takagi and K. Shin-ya, *J. Nat. Prod.*, 2013, **76**, 1231.
181 T. Kameyama, A. Takahashi, S. Kurasawa, M. Ishizuka, Y. Okami, T. Takeuchi and H. Umezawa, *J. Antibiot.*, 1987, **40**, 1664–1670.
182 A. Takahashi, H. Nakamura, T. Kameyama, S. Kurasawa, H. Naganawa, Y. Okami, T. Takeuchi, H. Umezawa and Y. Iitaka, *J. Antibiot.*, 1987, **40**, 1671–1676.
183 G. Winkelmann, B. Busch, A. Hartmann, G. Kirchhof, R. Sussmuth and G. Jung, *BioMetals*, 1999, **12**, 255–264.
184 M. J. Fujita, K. Nakano and R. Sakai, *Molecules*, 2013, **18**, 3917–3926.
185 Y. Hu, K. Wang and J. B. MacMillan, *Org. Lett.*, 2013, **15**, 390–393.
186 R. D. Shingare, R. Velayudham, J. R. Gawade and D. S. Reddy, *Org. Lett.*, 2013, **15**, 4556–4559.
187 G. Deltour, F. Binon, F. Henaux and R. Charlier, *Arch. Int. Pharmacodyn. Ther.*, 1961, **131**, 84–106.
188 H. Koshima, K. Ding, Y. Chisaka, T. Matsuura, I. Miyahara and K. Hirotsu, *J. Am. Chem. Soc.*, 1997, **119**, 10317–10324.
189 C. Gang, M.-X. Shen, W. Xin, X.-M. Fan, H.-M. Ma, H.-H. Wu and Y.-H. Pei, *Chem. Nat. Compd.*, 2013, **49**, 291–293.
190 K. Hong, G. Yuan, H. Lin, Q. Xie, C. Wang, X. Huang and Y. Tang, Faming Zhuanli Shenqing, CN 101792474 A 20100804, 2010.
191 G. Yuan, K. Hong, H. Lin, Z. She and J. Li, *Mar. Drugs*, 2013, **11**, 817–829.
192 W.-J. Ding, S.-Q. Zhang, J.-H. Wang, Y.-X. Lin, Q.-X. Liang, W.-J. Zhao and C.-Y. Li, *J. Asian Nat. Prod. Res.*, 2013, **15**, 209–214.
193 G. Assante, S. Dallavalle, L. Malpezzi, G. Nasini, S. Burruano and L. Torta, *Tetrahedron*, 2005, **61**, 7686–7692.
194 Suciati, J. A. Fraser, L. K. Lambert, G. K. Pierens, P. V. Bernhardt and M. J. Garson, *J. Nat. Prod.*, 2013, **76**, 1432–1440.
195 D. Li, Q. Gu, G. Zhang and T. Zhu, Faming Zhuanli Shenqing, CN 102001921 A 20110406, 2011.
196 G. Zhang, G. Wu, T. Zhu, T. Kurtán, A. Mándi, J. Jiao, J. Li, X. Qi, Q. Gu and D. Li, *J. Nat. Prod.*, 2013, **76**, 1946–1957.
197 L.-R. Xie, D.-Y. Li, Z.-L. Li, H.-M. Hua, P.-L. Wang and X. Wu, *Nat. Prod. Res.*, 2013, **27**, 847–850.
198 L. Chen, W.-W. Zhang, Q.-H. Zheng, Q.-Y. Liu, P. Zhong, X. Hu, Z.-X. Fang and Q.-Q. Zhang, *Heterocycles*, 2013, **87**, 861–868.
199 O. I. Zhuravleva, S. S. Afiyatullov, E. A. Yurchenko, V. A. Denisenko, N. N. Kirichuk and P. S. Dmitrenok, *Nat. Prod. Commun.*, 2013, **8**, 1071–1074.
200 W. Jiang, P. Ye, C.-T. A. Chen, K. Wang, P. Liu, S. He, X. Wu, L. Gan, Y. Ye and B. Wu, *Mar. Drugs*, 2013, **11**, 4761–4772.
201 G.-X. Zhou, E. M. K. Wijeratne, D. Bigelow, L. S. Pierson III, H. D. VanEtten and A. A. L. Gunatilaka, *J. Nat. Prod.*, 2004, **67**, 328–332.
202 W. Keller-Schierlein and E. Kupfer, *Helv. Chim. Acta*, 1979, **62**, 1501–1524.
203 Z. Lin, T. Zhu, H. Wei, G. Zhang, H. Wang and Q. Gu, *Eur. J. Org. Chem.*, 2009, 3045–3051.
204 T. Tomikawa, K. Shin-Ya, H. Seto, N. Okusa, T. Kajiura and Y. Hayakawa, *J. Antibiot.*, 2002, **55**, 666–668.
205 C.-J. Zheng, C.-L. Shao, L.-Y. Wu, M. Chen, K.-L. Wang, D.-L. Zhao, X.-P. Sun, G.-Y. Chen and C.-Y. Wang, *Mar. Drugs*, 2013, **11**, 2054–2068.
206 X. Liu, F. Song, L. Ma, C. Chen, X. Xiao, B. Ren, X. Liu, H. Dai, A. M. Piggott, Y. Av-Gay, L. Zhang and R. J. Capon, *Tetrahedron Lett.*, 2013, **54**, 6081–6083.
207 G.-Y. Li, B.-G. Li, T. Yang, J.-H. Yin, H.-Y. Qi, G.-Y. Liu and G.-L. Zhang, *J. Nat. Prod.*, 2005, **68**, 1243–1246.
208 K. Arai, T. Yoshimura, Y. Itatani and Y. Yamamoto, *Chem. Pharm. Bull.*, 1983, **31**, 925–933.
209 M. H. Haroon, S. R. Premaratne, M. I. Choudhry and H. R. W. Dharmaratne, *Nat. Prod. Res.*, 2013, **27**, 1060–1066.
210 F. He, J. Bao, X.-Y. Zhang, Z.-C. Tu, Y.-M. Shi and S.-H. Qi, *J. Nat. Prod.*, 2013, **76**, 1182–1186.
211 S. Sureram, C. Kesornpun, C. Mahidol, S. Ruchirawat and P. Kittakoop, *RSC Adv.*, 2013, **3**, 1781–1788.
212 S. Nozoe, M. Morisaki, K. Fukushima and S. Okuda, *Tetrahedron Lett.*, 1968, **42**, 4457–4458.
213 H.-B. Liu, R. Edrada-Ebel, R. Ebel, Y. Wang, B. Schulz, S. Draeger, W. E. G. Mueller, V. Wray, W.-H. Lin and P. Proksch, *Helv. Chim. Acta*, 2011, **94**, 623–631.
214 X.-H. Liu, F.-P. Miao, M.-F. Qiao, R. H. Cichewicz and N.-Y. Ji, *RSC Adv.*, 2013, **3**, 588–595.
215 K. Yamada, M. Doi, T. Yamada, K. Minoura and A. Numata, *Tennen Yuki Kagobutsu Toronkai Koen Yoshishu*, 2000, **42**, 397–402.
216 K. Nakanishi, M. Doi, Y. Usami, T. Amagata, K. Minoura, R. Tanaka, A. Numata and T. Yamada, *Tetrahedron*, 2013, **69**, 4617–4623.
217 N.-Y. Ji, X.-H. Liu, F.-P. Miao and M.-F. Qiao, *Org. Lett.*, 2013, **15**, 2327–2329.
218 L.-N. Zhou, H.-Q. Gao, S.-X. Cai, T.-J. Zhu, Q.-Q. Gu and D.-H. Li, *Helv. Chim. Acta*, 2011, **94**, 1065–1070.
219 H. Gao, L. Zhou, S. Cai, G. Zhang, T. Zhu, Q. Gu and D. Li, *J. Antibiot.*, 2013, **66**, 539–542.
220 M. N. Oliveira, L. S. Santos, G. M. S. P. Guilhon, A. S. Santos, I. C. S. Ferreira, M. L. Lopes-Junior, M. S. P. Arruda, A. M. R. Marinho, M. N. da Silva, E. Rodrigues-Filho and M. C. F. Oliveira, *J. Braz. Chem. Soc.*, 2011, **22**, 993–996.
221 H.-F. Sun, X.-M. Li, L.-H. Meng, C.-M. Cui, S.-S. Gao, C.-S. Li and B.-G. Wang, *Helv. Chim. Acta*, 2013, **96**, 458–462.
222 R.-R. Sun, F.-P. Miao, J. Zhang, G. Wang, X.-L. Yin and N.-Y. Ji, *Magn. Reson. Chem.*, 2013, **51**, 65–68.
223 J. Peng, X.-Y. Zhang, Z.-C. Tu, X.-Y. Xu and S.-H. Qi, *J. Nat. Prod.*, 2013, **76**, 983–987.
224 S. Tsukamoto, H. Hirota, M. Imachi, M. Fujimuro, H. Onuki, T. Ohta and H. Yokosawa, *Bioorg. Med. Chem. Lett.*, 2005, **15**, 191–194.
225 T. Kuwana, M. Miyazaki, H. Kato and S. Tsukamoto, *Chem. Pharm. Bull.*, 2013, **61**, 105–107.
226 J. Bao, X.-Y. Zhang, X.-Y. Xu, F. He, X.-H. Nong and S.-H. Qi, *Tetrahedron*, 2013, **69**, 2113–2117.

227 Y. Zhou, A. Debbab, A. Mándi, V. Wray, B. Schulz, W. E. G. Müller, M. Kassack, W. Lin, T. Kurtán, P. Proksch and A. H. Aly, *Eur. J. Org. Chem.*, 2013, **5**, 894–906.
228 J. Wang, Z. Lu, P. Liu, Y. Wang, J. Li, K. Hong and W. Zhu, *Planta Med.*, 2012, **78**, 1861–1866.
229 K. A. Miller, S. Tsukamoto and R. M. Williams, *Nat. Chem.*, 2009, **1**, 63–68.
230 H. Kato, T. Yoshida, T. Tokue, Y. Nojiri, H. Hirota, T. Ohta, R. M. Williams and S. Tsukamoto, *Angew. Chem., Int. Ed.*, 2007, **46**, 2254–2256.
231 S. Li, J. M. Finefield, J. D. Sunderhaus, T. J. McAfoos, R. M. Williams and D. H. Sherman, *J. Am. Chem. Soc.*, 2012, **134**, 788–791.
232 M. Chen, C.-L. Shao, X.-M. Fu, R.-F. Xu, J.-J. Zheng, D.-L. Zhao, Z.-G. She and C.-Y. Wang, *J. Nat. Prod.*, 2013, **76**, 547–553.
233 S. Tsukamoto, H. Kato, M. Samizo, Y. Nojiri, H. Onuki, H. Hirota and T. Ohta, *J. Nat. Prod.*, 2008, **71**, 2064–2067.
234 S. Tsukamoto, H. Umaoka, K. Yoshikawa, T. Ikeda and H. Hirota, *J. Nat. Prod.*, 2010, **73**, 1438–1440.
235 J. M. Finefield and R. M. Williams, *J. Org. Chem.*, 2010, **75**, 2785–2789.
236 J. M. Finefield and R. M. Williams, *J. Org. Chem.*, 2013, **78**, 8214.
237 S. Tsukamoto, H. Kato, M. Samizo, Y. Nojiri, H. Ohnuki, H. Hirota and T. Ohta, *J. Nat. Prod.*, 2013, **76**, 1233.
238 S. Tsukamoto, H. Umaoka, K. Yoshikawa, T. Ikeda and H. Hirota, *J. Nat. Prod.*, 2013, **76**, 1232.
239 J. Bao, X.-Y. Xu, X.-Y. Zhang and S.-H. Qi, *Nat. Prod. Commun.*, 2013, **8**, 1127–1128.
240 G. N. Belofsky, P. R. Jensen, M. K. Renner and W. Fenical, *Tetrahedron*, 1998, **54**, 1715–1724.
241 G. Assante, L. Carmada, R. Locci, L. Merlini, G. Nasini and E. Papadopoulos, *J. Agric. Food Chem.*, 1981, **29**, 785–787.
242 X. Xu, F. He, X. Zhang, J. Bao and S. Qi, *Food Chem. Toxicol.*, 2013, **53**, 46–51.
243 X.-Y. Xu, X.-Y. Zhang, F. He, J. Peng, X.-H. Nong and S.-H. Qi, *Nat. Prod. Commun.*, 2013, **8**, 1069–1070.
244 M. F. Elsebai, V. Rempel, G. Schnakenburg, S. Kehraus, C. E. Müller and G. M. König, *ACS Med. Chem. Lett.*, 2011, **2**, 866–869.
245 F. Zhu, G. Y. Chen, J. Wu and J. Pan, *Nat. Prod. Res.*, 2013, **27**, 1960–1964.
246 L.-Y. Zang, W. Wei, T. Wang, Y. Guo, R.-X. Tan and H.-M. Ge, *Nat. Prod. Bioprospect.*, 2012, **2**, 117–120.
247 E. Yoshida, H. Fujimoto, M. Baba and M. Yamazaki, *Tennen Yuki Kagobutsu Toronkai Koen Yoshishu*, 1993, **35**, 290–297.
248 X.-L. Sun, H. Takayanagi, K. Matsuzaki, H. Tanaka, K. Furuhata and S. Omura, *J. Antibiot.*, 1996, **49**, 689–692.
249 N. Jansen, B. Ohlendorf, A. Erhard, T. Bruhn, G. Bringmann and J. F. Imhoff, *Mar. Drugs*, 2013, **11**, 800–816.
250 G. Schlingmann, L. Milne and G. T. Carter, *Tetrahedron*, 2002, **58**, 6825–6835.
251 J. Silber, B. Ohlendorf, A. Labes, A. Erhard and J. F. Imhoff, *Mar. Drugs*, 2013, **11**, 3309–3323.
252 H. Matsumoto, K. Yoshikawa, S. Arihara and T. Miyataka, Jpn. Kokai Tokkyo Koho, JP 2005213144 A 20050811, 2005.
253 Y. Zhao, S.-Q. Li, H.-J. Li and W.-J. Lan, *Chem. Nat. Compd.*, 2013, **49**, 653–656.
254 Y.-M. Ying, W.-G. Shan, L.-W. Zhang, Y. Chen and Z.-J. Zhan, *Helv. Chim. Acta*, 2013, **96**, 2092–2097.
255 H.-J. Li, Y.-L. Xie, Z.-L. Xie, Y. Chen, C.-K. Lam and W.-J. Lan, *Mar. Drugs*, 2012, **10**, 627–638.
256 H. Takazawa and S. Kashino, *Chem. Pharm. Bull.*, 1991, **39**, 555–557.
257 E. Amouzou, W. A. Ayer and L. M. Browne, *J. Nat. Prod.*, 1989, **52**, 1042–1054.
258 F. Bohlmann, E. Inhoffen and P. Herbst, *Chem. Ber.*, 1957, **90**, 1661–1667.
259 H.-J. Li, T. Chen, Y.-L. Xie, W.-D. Chen, X.-F. Zhu and W.-J. Lan, *Mar. Drugs*, 2013, **11**, 551–558.
260 J. Jeon, E. Julianti, H. Oh, W. Park, D.-C. Oh, K.-B. Oh and J. Shin, *Tetrahedron Lett.*, 2013, **54**, 3111–3115.
261 P. Sun, D.-X. Xu, A. Mándi, T. Kurtán, T.-J. Li, B. Schulz and W. Zhang, *J. Org. Chem.*, 2013, **78**, 7030–7047.
262 L. Sun, D. Li, M. Tao, Y. Chen, Q. Zhang, F. Dan and W. Zhang, *Nat. Prod. Res.*, 2013, **27**, 1298–1304.
263 T. Amagata, M. Tanaka, T. Yamada, K. Minoura and A. Numata, *J. Nat. Prod.*, 2008, **71**, 340–345.
264 T. Amagata, M. Tanaka, T. Yamada, Y.-P. Chen, K. Minoura and A. Numata, *Tetrahedron Lett.*, 2013, **54**, 5960–5962.
265 J. Sanz, A. C. Soria and M. C. Garcia-Vallejo, *J. Chromatogr. A*, 2004, **1024**, 139–146.
266 K. Mori, *Agric. Biol. Chem.*, 1976, **40**, 1617–1619.
267 H. Zhu, X. Hua, T. Gong, J. Pang, Q. Hou and P. Zhu, *Phytochem. Lett.*, 2013, **6**, 392–396.
268 A. N. Yurchenko, O. F. Smetanina, Y. V. Khudyakova, N. N. Kirichuk, E. L. Chaikina, M. M. Anisimov and S. S. Afiyatullov, *Chem. Nat. Compd.*, 2013, **49**, 857–860.
269 S. B. Singh, D. L. Zink, G. F. Bills, A. Teran, K. C. Silverman, R. B. Lingham, P. Felock and D. J. Hazuda, *Bioorg. Med. Chem. Lett.*, 2003, **13**, 713–717.
270 K. Koyama, K. Kinoshita, N. Hamada, S. Natori and Y. Iitaka, *Tennen Yuki Kagobutsu Toronkai Koen Yoshishu*, 1987, **29**, 713–720.
271 X. Kong, X. Ma, Y. Xie, S. Cai, T. Zhu, Q. Gu and D. Li, *Arch. Pharmacal Res.*, 2013, **36**, 739–744.
272 A. Eamvijarn, N. M. Gomes, T. Dethoup, J. Buaruang, L. Manoch, A. Silva, M. Pedro, I. Marini, V. Roussis and A. Kijjoa, *Tetrahedron*, 2013, **49**, 8583–8591.
273 N. Xu, Y. Cao, L. Wang, G. Chen and Y.-H. Pei, *J. Asian Nat. Prod. Res.*, 2013, **15**, 731–736.
274 F.-T. Sun, G. Chen, J. Bai, W. Li and Y.-H. Pei, *J. Asian Nat. Prod. Res.*, 2012, **14**, 1109–1115.
275 Z. Mosadeghzad, Z. Zuriati, A. Asmat, U. Gires, R. Wickneswari, P. Pittayakhajonwut and G. H. N. Farahani, *Chem. Nat. Compd.*, 2013, **49**, 621–625.
276 C.-Y. An, X.-M. Li, C.-S. Li, S.-S. Gao, Z. Shang and B.-G. Wang, *Helv. Chim. Acta*, 2013, **96**, 682–687.
277 P. Wang, D. Li, L. Xie, X. Wu, H. Hua and Z. Li, *Nat. Prod. Commun.*, 2013, **8**, 1397–1398.

278 S. Shen, W. Li and J. Wang, *Nat. Prod. Res.*, 2013, **27**, 2286–2291.
279 Y.-L. Sun, J. Bao, K.-S. Liu, X.-Y. Zhang, F. He, Y.-F. Wang, X.-H. Nong and S.-H. Qi, *Planta Med.*, 2013, **79**, 1474–1479.
280 T. Sassa, H. Kachi and M. Nukina, *J. Antibiot.*, 1985, **38**, 439–441.
281 M. Imran, L. Mitu, S. Latif, Z. Mahmood, I. Naimat, S. S. Zaman and S. Fatima, *J. Serb. Chem. Soc.*, 2010, **75**, 1075–1084.
282 C.-S. Li, X.-M. Li, S.-S. Gao, Y.-H. Lu and B.-G. Wang, *Mar. Drugs*, 2013, **11**, 3068–3076.
283 F. Sóti, M. Incze, M. Kajtár-Peredy, E. Baitz-Gács, L. Imre and L. Farkas, *Chem. Ber.*, 1977, **110**, 979–984.
284 N. Tan, Y. Tao, J. Pan, S. Wang, F. Xu, Z. She, Y. Lin and E. B. G. Jones, *Chem. Nat. Compd.*, 2008, **44**, 296–300.
285 K. Drauz, A. Kleemann, J. Martens, P. Scherberich and F. Effenberger, *J. Org. Chem.*, 1986, **51**, 3494–3498.
286 S. Jin, P. Wessig and J. Liebscher, *Eur. J. Org. Chem.*, 2000, 1993–1999.
287 Y. Kimura, T. Yoshinari, H. Koshino, S. Fujioka, K. Okada and A. Shimada, *Biosci., Biotechnol., Biochem.*, 2007, **71**, 1896–1901.
288 M.-H. Wang, X.-M. Li, C.-S. Li, N.-Y. Ji and B.-G. Wang, *Mar. Drugs*, 2013, **11**, 2230–2238.
289 M. Vansteelandt, E. Blanchet, M. Egorov, F. Petit, L. Toupet, A. Bondon, F. Monteau, B. Le Bizec, O. P. Thomas, Y. F. Pouchus, R. Le Bot and O. Grovel, *J. Nat. Prod.*, 2013, **76**, 297–301.
290 H. Gao, L. Zhou, D. Li, Q. Gu and T.-J. Zhu, *Helv. Chim. Acta*, 2013, **96**, 514–519.
291 E. Julianti, J.-H. Lee, L. Liao, W. Park, S. Park, D.-C. Oh, K.-B. Oh and J. Shin, *Org. Lett.*, 2013, **15**, 1286–1289.
292 A. Numata, C. Takahashi, T. Matsushita, T. Miyamoto, K. Kawai, Y. Usami, E. Matsumura, M. Inoue, H. Ohishi and T. Shingu, *Tetrahedron Lett.*, 1992, **33**, 1621–1624.
293 C.-B. Cui, H. Kakeya and H. Osada, *Tennen Yuki Kagobutsu Toronkai Koen Yoshishu*, 1996, **38**, 49–54.
294 C. Takahashi, T. Matsushita, M. Doi, K. Minoura, T. Shingu, Y. Kumeda and A. Numata, *J. Chem. Soc., Perkin Trans. 1*, 1995, 2345–2353.
295 P. M. Scott, J. Polonsky and M. A. Merrien, *J. Agric. Food Chem.*, 1979, **27**, 201–202.
296 K. Nozawa and S. Nakajima, *J. Nat. Prod.*, 1979, **42**, 374–377.
297 S. Ohmomo, T. Sato, T. Utagawa and M. Abe, *Agric. Biol. Chem.*, 1975, **3**, 1333–1334.
298 K. F. Nielsen, M. W. Sumarah, J. C. Frisvad and J. D. Miller, *J. Agric. Food Chem.*, 2006, **54**, 3756–3763.
299 F. He, Z. Han, J. Peng, P.-Y. Qian and S.-H. Qi, *Nat. Prod. Commun.*, 2013, **8**, 329–332.
300 R. J. Capon, M. Stewart, R. Ratnayake, E. Lacey and J. H. Gill, *J. Nat. Prod.*, 2007, **70**, 1746–1752.
301 D.-S. Lee, J.-H. Jang, W. Ko, K.-S. Kim, J. H. Sohn, M.-S. Kang, J. S. Ahn, Y.-C. Kim and H. Oh, *Mar. Drugs*, 2013, **11**, 1409–1426.
302 H. Ren, L. Tian, Q. Gu and W. Zhu, *Arch. Pharmacal Res.*, 2006, **29**, 59–63.
303 V. H. Powell and M. D. Sutherland, *Aust. J. Chem.*, 1967, **20**, 541–553.
304 T. Jiang, L. Tian, A. Guo, H. Fu, Y. Pei and W. Lin, *Yaoxue Xuebao*, 2002, **37**, 271–274.
305 J. Bao, Y.-L. Sun, X.-Y. Zhang, Z. Han, H.-C. Gao, F. He, P.-Y. Qian and S.-H. Qi, *J. Antibiot.*, 2013, **66**, 219–223.
306 J. Qi, C.-L. Shao, Z.-Y. Li, L.-S. Gan, X.-M. Fu, w.-T. Bian, H.-Y. Zhao and C.-Y. Wang, *J. Nat. Prod.*, 2013, **76**, 571–579.
307 M. H. Kossuga, A. G. Ferreira, L. D. Sette and R. G. S. Berlinck, *Rev. Bras. Farmacogn.*, 2012, **22**, 257–267.
308 M. H. Kossuga, A. G. Ferreira, L. D. Sette and R. G. S. Berlinck, *Nat. Prod. Commun.*, 2013, **8**, 721–724.
309 G. Wu, A. Lin, Q. Gu, T. Zhu and D. Li, *Mar. Drugs*, 2013, **11**, 1399–1408.
310 P. S. Baran and E. J. Corey, *J. Am. Chem. Soc.*, 2002, **124**, 7904–7905.
311 T. H. Quang, D.-S. Lee, J. H. Sohn, Y.-C. Kim and H. Oh, *Bull. Korean Chem. Soc.*, 2013, **34**, 3109–3112.
312 E. Li, L. Jiang, L. Guo, H. Zhang and Y. Che, *Bioorg. Med. Chem.*, 2008, **16**, 7894–7899.
313 M.-Y. Wei, D. Li, C.-L. Shao, D.-S. Deng and C.-Y. Wang, *Mar. Drugs*, 2013, **11**, 1050–1060.
314 B. Wu, X. Wu, M. Sun and M. Li, *Mar. Drugs*, 2013, **11**, 2713–2721.
315 M. F. Elsebai, S. Kehraus and G. M. König, *Steroids*, 2013, **78**, 880–883.
316 V. Rukachaisirikul, S. Kannai, S. Klaiklay, S. Phongpaichit and J. Sakayaroj, *Tetrahedron*, 2013, **69**, 6981–6986.
317 C.-L. Shao, R.-F. Xu, M.-Y. Wei, Z.-G. She and C.-Y. Wang, *J. Nat. Prod.*, 2013, **76**, 779–782.
318 M. J. Vazquez, A. Vega, A. Rivera-Sagredo, M. D. Jimenez-Alfaro, E. Diez and J. A. Hueso-Rodriguez, *Tetrahedron*, 2004, **60**, 2379–2385.
319 X. Ma, L. Li, T. Zhu, M. Ba, G. Li, Q. Gu, Y. Guo and D. Li, *J. Nat. Prod.*, 2013, **76**, 2298–2306.
320 M. Muto, H. Kohri, H. Ishitani and K. Higaki, *Nagoya Kogyo Daigaku Gakuho*, 1970, **22**, 159–164.
321 C. Almeida, E. Eguereva, S. Kehraus and G. M. König, *J. Nat. Prod.*, 2013, **76**, 322–326.
322 A. Haga, H. Tamoto, M. Ishino, E. Kimura, T. Sugita, K. Kinoshita, K. Takahashi, M. Shiro and K. Koyama, *J. Nat. Prod.*, 2013, **76**, 750–754.
323 L. Chen, P. Zhong, J.-R. Pan, K.-J. Zhou, K. Huang, Z.-X. Fang and Q.-Q. Zhang, *Heterocycles*, 2013, **87**, 645–655.
324 J. Ren, Y. Yang, D. Liu, W. Chen, P. Proksch, B. Shao and W. Lin, *J. Chromatogr. A*, 2013, **1309**, 90–95.
325 A. Carroux, A.-I. van Bohemen, C. Roullier, T. R. du Pont, M. Vansteelandt, A. Bondon, A. Zalouk-Vergnoux, Y. F. Pouchus and N. Ruiz, *Chem. Biodiversity*, 2013, **10**, 772–786.
326 I. Panizel, O. Yarden, M. Ilan and S. Carmeli, *Mar. Drugs*, 2013, **11**, 4937–4960.
327 Z.-L. Xie, H.-J. Li, L.-Y. Wang, W.-L. Liang, W. Liu and W.-J. Lan, *Nat. Prod. Commun.*, 2013, **8**, 67–68.
328 B. R. Clark, R. J. Capon, E. Lacey, S. Tennant and J. H. Gill, *Org. Biomol. Chem.*, 2006, **4**, 1520–1528.

329 M. M. Chien, P. L. Schiff Jr, D. J. Slatkin and J. E. Knapp, *Lloydia*, 1977, **40**, 301–302.
330 S. Iwasaki, H. Muro, S. Nozoe, S. Okuda and Z. Sato, *Tetrahedron Lett.*, 1972, 13–16.
331 X.-H. Nong, Z.-H. Zheng, X.-Y. Zhang, X.-H. Lu and S.-H. Qi, *Mar. Drugs*, 2013, **11**, 1718–1727.
332 L. Chen, W. Liu, K. Huang, X. Hu, Z.-X. Fang, J.-L. Wu and Q.-Q. Zhang, *Heterocycles*, 2011, **83**, 1853–1858.
333 L. Xu, J. Xue, H. Xu, X. Liu, W. Ma and X. Wei, *Heterocycles*, 2006, **68**, 1955–1959.
334 L. Chen, K. Huang, P. Zhong, X. Hu, Z.-X. Fang, J. Wu and Q.-Q. Zhang, *Heterocycles*, 2012, **85**, 413–419.
335 N. Khamthong, V. Rukachaisirikul, S. Phongpaichit, S. Preedanon and J. Sakayaroj, *Tetrahedron*, 2012, **68**, 8245–8250.
336 C.-L. Shao, H.-X. Wu, C.-Y. Wang, Q.-A. Liu, Y. Xu, M.-Y. Wei, P.-Y. Qian, Y.-C. Gu, C.-J. Zheng, Z.-G. She and Y.-C. Lin, *J. Nat. Prod.*, 2011, **74**, 629–633.
337 C.-L. Shao, H.-X. Wu, C.-Y. Wang, Q.-A. Liu, Y. Xu, M.-Y. Wei, P.-Y. Qian, Y.-C. Gu, C.-J. Zheng, Z.-G. She and Y.-C. Lin, *J. Nat. Prod.*, 2013, **76**, 302.
338 A. McClay, H. van Den Berg, P. Johnston, W. Watters, K. McGarell, D. Waugh, P. Armstrong, Z. Delbederi, C. Higgins and T. Mills, PCT Int. Appl., WO 2006046071 A1 20060504, 2006.
339 C. D. Donner and M. Gill, *J. Chem. Soc., Perkin Trans. 1*, 2002, 938–948.
340 K. Yun, Z. Feng, H. D. Choi, J. S. Kang and B. W. Son, *Chem. Nat. Compd.*, 2013, **49**, 24–26.
341 S. Tamura and A. Sakurai, *Agric. Biol. Chem.*, 1964, **28**, 331–336.
342 A. Abdel-Lateff, T. Okino, W. M. Alarif and S. S. Al-Lihaibi, *J. Saudi Chem. Soc.*, 2013, **17**, 161–165.
343 H. Nagasawa, A. Suzuki and S. Tamura, *Agric. Biol. Chem.*, 1978, **42**, 1303–1304.
344 A. J. Flewelling, J. A. Johnson and C. A. Gray, *Nat. Prod. Commun.*, 2013, **8**, 373–374.
345 G. Gatti, R. Cardillo, C. Fuganti and D. Ghiringhelli, *J. Chem. Soc., Chem. Commun.*, 1976, 435–436.
346 D.-L. Li, X.-M. Li, T.-G. Li, H.-Y. Dang and B.-G. Wang, *Helv. Chim. Acta*, 2008, **91**, 1888–1893.
347 H. Gao, T. Zhu, D. Li, Q. Gu and W. Liu, *Arch. Pharmacal Res.*, 2013, **36**, 952–956.
348 S.-W. Sun, C.-Z. Ji, Q.-Q. Gu, D.-H. Li and T.-J. Zhu, *J. Asian Nat. Prod. Res.*, 2013, **15**, 956–961.
349 S. A. Neff, S. U. Lee, Y. Asami, J. S. Ahn, H. Oh, J. Baltrusaitis, J. B. Gloer and D. T. Wicklow, *J. Nat. Prod.*, 2012, **75**, 464–472.
350 C.-Y. An, X.-M. Li, H. Luo, C.-S. Li, M.-H. Wang, G.-M. Xu and B.-G. Wang, *J. Nat. Prod.*, 2013, **76**, 1896–1901.
351 C.-Y. An, X.-M. Li, C.-S. Li, M.-H. Wang, G.-M. Xu and B.-G. Wang, *Mar. Drugs*, 2013, **11**, 2682–2694.
352 D. Liu, X.-M. Li, C.-S. Li and B.-G. Wang, *Helv. Chim. Acta*, 2013, **96**, 1055–1061.
353 N. Ojima, S. Takenaka and S. Seto, *Phytochemistry*, 1973, **12**, 2527–2529.
354 P. Karrer, K. A. Gehrckens and W. Heuss, *Helv. Chim. Acta*, 1926, **9**, 446–457.
355 H. Gao, W. Guo, Q. Wang, L. Zhang, M. Zhu, T. Zhu, Q. Gu, W. Wang and D. Li, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 1776–1778.
356 S. Cai, S. Sun, H. Zhou, X. Kong, T. Zhu, D. Li and Q. Gu, *J. Nat. Prod.*, 2011, **74**, 1106–1110.
357 T. J. Greshock, A. W. Grubbs, P. Jiao, D. T. Wicklow, J. B. Gloer and R. M. Williams, *Angew. Chem., Int. Ed.*, 2008, **47**, 3573–3577.
358 S. Cai, Y. Luan, X. Kong, T. Zhu, Q. Gu and D. Li, *Org. Lett.*, 2013, **15**, 2168–2171.
359 C. Deng, C. Huang, Q. Wu, J. Pang and Y. Lin, *Nat. Prod. Res.*, 2013, **27**, 1882–1887.
360 G. A. Ellestad, R. H. Evans Jr and M. P. Kunstmann, *Tetrahedron Lett.*, 1971, 497–500.
361 H.-F. Sun, X.-M. Li, L. Meng, C.-M. Cui, S.-S. Gao, C.-S. Li, C.-G. Huang and B.-G. Wang, *J. Nat. Prod.*, 2012, **75**, 148–152.
362 H. M. T. Bandara Herath, W. H. M. W. Herath, P. Carvalho, S. I. Khan, B. L. Tekwani, S. O. Duke, M. Tomaso-Peterson and N. P. D. Nanayakkara, *J. Nat. Prod.*, 2009, **72**, 2091–2097.
363 B. Caron and P. Brassard, *Tetrahedron*, 1991, **47**, 4287–4298.
364 C.-M. Deng, S.-X. Liu, C.-H. Huang, J.-Y. Pang and Y.-C. Lin, *Mar. Drugs*, 2013, **11**, 2616–2624.
365 X. Huang, H. Huang, H. Li, X. Sun, H. Huang, Y. Lu, Y. Lin, Y. Long and Z. She, *Org. Lett.*, 2013, **15**, 721–723.
366 Z. Xiao, H. Huang, C. Shao, X. Xia, L. Ma, X. Huang, Y. Lu, Y. Lin, Y. Long and Z. She, *Org. Lett.*, 2013, **15**, 2522–2525.
367 G. Buechi, K. C. Luk, B. Kobbe and J. M. Townsend, *J. Org. Chem.*, 1977, **42**, 244–246.
368 J. Clardy, J. P. Springer, G. Buechi, K. Matsuo and R. Wightman, *J. Am. Chem. Soc.*, 1975, **97**, 663–665.
369 N. Koyama, Y. Inoue, M. Sekine, Y. Hayakawa, H. Homma, S. Oinmura and H. Tomoda, *Org. Lett.*, 2008, **10**, 5273–5276.
370 J. Peng, T. Lin, W. Wang, Z. Xin, T. Zhu, Q. Gu and D. Li, *J. Nat. Prod.*, 2013, **76**, 1133–1140.
371 W. Ebrahim, A. H. Aly, A. Mandi, F. Totzke, M. H. G. Kubbutat, V. Wray, W.-H. Lin, H. Dai, P. Proksch, T. Kurtán and A. Debbab, *Eur. J. Org. Chem.*, 2012, 3476–3484.
372 W. Ebrahim, A. H. Aly, V. Wray, P. Proksch and A. Debbab, *Tetrahedron Lett.*, 2013, **54**, 6611–6614.
373 L. Calcul, C. Waterman, W. S. Ma, M. D. Lebar, C. Harter, T. Mutka, L. Morton, P. Maignan, A. van Olphen, D. E. Kyle, L. Vrijmoed, K.-L. Pang, C. Pearce and B. J. Baker, *Mar. Drugs*, 2013, **11**, 5036–5050.
374 D. Liu, X.-M. Li, C.-S. Li and B.-G. Wang, *Helv. Chim. Acta*, 2013, **96**, 437–444.
375 Z. Huang, C. Shao, Y. Chen, Z. She, Y. Lin and S. Zhou, *Chem. Nat. Compd.*, 2007, **43**, 655–658.
376 G. N. Belofsky, J. B. Gloer, D. T. Wicklow and P. F. Dowd, *Tetrahedron*, 1995, **51**, 3959–3968.
377 T. Fehr and W. Acklin, *Helv. Chim. Acta*, 1966, **49**, 1907–1910.

378 H. Sun, S. Gao, X. Li, C. Li and B. Wang, *Chin. J. Oceanol. Limnol.*, 2013, **31**, 464–470.
379 H. Seya, K. Nozawa, S. Udagawa, S. Nakajima and K. Kawai, *Chem. Pharm. Bull.*, 1986, **34**, 2411–2416.
380 P. G. Mantle and C. M. Weedon, *Phytochemistry*, 1994, **36**, 1209–1217.
381 Y. Fan, Y. Wang, P. Liu, P. Fu, T. Zhu, W. Wang and W. Zhu, *J. Nat. Prod.*, 2013, **76**, 1328–1336.
382 L.-H. Meng, X.-M. Li, C.-T. Lv, C.-S. Li, G.-M. Xu, C.-G. Huang and B.-G. Wang, *J. Nat. Prod.*, 2013, **76**, 2145–2149.
383 CAS Registry Number: 1235379-39-1, Ambinter Stock Screening Collection, Ambinter, Amb15769954, 21 Feb 2014.
384 CAS Registry Number: 1235379-39-1, Analyticon Discovery MEGx Catalog, AnalytiCon Discovery GmbH, NP-002355, NP-003261, 29 Jan 2014.
385 CAS Registry Number: 1235379-39-1, K13.052.753, Aurora Screening Library, Aurora Fine Chemicals LLC, 3 Jul 2013.
386 M. L. Wang, C. H. Lu, Q. Y. Xu, S. Y. Song, Z. Y. Hu and Z. H. Zheng, *Molecules*, 2013, **18**, 5723–5735.
387 X. Huang, X. Sun, B. Ding, M. Lin, L. Liu, H. Huang and Z. She, *Planta Med.*, 2013, **79**, 1572–1575.
388 K. Otoguro, K. Shiomi, Y. Yamaguchi, N. Arai, T. Sunazuka, R. Masuma, Y. Iwai and S. Omura, *J. Antibiot.*, 2000, **53**, 50–57.
389 J. Yang, R. Huang, S. Qiu, Z. She and Y. Lin, *Nat. Prod. Res.*, 2013, **27**, 1902–1905.
390 Y. Hemberger, J. Xu, V. Wray, P. Proksch, J. Wu and G. Bringmann, *Chem.–Eur. J.*, 2013, **19**, 15556–15564.
391 D. Rönsberg, A. Debbab, A. Mándi, V. Wray, H. Dai, T. Kurtán, P. Proksch and A. H. Aly, *Tetrahedron Lett.*, 2013, **54**, 3256–3259.
392 W. J. McGahren, G. A. Ellestad, G. O. Morton, M. P. Kunstmann and P. Mullen, *J. Org. Chem.*, 1973, **38**, 3542–3544.
393 Z. Huang, J. Yang, F. Lei, Z. She and Y. Lin, *Chem. Nat. Compd.*, 2013, **49**, 27–30.
394 J. X. Yang, S. Qiu, Z. She and Y. Lin, *Chem. Nat. Compd.*, 2013, **49**, 31–33.
395 J. X. Yang, S. Qiu, Z. She and Y. Lin, *Chem. Nat. Compd.*, 2013, **49**, 246–248.
396 M. M. Wagenaar and J. Clardy, *J. Nat. Prod.*, 2001, **64**, 1006–1009.
397 V. Rukachaisirikul, U. Sommart, S. Phongpaichit, J. Sakayaroj and K. Kirtikara, *Phytochemistry*, 2008, **69**, 783–787.
398 S. Cao, D. W. McMillin, G. Tamayo, J. Delmore, C. S. Mitsiades and J. Clardy, *J. Nat. Prod.*, 2012, **75**, 793–797.
399 B. Ding, J. Yuan, X. Huang, W. wWn, X. Zhu, Y. Liu, H. Li, Y. Lu, L. He, H. Tan and Z. She, *Mar. Drugs*, 2013, **11**, 4961–4972.
400 Y. Shiono, T. Sasaki, F. Shibuya, Y. Yasuda, T. Koseki and U. Supratman, *Nat. Prod. Commun.*, 2013, **8**, 1735–1737.
401 J. Wang, W. Ding, C. Li, S. Huang, Z. She and Y. Lin, *Chem. Nat. Compd.*, 2013, **49**, 799–802.
402 Z. Feng and L. Yongcheng, *Chin. Sci. Bull.*, 2006, **51**, 1426–1430.
403 C.-L. Shao, C.-Y. Wang, Y.-C. Gu, M.-Y. Wei, J.-H. Pan, D.-S. Deng, Z.-G. She and Y.-C. Lin, *Bioorg. Med. Chem. Lett.*, 2010, **20**, 3284–3286.
404 L. A. Shaala, D. T. A. Youssef, K. L. McPhail and M. Elbandy, *Phytochem. Lett.*, 2013, **6**, 183–188.
405 S. P. Gunasekera, R. Ritson-Williams and V. J. Paul, *J. Nat. Prod.*, 2008, **71**, 2060–2063.
406 J. I. Jiménez, T. Vansach, W. Y. Yoshida, B. Sakamoto, P. Pörzgen and F. D. Horgen, *J. Nat. Prod.*, 2009, **72**, 1573–1578.
407 E. Mevers, T. Byrum and W. H. Gerwick, *J. Nat. Prod.*, 2013, **76**, 1810–1814.
408 C. C. Thornburg, E. S. Cowley, J. Sikorska, L. A. Shaala, J. E. Ishmael, D. T. A. Youssef and K. L. McPhail, *J. Nat. Prod.*, 2013, **76**, 1781–1788.
409 L. T. Tan, T. Okino and W. H. Gerwick, *Mar. Drugs*, 2013, **11**, 3015–3024.
410 R. Montaser, V. J. Paul and H. Luesch, *Org. Lett.*, 2013, **15**, 4050–4053.
411 C. M. Pavlik, C. Y. B. Wong, S. Ononye, D. D. Lopez, N. Engene, K. L. McPhail, W. H. Gerwick and M. J. Balunas, *J. Nat. Prod.*, 2013, **76**, 2026–2033.
412 K. Kumagai, M. Tsuda, E. Fukushi and J. Kawabata, *Heterocycles*, 2013, **87**, 2615–2623.
413 R. Watanabe, H. Uchida, T. Suzuki, R. Matsushima, M. Nagae, Y. Toyohara, M. Satake, Y. Oshima, A. Inoue and T. Yasumoto, *Tetrahedron*, 2013, **69**, 10299–10303.
414 C. Tsukano and M. Sasaki, *Tetrahedron Lett.*, 2006, **47**, 6803–6807.
415 Y. Tanaka, M. Satake, M. Yotsu-Yamashita and Y. Oshima, *Heterocycles*, 2013, **87**, 2037–2046.
416 B. S. Hwang, E. Y. Yoon, H. S. Kim, W. Yih, J. Y. Park, H. J. Jeong and J.-R. Rho, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 3023–3027.
417 H. Uchida, Y. Taira and T. Yasumoto, *Rapid Commun. Mass Spectrom.*, 2013, **27**, 1999–2008.
418 J. L. Dahmen and J. D. Leblond, *Protist*, 2013, **164**, 183–194.
419 A. I. Selwood, A. L. Wilkins, R. Munday, F. Shi, L. L. Rhodes and P. T. Holland, *Tetrahedron Lett.*, 2013, **54**, 4705–4707.
420 M. Ishibashi, N. Yamaguchi, T. Sasaki and J. Kobayashi, *J. Chem. Soc., Chem. Commun.*, 1994, 1455–1456.
421 Y. Takahashi, T. Kubota, M. Imachi, M. R. Wälchli and J. Kobayashi, *J. Antibiot.*, 2013, **66**, 277–279.
422 J. D. Leblond, H. I. Timofte, S. A. Roche and N. M. Porter, *Phycol. Res.*, 2010, **58**, 222–229.
423 A. Nagatsu, M. Watanabe, K. Ikemoto, M. Hashimoto, N. Murakami, J. Sakakibara, H. Tokuda, H. Nishino, A. Iwashima and K. Yazawa, *Bioorg. Med. Chem. Lett.*, 1994, **4**, 1619–1622.
424 A. H. Banskota, R. Stefanova, P. Gallant and P. J. McGinn, *J. Appl. Phycol.*, 2013, **25**, 349–357.
425 A. Arakaki, D. Iwama, Y. Liang, N. Murakami, M. Ishikura, T. Tanaka and T. Matsunaga, *Phytochemistry*, 2013, **85**, 107–114.

426 E. Julianti, H. Oh, H.-S. Lee, D.-C. Oh, K.-B. Oh and J. Shin, *Tetrahedron Lett.*, 2012, **53**, 2885–2886.
427 K. Banert, *Tetrahedron Lett.*, 2012, **53**, 6443–6445.
428 L. A. Januar and T. F. Molinski, *Org. Lett.*, 2013, **15**, 2370–2373.
429 Q.-X. Wu, M. S. Crews, M. Draskovic, J. Sohn, T. A. Johnson, K. Tenney, F. A. Valeriote, X.-J. Yao, L. F. Bjeldanes and P. Crews, *Org. Lett.*, 2010, **12**, 4458–4461.
430 J.-C. Zhao, S.-M. Yu, Y. Liu and Z.-J. Yao, *Org. Lett.*, 2013, **15**, 4300–4303.
431 Y. Zhuang, X. Teng, Y. Wang, P. Liu, H. Wang, J. Li, G. Li and W. Zhu, *Tetrahedron*, 2011, **67**, 7085–7089.
432 L. Wang and W. Zhu, *Tetrahedron Lett.*, 2013, **54**, 6729–6731.
433 J. Zhang, L. He, H. Xue and R. Feng, *Chin. Chem. Lett.*, 1990, **1**, 223–224.
434 J. Zhang and L. He, *Yaoxue Xuebao*, 1986, **21**, 273–278.
435 M. Tsuda, Y. Kasai, K. Komatsu, T. Sone, M. Tanaka, Y. Mikami and J. Kobayashi, *Org. Lett.*, 2004, **6**, 3087–3089.
436 T. Mugishima, M. Tsuda, Y. Kasai, H. Ishiyama, E. Fukushi, J. Kawabata, M. Watanabe, K. Akao and J. Kobayashi, *J. Org. Chem.*, 2005, **70**, 9430–9435.
437 Z. Bian, C. C. Marvin and S. F. Martin, *J. Am. Chem. Soc.*, 2013, **135**, 10886–10889.
438 K. Kong, J. A. Enquist Jr, M. E. McCallum, G. M. Smith, T. Matsumaru, E. Menhaji-Klotz and J. L. Wood, *J. Am. Chem. Soc.*, 2013, **135**, 10890–10893.
439 Y. Sun, L. Tian, J. Huang, H.-Y. Ma, Z. Zheng, A.-L. Lv, K. Yasukawa and Y.-H. Pei, *Org. Lett.*, 2008, **10**, 393–396.
440 H. Shigehisa, Y. Suwa, N. Furiya, Y. Nakaya, M. Fukushima, Y. Ichihashi and K. Hiroya, *Angew. Chem., Int. Ed.*, 2013, **52**, 3646–3649.
441 Q. Li, Y.-S. Xu, G. A. Ellis, T. S. Bugni, Y. Tang and R. P. Hsung, *Tetrahedron Lett.*, 2013, **54**, 5567–5572.
442 Z.-J. Lin, Z.-Y. Lu, T.-J. Zhu, Y.-C. Fang, Q.-Q. Gu and W.-M. Zhu, *Chem. Pharm. Bull.*, 2008, **56**, 217–221.
443 K. Kempf, A. Raja, F. Sasse and R. Schobert, *J. Org. Chem.*, 2013, **78**, 2455–2461.
444 J. Xu, J. Kjer, J. Sendker, V. Wray, H. Guan, R. Edrada, W. Lin, J. Wu and P. Proksch, *J. Nat. Prod.*, 2009, **72**, 662–665.
445 A. M. Beekman and R. A. Barrow, *J. Nat. Prod.*, 2013, **76**, 2054–2059.
446 F. Xu, J. Pang, B. Lu, J. Wang, Y. Zhang, Z. She, L. L. P. Vrijmoed, E. B. Gareth Jones and Y. Lin, *Chin. J. Chem.*, 2009, **27**, 365–368.
447 R.-A. F. Rarig, M. N. Tran and D. M. Chenoweth, *J. Am. Chem. Soc.*, 2013, **135**, 9213–9219.
448 W. P. Frankmolle, G. Knubel, R. E. Moore and G. M. L. Patterson, *J. Antibiot.*, 1992, **45**, 1458–1466.
449 I. Bonnard, M. Rolland, C. Francisco and B. Banaigs, *Lett. Pept. Sci.*, 1997, **4**, 289–292.
450 N. Maru, O. Ohno and D. Uemura, *Tetrahedron Lett.*, 2010, **51**, 6384–6387.
451 F. Boyaud, Z. Mahiout, C. Lenoir, S. Tang, J. Wdzieczak–Bakala, A. Witczak, I. Bonnard, B. Banaigs, T. Ye and N. Inguimbert, *Org. Lett.*, 2013, **15**, 3898–3901.
452 B. Adams, P. Poerzgen, E. Pittman, W. Y. Yoshida, H. E. Westenburg and F. D. Horgen, *J. Nat. Prod.*, 2008, **71**, 750–754.
453 P. K. Gajula, S. Sharma, R. S. Ampapathi and T. K. Chakraborty, *Org. Biomol. Chem.*, 2013, **11**, 257–260.
454 M. Murata, S. Matsuoka, N. Matsumori, G. K. Paul and K. Tachibana, *J. Am. Chem. Soc.*, 1999, **121**, 870–871.
455 M. Ebine, M. Kanemoto, Y. Manabe, Y. Konno, K. Sakai, N. Matsumori, M. Murata and T. Oishi, *Org. Lett.*, 2013, **15**, 2846–2849.
456 M. A. M. Mondol, J. H. Kim, M. A. Lee, F. S. Tareq, H.-S. Lee, Y.-J. Lee and H. J. Shin, *J. Nat. Prod.*, 2011, **74**, 1606–1612.
457 V. T. Salunkhe, S. Bhosale, P. Punde, D. Bhuniya and S. Koul, *Tetrahedron Lett.*, 2013, **54**, 2489–2491.
458 E. N. Reddy, A. Krishnaiah and T. P. Rao, *Tetrahedron: Asymmetry*, 2013, **24**, 724–728.
459 S. Das and R. K. Goswami, *J. Org. Chem.*, 2013, **78**, 7274–7280.
460 N. N. Rao and H. M. Meshram, *Tetrahedron Lett.*, 2013, **54**, 4544–4546.
461 F. S. Tareq, J. H. Kim, M. A. Lee, H.-S. Lee, Y.-J. Lee, J. S. Lee and H. J. Shin, *Org. Lett.*, 2012, **14**, 1464–1467.
462 C. R. Reddy, E. Jithender and K. R. Prasad, *J. Org. Chem.*, 2013, **78**, 4251–4260.
463 F. S. Tareq, J. H. Kim, M. A. Lee, H.-S. Lee, Y.-J. Lee, J. S. Lee and H. J. Shin, *Org. Lett.*, 2013, **15**, 2071.
464 H. Huang, Y. Yao, Z. He, T. Yang, J. Ma, X. Tian, Y. Li, C. Huang, X. Chen, W. Li, S. Zhang, C. Zhang and J. Ju, *J. Nat. Prod.*, 2011, **74**, 2122–2127.
465 S. Tagawa, T. Choshi, A. Okamoto, T. Nishiyama, S. Watanabe, N. Hatae and S. Hibino, *Heterocycles*, 2013, **87**, 357–367.
466 Y. Matsuo, K. Kanoh, T. Yamori, H. Kasai, A. Katsuta, K. Adachi, K. Shin-ya and Y. Shizuri, *J. Antibiot.*, 2007, **60**, 251–255.
467 Y. Matsuo, K. Kanoh, H. Imagawa, K. Adachi, M. Nishizawa and Y. Shizuri, *J. Antibiot.*, 2007, **60**, 256–260.
468 C.-C. Lin, W. Tantisantisom and S. R. McAlpine, *Org. Lett.*, 2013, **15**, 3574–3577.
469 T. Tamaoki, K. Shirahata, T. Iida and F. Tomita, *J. Antibiot.*, 1981, **34**, 1525–1530.
470 R. P. Maskey, E. Helmke, O. Kayser, H. H. Fiebig, A. Maier, A. Busche and H. Laatsch, *J. Antibiot.*, 2004, **57**, 771–779.
471 T. Magauer, D. J. Smaltz and A. G. Myers, *Nat. Chem. Biol.*, 2013, **5**, 886–893.
472 S. Sato, F. Iwata, T. Mukai, S. Yamada, J. Takeo, A. Abe and H. Kawahara, *J. Org. Chem.*, 2009, **74**, 5502–5509.
473 O. F. Jeker and E. M. Carreira, *Angew. Chem., Int. Ed.*, 2012, **51**, 3474–3477.
474 C. He, C. Zhu, Z. Dai, C.-C. Tseng and H. Ding, *Angew. Chem., Int. Ed.*, 2013, **52**, 13256–13260.
475 M. L. Ciavatta, M. P. Lopez-Gresa, M. Gavagnin, R. Nicoletti, E. Manzo, E. Mollo, Y.-W. Guo and G. Cimino, *Tetrahedron*, 2008, **64**, 5365–5369.
476 J. Vannada, L. Niehues, B. König and G. Mehta, *Tetrahedron*, 2013, **69**, 6034–6040.
477 G. K. Poch and J. B. Gloer, *J. Nat. Prod.*, 1989, **52**, 257–260.

478 J. S. Yadav, A. B. Reddy and K. S. Shankar, *Synthesis*, 2013, **45**, 1034–1038.
479 C. Takahashi, A. Numata, Y. Ito, E. Matsumura, H. Araki, H. Iwaki and K. Kushida, *J. Chem. Soc., Perkin Trans. 1*, 1994, 1859–1864.
480 J.-Y. Dong, H.-P. He, Y.-M. Shen and K.-Q. Zhang, *J. Nat. Prod.*, 2005, **68**, 1510–1513.
481 F.-Z. Wang, Z. Huang, X.-F. Shi, Y.-C. Chen, W.-M. Zhang, X.-P. Tian, J. Li and S. Zhang, *Bioorg. Med. Chem. Lett.*, 2012, **22**, 7265–7267.
482 J. E. DeLorbe, D. Horne, R. Jove, S. M. Mennen, S. Nam, F.-L. Zhanag and L. E. Overman, *J. Am. Chem. Soc.*, 2013, **135**, 4117–4128.
483 K. Trisuwan, V. Rukachaisirikul, Y. Sukpondma, S. Phongpaichit, S. Preedanon and J. Sakayaroj, *Chem. Pharm. Bull.*, 2009, **57**, 1100–1102.
484 L. Song, H. Yao, L. Zhu and R. Tong, *Org. Lett.*, 2013, **15**, 6–9.
485 G. Carr, W. Tay, H. Bottriell, S. K. Andersen, A. G. Mauk and R. J. Andersen, *Org. Lett.*, 2009, **11**, 2996–2999.
486 S. Y. Jabri and L. E. Overman, *J. Am. Chem. Soc.*, 2013, **135**, 4231–4234.
487 S. Y. Jabri and L. E. Overman, *J. Org. Chem.*, 2013, **78**, 8766–8788.
488 J. Orjala and W. H. Gerwick, *Phytochemistry*, 1997, **45**, 1087–1090.
489 A. Phanumartwiwath, T. W. Hornsby, J. Jamalis, C. D. Bailey and C. L. Willis, *Org. Lett.*, 2013, **15**, 5734–5737.
490 G. E. Chlipala, P. H. Tri, N. van Hung, A. Krunic, S. H. Shim, D. D. Soejarto and J. Orjala, *J. Nat. Prod.*, 2010, **73**, 784–787.
491 A. Kamal and S. R. Vangala, *Org. Biomol. Chem.*, 2013, **11**, 4442–4448.
492 M. Gutierrez, A. R. Pereira, H. M. Debonsi, A. Ligresti, V. Di Marzo and W. H. Gerwick, *J. Nat. Prod.*, 2011, **74**, 2313–2317.
493 Y.-R. Gao, S.-H. Guo, Z.-X. Zhang, S. Mao, Y.-L. Zhang and Y.-Q. Wang, *Tetrahedron Lett.*, 2013, **54**, 6511–6513.
494 P. D. Boudreau, T. Byrum, W.-T. Liu, P. C. Dorrestein and W. H. Gerwick, *J. Nat. Prod.*, 2012, **75**, 1560–1570.
495 D. Wang, S. Song, Y. Tian, Y. Xu, Z. Miao and A. Zhang, *J. Nat. Prod.*, 2013, **76**, 974–978.
496 J. Kobayashi, M. Ishibashi, M. R. Walchli, H. Nakamura, Y. Hirata, T. Sasaki and Y. Ohizumi, *J. Am. Chem. Soc.*, 1988, **110**, 490–494.
497 S. Mahapatra and R. G. Carter, *J. Am. Chem. Soc.*, 2013, **135**, 10792–10803.
498 S. B. Singh, J. L. Smith, G. S. Sabnis, A. W. Dombrowski, J. M. Schaeffer, M. A. Goetz and G. F. Bills, *Tetrahedron*, 1991, **47**, 6931–6938.
499 H. Wei, T. Itoh, M. Kinoshita, Y. Nakai, M. Kurotaki and M. Kobayashi, *Tetrahedron*, 2004, **60**, 6015–6019.
500 M. Arai, H. Niikawa and M. Kobayashi, *J. Nat. Med.*, 2013, **67**, 271–275.
501 S. T. Carey and M. S. R. Nair, *J. Nat. Prod.*, 1979, **42**, 231.
502 M. García-Caballero, M. Marí-Beffa, L. Cañedo, M. A. Medina and A. R. Quesada, *Biochem. Pharmacol.*, 2013, **85**, 1727–1740.
503 J. H. Sohn, Y.-R. Lee, D.-S. Lee, Y.-C. Kim and H. Oh, *J. Microbiol. Biotechnol.*, 2013, **23**, 1206–1211.
504 K. Arai, K. Kimura, T. Mushiroda and Y. Yamamoto, *Chem. Pharm. Bull.*, 1989, **37**, 2937–2939.
505 Y. S. Mohammed and M. Luckner, *Tetrahedron Lett.*, 1963, 1953–1958.
506 A. Quilico, *Gazz. Chim. Ital.*, 1948, **78**, 111–135.
507 B. S. Gould and H. Raistrick, *Biochem. J.*, 1934, **28**, 1640–1656.
508 M. Isaka, S. Palasarn, P. Rachtawee, S. Vimuttipong and P. Kongsaeree, *Org. Lett.*, 2005, **7**, 2257–2260.
509 W. Zhao, Q. Gu and W. Zhu, *Huaxue Yanjiu*, 2007, **18**, 10–13.
510 X. Han, X. Xu, C. Cui and Q. Gu, *Zhongguo Yaowu Huaxue Zazhi*, 2007, **17**, 155–159.
511 Y. Song, H. Dou, W. Gong, X. Liu, Z. Yu, E. Li, R. Tan and Y. Hou, *Eur. J. Pharmacol.*, 2013, **705**, 49–60.
512 H. He, W.-D. Ding, V. S. Bernan, A. D. Richardson, C. M. Ireland, M. Greenstein, G. A. Ellestad and G. T. Carter, *J. Am. Chem. Soc.*, 2001, **123**, 5362–5363.
513 R. D. Kersten, A. L. Lane, M. Nett, T. K. S. Richter, B. M. Duggan, P. C. Dorrestein and B. S. Moore, *ChemBioChem*, 2013, **14**, 955–962.
514 X.-G. Li, X.-M. Tang, J. Xiao, G.-H. Ma, L. Xu, S.-J. Xie, M.-J. Xu, X. Xiao and J. Xu, *Mar. Drugs*, 2013, **11**, 3875–3890.
515 J. Qian-Cutrone, S. Huang, Y.-Z. Shu, D. Vyas, C. Fairchild, A. Menendez, K. Krampitz, R. Dalterio, S. E. Klohr and Q. Gao, *J. Am. Chem. Soc.*, 2002, **124**, 14556–14557.
516 Y. Ding, J. R. de Wet, J. Cavalcoli, S. Li, T. J. Greshock, K. A. Miller, J. M. Finefield, J. D. Sunderhaus, T. J. McAfoos, S. Tsukamoto, R. M. Williams and D. H. Sherman, *J. Am. Chem. Soc.*, 2010, **132**, 12733–12740.
517 J. D. Sunderhaus, T. J. McAfoos, J. M. Finefield, H. Kato, S. Li, S. Tsukamoto, D. H. Sherman and R. M. Williams, *Org. Lett.*, 2013, **15**, 22–25.
518 J. D. Hackett, J. H. Wisecaver, M. L. Brosnahan, D. M. Kulis, D. M. Anderson, D. Bhattacharya, F. G. Plumley and D. L. Erdner, *Mol. Biol. Evol.*, 2013, **30**, 70–78.
519 D.-Q. Liu, S.-C. Mao, X.-Q. Yu, L.-H. Feng and X.-P. Lai, *Heterocycles*, 2012, **85**, 661–666.
520 A.-H. Liu, D.-Q. Liu, T.-J. Liang, X.-Q. Yu, M.-T. Feng, L.-G. Yao, Y. Fang, B. Wang, L.-H. Feng, M.-X. Zhang and S.-C. Mao, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 2491–2494.
521 R. Wang, V. J. Paul and H. Luesch, *Free Radical Biol. Med.*, 2013, **57**, 141–153.
522 D. E. Williams, C. M. Sturgeon, M. Roberge and R. J. Andersen, *J. Am. Chem. Soc.*, 2007, **129**, 5822–5823.
523 N. Kinashi, K. Fujiwara, T. Tsunoda, R. Katoono, H. Kawai and T. Suzuki, *Tetrahedron Lett.*, 2013, **54**, 4564–4567.
524 I. Rubinstein and L. J. Goad, *Phytochemistry*, 1974, **13**, 481–484.
525 A. D. Kim, Y. Lee, S.-H. Kang, G. Y. Kim, H. S. Kim and J. W. Hyun, *Mar. Drugs*, 2013, **11**, 418–430.
526 G. Aguilar-Santos and M. S. Doty, *Drugs Sea, Trans. Symp.*, ed. H. D. Freudenthal, 1968, pp. 173–176.
527 L. H. A. Cavalcante-Silva, A. C. D. Correia, J. M. Barbosa, B. A. da Silva, B. V. D. Santos, D. P. de Lira, J. C. F. Sousa,

G. E. C. de Miranda, F. D. Cavalcante and M. S. Alexandre-Moreira, *Mar. Drugs*, 2013, **11**, 1553–1564.
528 D. R. Hirschfeld, W. Fenical, G. H. Y. Lin, R. M. Wing, P. Radlick and J. J. Sims, *J. Am. Chem. Soc.*, 1973, **95**, 4049–4050.
529 G. S. E. Abou-El-Wafa, M. Shaaban, K. A. Shaaban, M. E. E. El-Naggar, A. Maier, H. H. Fiebig and H. Laatsch, *Mar. Drugs*, 2013, **11**, 3109–3123.
530 E. Ioannou, C. Vagias and V. Roussis, *Mar. Drugs*, 2013, **11**, 1104–1112.
531 V. L. M. Gouveia, A. M. L. Seca, M. C. Barreto, A. I. Neto, A. Kijjoa and A. M. S. Silva, *Phytochem. Lett.*, 2013, **6**, 593–597.
532 C. de los Reyes, H. Zbakh, V. Motilva and E. Zubía, *J. Nat. Prod.*, 2013, **76**, 621–629.
533 N. Penicooke, K. Walford, S. Badal, R. Delgoda, L. A. D. Williams, P. Joseph-Nathan, B. Gordillo-Roman and W. Gallimore, *Phytochemistry*, 2013, **87**, 96–101.
534 O. M. M. Sabry, S. Andrews, K. L. McPhail, D. E. Goeger, A. Yokochi, K. T. LePage, T. F. Murray and W. H. Gerwick, *J. Nat. Prod.*, 2005, **68**, 1022–1030.
535 W. H. Gerwick, W. Fenical, N. Fritsch and J. Clardy, *Tetrahedron Lett.*, 1979, **20**, 145–148.
536 A. Numata, S. Kanbara, C. Takahashi, R. Fujiki, M. Yoneda, Y. Usami and E. Fujita, *Phytochemistry*, 1992, **31**, 1209–1213.
537 Y. Kamei, M. Sueyoshi, K.-i. Hayashi, R. Terada and H. Nozaki, *J. Antibiot.*, 2009, **62**, 259–263.
538 R. Katsuta, K. Aoki, A. Yajima and T. Nukada, *Tetrahedron Lett.*, 2013, **54**, 347–350.
539 Y. Seo, K. E. Park and T. J. Nam, *Bull. Korean Chem. Soc.*, 2007, **28**, 1831–1833.
540 K. Kurata, K. Taniguchi, K. Shiraishi, N. Hayama, I. Tanaka and M. Suzuki, *Chem. Lett.*, 1989, 267–270.
541 J. Becker, L. Butt, V. von Kiedrowski, E. Mischler, F. Quentin and M. Hiersemann, *Org. Lett.*, 2013, **15**, 5982–5985.
542 H. A. Jung, S. E. Jin, B. R. Ahn, C. M. Lee and J. S. Choi, *Food Chem. Toxicol.*, 2013, **59**, 199–206.
543 T.-H. Kwon, H.-J. Suh, I.-K. Lee, B.-S. Yun, T.-W. Kim, D.-I. Hwang, Y.-J. Kim, M.-J. Kim, O.-O. Kwon, C.-G. Kim and N.-H. Park, *Eur. Food Res. Technol.*, 2013, **237**, 501–508.
544 J.-S. Yoon, A. K. Yadunandam, S.-J. Kim, H.-C. Woo, H.-R. Kim and G.-D. Kim, *J. Nat. Med.*, 2013, **67**, 519–527.
545 J.-Y. Park, J. H. Kim, J. M. Kwon, H.-J. Kwon, H. J. Jeong, Y. M. Kim, D. Kim, W. S. Lee and Y. B. Ryu, *Bioorg. Med. Chem.*, 2013, **21**, 3730–3737.
546 E. M. Balboa, E. Conde, A. Moure, E. Falqué and H. Domínguez, *Food Chem.*, 2013, **138**, 1764–1785.
547 K. H. S. Farvin and C. Jacobsen, *Food Chem.*, 2013, **138**, 1670–1681.
548 E. Plouguerné, L. M. de Souza, G. L. Sassaki, J. F. Cavalcanti, M. T. V. Romanos, B. A. P. da Gama, R. C. Pereira and E. Barreto-Bergter, *Mar. Drugs*, 2013, **11**, 4628–4640.
549 L. A. Miceli, V. L. Teixeira, H. C. Castro, C. R. Rodrigues, J. F. R. Mello, M. G. Albuquerque, L. M. Cabral, M. A. de Brito and A. M. T. de Souza, *Mar. Drugs*, 2013, **11**, 4127–4143.
550 W.-J. Yoon, S.-J. Heo, S.-C. Han, H.-J. Lee, G.-J. Kang, E.-J. Yang, S.-S. Park, H.-K. Kang and E.-S. Yoo, *Food Chem. Toxicol.*, 2012, **50**, 3273–3279.
551 W.-J. Yoon, K.-N. Kim, S.-J. Heo, S.-C. Han, J. Kim, Y.-J. Ko, H.-K. Kang and E.-S. Yoo, *Biochem. Biophys. Res. Commun.*, 2013, **434**, 892–897.
552 B.-G. Park, S. Oh, D. Kwon, Y. Cui, J. Ham, W.-S. Shin and S. Lee, *Bull. Korean Chem. Soc.*, 2013, **34**, 3121–3124.
553 S. L. Midland, R. M. Wing and J. J. Sims, *J. Org. Chem.*, 1983, **48**, 1906–1909.
554 K. E. Park, Y. A. Kim, H. A. Jung, H. J. Lee, J.-W. Ahn, B.-J. Lee and Y. Seo, *J. Korean Chem. Soc.*, 2004, **48**, 394–398.
555 R. K. Ko, M.-C. Kang, S. S. Kim, T. H. Oh, G.-O. Kim, C.-G. Hyun, J. W. Hyun and N. H. Lee, *Nat. Prod. Commun.*, 2013, **8**, 427–428.
556 J. I. Lee, M. K. Kwak, H. Y. Park and Y. Seo, *Nat. Prod. Commun.*, 2013, **8**, 431–432.
557 M. Guyot, M. Morel and C. Belaud, *J. Chem. Res., Synop.*, 1983, 188–189.
558 M. H. Moghadam, J. Firouzi, S. Saeidnia, H. Hajimehdipoor, S. Jamili, A. Rustaiyan and A. R. Gohari, *Daru, J. Pharm. Sci.*, 2013, 21–24.
559 S. R. Kumar, M. Hosokawa and K. Miyashita, *Mar. Drugs*, 2013, **11**, 5130–5147.
560 J. B. Gallé, B. Attioua, M. Kaiser, A. M. Rusig, A. Lobstein and C. Vonthron-Sénécheau, *Mar. Drugs*, 2013, **11**, 599–610.
561 C. Francisco, G. Combaut, J. Teste and M. Prost, *Phytochemistry*, 1978, **17**, 1003–1005.
562 S. Urban and M. Timmers, *Nat. Prod. Commun.*, 2013, **8**, 715–719.
563 M. Kitamura, P. J. Schupp, Y. Nakano and D. Uemura, *Tetrahedron Lett.*, 2009, **50**, 6606–6609.
564 N. Maru, T. Inuzuka, K. Yamamoto, M. Kitamura, P. J. Schupp, K. Yamada and D. Uemura, *Tetrahedron Lett.*, 2013, **54**, 4385–4387.
565 W. M. Abdel-Mageed, R. Ebel, F. A. Valeriote and M. Jaspars, *Tetrahedron*, 2010, **66**, 2855–2862.
566 M. T. Holmes and R. Britton, *Chem.–Eur. J.*, 2013, **19**, 12649–12652.
567 D. J. Shepherd, P. A. Broadwith, B. S. Dyson, R. S. Paton and J. W. Burton, *Chem.–Eur. J.*, 2013, **19**, 12644–12648.
568 J. G. Hall and J. A. Reiss, *Aust. J. Chem.*, 1986, **39**, 1401–1409.
569 S. G. Smith, R. S. Paton, J. W. Burton and J. M. Goodman, *J. Org. Chem.*, 2008, **73**, 4053–4062.
570 B. S. Dyson, J. W. Burton, T. I. Sohn, B. Kim, H. Bae and D. Kim, *J. Am. Chem. Soc.*, 2012, **134**, 11781–11790.
571 R. Brkljača and S. Urban, *Nat. Prod. Commun.*, 2013, **8**, 729–732.
572 M. L. Ciavatta, S. Wahidulla, L. D'Souza, G. Scognamiglio and G. Cimino, *Tetrahedron*, 2001, **57**, 617–623.
573 B. S. Underwood, J. Tanuwidjaja, S.-S. Ng and T. F. Jamison, *Tetrahedron*, 2013, **69**, 5205–5220.
574 C. P. Manríquez, M. L. Souto, J. A. Gavin, M. Norte and J. J. Fernández, *Tetrahedron*, 2001, **57**, 3117–3123.

575 X. D. Li, F. P. Miao, X. R. Liang, B. G. Wang and N. Y. Ji, *RSC Adv.*, 2013, **3**, 1953–1956.
576 T. Kamada and C. S. Vairappan, *Nat. Prod. Commun.*, 2013, **8**, 287–288.
577 L. Shide, A. Olbrich, R. Mayer and G. Rücker, *Planta Med.*, 1987, **53**, 556–558.
578 X. Xu, L. Yin, L. Gao, J. Gao, J. Chen, J. Li and F. Song, *Mar. Drugs*, 2013, **11**, 842–847.
579 X. Xu, L. Yin, Y. Wang, S. Wang and F. Song, *Nat. Prod. Res.*, 2013, **27**, 723–726.
580 E. K. Olsen, E. Hansen, J. Isaksson and J. H. Andersen, *Mar. Drugs*, 2013, **11**, 2769–2784.
581 W.-S. Sun, S. Su, R.-X. Zhu, G.-Z. Tu, W. Cheng, H. Liang, X.-Y. Guo, Y.-Y. Zhao and Q.-Y. Zhang, *Tetrahedron Lett.*, 2013, **54**, 3617–3620.
582 D. Iliopoulou, N. Mihopoulos, C. Vagias, P. Papazafiri and V. Roussis, *J. Org. Chem.*, 2003, **68**, 7667–7674.
583 A. E. Leung, M. Blair, C. M. Forsyth and K. L. Tuck, *Org. Lett.*, 2013, **15**, 2198–2201.
584 S. J. Rochfort and R. J. Capon, *Aust. J. Chem.*, 1996, **49**, 19–26.
585 X.-c. Huang, Y.-L. Sun, A. A. Salim, Z.-S. Chen and R. J. Capon, *Biochem. Pharmacol.*, 2013, **85**, 1257–1268.
586 D. Mikami, H. Kurihara, S. M. Kim and K. Takahashi, *Mar. Drugs*, 2013, **11**, 4050–4057.
587 M. Francavilla, M. Franchi, M. Monteleone and C. Caroppo, *Mar. Drugs*, 2013, **11**, 3754–3776.
588 L. Mata, E. Wright, L. Owens, N. Paul and R. de Nys, *J. Appl. Phycol.*, 2013, **25**, 1963–1973.
589 J. W. Blunt, B. R. Copp, R. A. Keyzers, M. H. G. Munro and M. R. Prinsep, *Nat. Prod. Rep.*, 2012, **29**, 144–222.
590 T. F. Molinski, R. Biegelmeyer, E. P. Stout, X. Wang, M. L. C. Frota and A. T. Henriques, *J. Nat. Prod.*, 2013, **76**, 374–381.
591 R. Huang, Y. Peng, X. Zhou, X. Yang and Y. Liu, *Nat. Prod. Res.*, 2013, **27**, 1537–1541.
592 T. N. Makarieva, P. S. Dmitrenok, A. M. Zakharenko, V. A. Denisenko, A. G. Guzii, R. Li, C. K. Skepper, T. F. Molinksi and V. A. Stonik, *J. Nat. Prod.*, 2007, **70**, 1991–1998.
593 J. Ko and T. F. Molinski, *J. Org. Chem.*, 2013, **78**, 498–505.
594 F. Farokhi, P. Grellier, M. Clément, C. Roussakis, P. M. Loiseau, E. Genin-Seward, J. M. Kornprobst, G. Barnathan and G. Wielgosz-Collin, *Mar. Drugs*, 2013, **11**, 1304–1315.
595 P. L. Katavic, K. W. L. Yong, J. N. Herring, M. A. Deseo, J. T. Blanchfield, V. Ferro and M. J. Garson, *Tetrahedron*, 2013, **69**, 8074–8079.
596 A. Cutignano, G. Nuzzo, D. D'Angelo, E. Borbone, A. Fusco and A. Fontana, *Angew. Chem., Int. Ed.*, 2013, **52**, 9256–9260.
597 X. Luo, F. Li, J. Hong, C.-O. Lee, C. J. Sim, K. S. Im and J. H. Jung, *J. Nat. Prod.*, 2006, **69**, 567–571.
598 R. Towada, Y. Kurashina and S. Kuwahara, *Tetrahedron Lett.*, 2013, **54**, 6878–6881.
599 N. Tanaka, M. Asai, A. Takahashi-Nakaguchi, T. Gonoi, J. Fromont and J. Kobayashi, *Org. Lett.*, 2013, **15**, 2518–2521.
600 K. Horikawa, T. Yagyu, Y. Yoshioka, T. Fujiwara, A. Kanamoto, T. Okamoto and M. Ojika, *Tetrahedron*, 2013, **69**, 101–106.
601 A. S. Reddy and P. Srihari, *Tetrahedron Lett.*, 2013, **54**, 6370–6372.
602 B.-K. Choi, B.-Y. Cha, T. Yagyu, J.-T. Woo and M. Ojika, *Bioorg. Med. Chem.*, 2013, **21**, 1804–1810.
603 Y. Hitora, K. Takada, S. Okada and S. Matsunaga, *Tetrahedron*, 2011, **67**, 4530–4534.
604 Y. Hitora, K. Takada and S. Matsunaga, *Tetrahedron*, 2013, **69**, 11070–11073.
605 Y. Inokuma, S. Yoshioka, J. Ariyoshi, T. Arai, Y. Hitora, K. Takada, S. Matsunaga, K. Rissanen and M. Fujita, *Nature*, 2013, **501**, 262.
606 T. Shirouzu, K. Watari, M. Ono, K. Koizumi, I. Saiki, C. Tanaka, R. W. M. van Soest and T. Miyamoto, *J. Nat. Prod.*, 2013, **76**, 1337–1342.
607 Y.-J. Lee, S.-J. Yoo, J. S. Kang, J. Yun, H. J. Shin, J. S. Lee and H.-S. Lee, *Lipids*, 2013, **48**, 87–91.
608 E. J. Mejia, L. B. Magranet, N. J. De Voogd, K. TenDyke, D. Qiu, Y. Y. Shen, Z. Zhou and P. Crews, *J. Nat. Prod.*, 2013, **76**, 425–432.
609 N. Legrave, S. Hamrouni-Buonomo, M. Dufies, V. Guérineau, J. Vacelet, P. Auberger, P. Amade and M. Mehiri, *Mar. Drugs*, 2013, **11**, 2282–2292.
610 S. Ohta, T. Ogawa, E. Ohta, T. Ikeuchi, K. Kamemura and S. Ikegami, *Nat. Prod. Res.*, 2013, **27**, 1842–1847.
611 T. Akiyama, K. Takada, T. Oikawa, N. Matsuura, Y. Ise, S. Okada and S. Matsunaga, *Tetrahedron*, 2013, **69**, 6560–6564.
612 N. Aoki, K. Yamamoto, T. Ogawa, E. Ohta, T. Ikeuchi, K. Kamemura, S. Ikegami and S. Ohta, *Nat. Prod. Res.*, 2013, **27**, 117–122.
613 W. M. Alarif, A. Abdel-Lateff, S. S. Al-Lihaibi, S.-E. N. Ayyad and F. A. Badria, *Z. Naturforsch., C: J. Biosci.*, 2013, **68**, 70–75.
614 H. Kim, J. Chin, H. Choi, K. Baek, T.-G. Lee, S. E. Park, W. Wang, D. Hahn, I. Yang, J. Lee, B. Mun, M. Ekins, S.-J. Nam and H. Kang, *Org. Lett.*, 2013, **15**, 100–103.
615 H. Kim, J. Chin, H. Choi, K. Baek, T.-G. Lee, S. E. Park, W. Wang, D. Hahn, I. Yang, J. Lee, B. Mun, M. Ekins, S.-J. Nam and H. Kang, *Org. Lett.*, 2013, **15**, 5614.
616 B. S. Hwang, K. Lee, C. Yang, E. J. Jeong and J.-R. Rho, *J. Nat. Prod.*, 2013, **76**, 2355–2359.
617 I. H. Hwang, J. Oh, A. Kochanowska-Karamyan, R. J. Doerksen, M. Na and M. T. Hamann, *Tetrahedron Lett.*, 2013, **54**, 3872–3876.
618 P. V. Kiem, N. X. Nhiem, N. V. Quang, C. V. Minh, N. H. Nam, N. T. Cuc, H. L. T. Anh, B. H. Tai, P. H. Yen, N. X. Cuong, N. P. Thao, N. T. Hoai, N. Y. Kim, S. J. Park and K. S. Hyun, *Nat. Prod. Commun.*, 2013, **8**, 1751–1752.
619 G. Chianese, F. Scala, B. Calcinai, C. Cerrano, H. A. Dien, M. Kaiser, D. Tasdemir and O. Taglialatela-Scafati, *Mar. Drugs*, 2013, **11**, 3297–3308.
620 J. S. Oh, B. S. Hwang, O.-H. Kang, D.-Y. Kwon and J.-R. Rho, *Mar. Drugs*, 2013, **11**, 4407–4418.

621 S. P. Gunasekera, M. Gunasekera, R. E. Longley and G. K. Schulte, *J. Org. Chem.*, 1990, **55**, 4912–4915.
622 C. Ruiz, K. Valderrama, S. Zea and L. Castellanos, *Mar. Biotechnol.*, 2013, **15**, 571–583.
623 S. Di Micco, A. Zampella, M. V. D'Auria, C. Festa, S. De Marino, R. Riccio, C. P. Butts and G. Bifulco, *Beilstein J. Org. Chem.*, 2013, **9**, 2940–2949.
624 J. Zhang, X. Tang, J. Li, P. Li, N. J. de Voogd, X. Ni, X. Jin, X. Yao, P. Li and G. Li, *J. Nat. Prod.*, 2013, **76**, 600–606.
625 P. Jumaryatno, L. K. Lambert, J. N. A. Hooper, J. T. Blanchfield and M. J. Garson, *Nat. Prod. Commun.*, 2013, **8**, 725–728.
626 C. Festa, S. De Marino, M. V. D'Auria, O. Taglialatela-Scafati, E. Deharo, S. Petek and A. Zampella, *Tetrahedron*, 2013, **69**, 3706–3713.
627 C. Festa, C. D'Amore, B. Renga, G. Lauro, S. De Marino, M. V. D'Auria, G. Bifulco, A. Zampella and S. Fiorucci, *Mar. Drugs*, 2013, **11**, 2314–2327.
628 S.-J. Piao, Y.-L. Song, W.-H. Jiao, F. Yang, X.-F. Liu, W.-S. Chen, B.-N. Han and H.-W. Lin, *Org. Lett.*, 2013, **15**, 3526–3529.
629 T. Kubota, Y. Ishiguro, A. Takahashi-Nakaguchi, J. Fromont, T. Gonoi and J. Kobayashi, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 244–247.
630 B. Yang, H. Tao, X. Zhou, X.-P. Lin and Y. Liu, *Nat. Prod. Res.*, 2013, **27**, 433–437.
631 M. Kimura, T. Wakimoto and I. Abe, *Tetrahedron Lett.*, 2013, **54**, 114–116.
632 Y. Imae, K. Takada, S. Okada, Y. Ise, H. Yoshimura, Y. Morii and S. Matsunaga, *J. Nat. Prod.*, 2013, **76**, 755–758.
633 Y. Nakao, S. Kawatsu, C. Okamoto, M. Okamoto, Y. Matsumoto, S. Matsunaga, R. van Soest and N. Fusetani, *J. Nat. Prod.*, 2008, **71**, 469–472.
634 J. A. Lewis, R. N. Daniels and C. W. Lindsley, *Org. Lett.*, 2008, **10**, 4545–4548.
635 M. J. Martin, L. Coello, R. Fernández, F. Reyes, A. Rodríguez, C. Murcia, M. Garranzo, C. Mateo, F. Sánchez–Sancho, S. Bueno, C. de Eguilior, A. Francesch, S. Munt and C. Cuevas, *J. Am. Chem. Soc.*, 2013, **135**, 10164–10171.
636 C. A. Bewley, C. Debitus and D. J. Faulkner, *J. Am. Chem. Soc.*, 1994, **116**, 7631–7636.
637 E. W. Schmidt and D. J. Faulkner, *Tetrahedron*, 1998, **54**, 3043–3056.
638 T. Hoffmann, S. Müller, S. Nadmid, R. Garcia and R. Müller, *J. Org. Chem.*, 2013, **135**, 16904–16911.
639 J.-K. Woo, J.-E. Jeon, C.-K. Kim, C.-J. Sim, D.-C. Oh, K.-B. Oh and J. Shin, *J. Nat. Prod.*, 2013, **76**, 1380–1383.
640 M. Kita, B. Gise, A. Kawamura and H. Kigoshi, *Tetrahedron Lett.*, 2013, **54**, 6826–6828.
641 E. Avilés and A. D. Rodríguez, *Tetrahedron*, 2013, **69**, 10797–10804.
642 A. Napolitano, M. Rodriquez, I. Bruno, S. Marzocco, G. Autore, R. Riccio and L. Gomez-Paloma, *Tetrahedron Lett.*, 2003, **59**, 10203–10211.
643 M. Pelay-Gimeno, A. Meli, J. Tulla-Puche and F. Albericio, *J. Med. Chem.*, 2013, **56**, 9780–9788.
644 S. Matsunaga and N. Fusetani, *J. Org. Chem.*, 1995, **60**, 1177–1181.
645 R. A. Espiritu, N. Matsumori, M. Murata, S. Nishimura, H. Kakeya, S. Matsunaga and M. Yoshida, *Biochemistry*, 2013, **52**, 2410–2418.
646 A. Sinisi, B. Calcinai, C. Cerrano, H. A. Dien, A. Zampella, C. D'Amore, B. Renga, S. Fiorucci and O. Taglialatela-Scafati, *Beilstein J. Org. Chem.*, 2013, **9**, 1643–1651.
647 R. Ueoka, Y. Ise, S. Ohtsuka, S. Okada, T. Yamori and S. Matsunaga, *J. Am. Chem. Soc.*, 2010, **132**, 17692–17694.
648 T. Kuranaga, Y. Sesoko, K. Sakata, N. Maeda, A. Hayata and M. Inoue, *J. Am. Chem. Soc.*, 2013, **135**, 5467–5474.
649 H. Li, J. J. Bowling, F. R. Fronczek, J. Hong, S. V. Jabba, T. F. Murray, N.-C. Ha, M. T. Hamann and J. H. Jung, *Biochim. Biophys. Acta*, 2013, **1830**, 2591–2599.
650 T. Amagata, T. A. Johnson, R. H. Cichewicz, K. Tenney, S. L. Mooberry, J. Media, M. Edelstein, F. A. Valeriote and P. Crews, *J. Med. Chem.*, 2008, **51**, 7234–7242.
651 A. Randazzo, C. Debitus and L. Gomez-Paloma, *Tetrahedron*, 2001, **57**, 4443–4446.
652 B. D. Williams and A. B. Smith III, *Org. Lett.*, 2013, **15**, 4584–4587.
653 B. Pfeiffer, S. Speck–Gisler, L. Barandun, U. Senft, C. de Groot, I. Lehmann, W. Ganci, J. Gertsch and K. H. Altmann, *J. Org. Chem.*, 2013, **78**, 2553–2563.
654 T. Sirirak, L. Brecker and A. Plubrukarn, *Nat. Prod. Res.*, 2013, **27**, 1213–1219.
655 J. Kobayashi, K. Kondo, M. Ishibashi, M. R. Walchli and T. Nakamura, *J. Am. Chem. Soc.*, 1993, **115**, 6661–6665.
656 K. Kondo, M. Ishibashi and J. Kobayashi, *Tetrahedron*, 1994, **50**, 8355–8362.
657 K. Nozawa, M. Tsuda, N. Tanaka, T. Kubota, E. Fukushi, J. Kawabata and J. Kobayashi, *Tetrahedron Lett.*, 2013, **54**, 783–787.
658 A. Sinisi, B. Calcinai, C. Cerrano, H. A. Dien, A. Zampella, C. D'Amore, B. Renga, S. Fiorucci and O. Taglialatela–Scafati, *Bioorg. Med. Chem.*, 2013, **21**, 5332–5338.
659 R. Sakai, K. Suzuki, K. Shimamoto and H. Kamiya, *J. Org. Chem.*, 2004, **69**, 1180–1185.
660 M. Sakai, Y. Ishikawa, S. Takamizawa and M. Oikawa, *Tetrahedron Lett.*, 2013, **54**, 5911–5912.
661 T. Nishi, T. Kubota, J. Fromont, T. Sasaki and J. Kobayashi, *Tetrahedron*, 2008, **64**, 3127–3132.
662 S. G. Davies, P. M. Roberts, R. S. Shah and J. E. Thomson, *Tetrahedron Lett.*, 2013, **54**, 6423–6426.
663 N. L. Seagraves and P. Crews, *J. Nat. Prod.*, 2005, **68**, 118–121.
664 T. Okaki, R. Fujimura, M. Sekiguchi, D. Zhou, K. Sugimoto, D. Minato, Y. Matsuya, A. Kato, I. Adachi, Y. Tezuka, R. A. Saporito and N. Toyooka, *Eur. J. Org. Chem.*, 2013, **14**, 2841–2848.
665 R. Sakai, T. Higa, C. W. Jefford and G. Bernardinelli, *J. Am. Chem. Soc.*, 1986, **108**, 6404–6405.
666 G. Kallifatidis, D. Hoepfner, T. Jaeg, E. A. Guzmán and A. E. Wright, *Mar. Drugs*, 2013, **11**, 3500–3516.
667 K. Eguchi, Y. Fujiwara, A. Hayashida, H. Horlad, H. Kato, H. Rotinsulu, F. Losung, R. E. P. Mangindaan, N. J. de

Voogd, M. Takeya and S. Tsukamoto, *Bioorg. Med. Chem.*, 2013, **21**, 3831–3838.
668 T. Kubota, Y. Kamijyo, A. Takahashi-Nakaguchi, J. Fromont, T. Gonoi and J. Kobayashi, *Org. Lett.*, 2013, **15**, 610–612.
669 J. I. Jiménez, G. Goetz, C. M. S. Mau, W. Y. Yoshida, P. J. Scheuer, R. T. Williamson and M. Kelly, *J. Org. Chem.*, 2000, **65**, 8465–8469.
670 W. P. Unsworth, K. A. Gallagher, M. Jean, J. P. Schmidt, L. J. Diorazio and R. J. K. Taylor, *Org. Lett.*, 2013, **15**, 262–265.
671 V. Damodaran, J. L. Ryan and R. A. Keyzers, *J. Nat. Prod.*, 2013, **76**, 1997–2001.
672 Y. Takekawa, S. Matsunaga, R. W. M. van Soest and N. Fusetani, *J. Nat. Prod.*, 2006, **69**, 1503–1505.
673 J. M. Langenhan, E. Mullarky, D. K. Rogalsky, J. R. Rohlfing, A. E. Tjaden, H. M. Werner, L. M. Rozal and S. A. Loskot, *J. Org. Chem.*, 2013, **78**, 1670–1676.
674 T. Kubota, K. Kura, J. Fromont and J. Kobayashi, *Tetrahedron*, 2013, **69**, 96–100.
675 S. Khokhar, Y. Feng, M. R. Campitelli, R. J. Quinn, J. N. A. Hooper, M. G. Ekins and R. A. Davis, *J. Nat. Prod.*, 2013, **76**, 2100–2105.
676 E. Dumdei and R. J. Andersen, *J. Nat. Prod.*, 1993, **56**, 792–794.
677 E. Dickson, B. R. Copp and D. Barker, *Tetrahedron Lett.*, 2013, **54**, 5239–5242.
678 Y.-J. Lee, D.-G. Lee, H. S. Rho, V. B. Krasokhin, H. J. Shin, J. S. Lee and H.-S. Lee, *J. Heterocycl. Chem.*, 2013, **50**, 1400–1404.
679 K. Imada, E. Sakai, H. Kato, T. Kawabata, S. Yoshinaga, T. Nehira, H. Terasawa and S. Tsukamoto, *Tetrahedron*, 2013, **69**, 7051–7055.
680 B. Bao, Q. Sun, X. Yao, J. Hong, C.-O. Lee, C. J. Sim, K. S. Im and J. H. Jung, *J. Nat. Prod.*, 2005, **68**, 711–715.
681 G. D. Kim, O. J. Cheong, S. Y. Bae, J. Shin and S. K. Lee, *Mar. Drugs*, 2013, **11**, 1087–1103.
682 D. T. A. Youssef, L. A. Shaala and H. Z. Asfour, *Mar. Drugs*, 2013, **11**, 1061–1070.
683 F. Russell, D. Harmody, P. J. McCarthy, S. A. Pomponi and A. E. Wright, *J. Nat. Prod.*, 2013, **76**, 1989–1992.
684 R. Momose, N. Tanaka, J. Fromont and J. Kobayashi, *Org. Lett.*, 2013, **15**, 2010–2013.
685 N. Tanaka, R. Momose, Y. Takahashi, T. Kubota, A. Takahashi-Nakaguchi, T. Gonoi, J. Fromont and J. Kobayashi, *Tetrahedron Lett.*, 2013, **54**, 4038–4040.
686 R. A. Davis, S. Duffy, S. Fletcher, V. M. Avery and R. J. Quinn, *J. Org. Chem.*, 2013, **78**, 9608–9613.
687 N. K. Utkina, A. E. Makarchenko, V. A. Denisenko and P. S. Dmitrenok, *Tetrahedron Lett.*, 2004, **45**, 7491–7494.
688 N. K. Utkina, A. E. Makarchenko and V. A. Denisenko, *J. Nat. Prod.*, 2005, **68**, 1424–1427.
689 D. H. Nadkarni, S. Murugesan and S. E. Velu, *Tetrahedron*, 2013, **69**, 4105–4113.
690 Y. Zou and M. T. Hamann, *Org. Lett.*, 2013, **15**, 1516–1519.
691 C.-D. Pham, R. Hartmann, W. E. G. Müller, N. de Voogd, D. Lai and P. Proksch, *J. Nat. Prod.*, 2013, **76**, 103–106.
692 X. Fu, J. R. Barnes, T. Do and F. J. Schmitz, *J. Nat. Prod.*, 1997, **60**, 497–498.
693 J. Das, A. Bhan, S. S. Mandal and C. J. Lovely, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 6183–6187.
694 A. G. Guzii, T. N. Makarieva, Y. V. Korolkova, Y. A. Andreev, I. V. Mosharova, K. M. Tabakmaher, V. A. Denisenko, P. S. Dmitrenok, E. K. Ogurtsova, A. S. Antonov, H.-S. Lee and E. V. Grishin, *Tetrahedron Lett.*, 2013, **54**, 1247–1250.
695 T. N. Makarieva, E. K. Ogurtsova, Y. V. Korolkova, Y. A. Andreev, I. V. Mosharova, K. M. Tabakmakher, A. G. Guzii, V. A. Denisenko, P. S. Dmitrenok, H.-S. Lee, E. V. Grishin and V. Stonik, *Nat. Prod. Commun.*, 2013, **8**, 1229–1232.
696 K. M. Tabakmakher, V. A. Denisenko, A. G. Guzii, P. S. Dmitrenok, S. A. Dyshlovoy, H. S. Lee and T. N. Makarieva, *Nat. Prod. Commun.*, 2013, **8**, 1399–1402.
697 K. Inaba, H. Sato, M. Tsuda and J. Kobayashi, *J. Nat. Prod.*, 1998, **61**, 693–695.
698 M. Yamaguchi, M. Miyazaki, M. P. Kodrasov, H. Rotinsulu, F. Losung, R. E. P. Mangindaan, N. J. de Voogd, H. Yokosawa, B. Nicholson and S. Tsukamoto, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 3884–3886.
699 N. Tanaka, T. Kusama, A. Takahashi-Nakaguchi, T. Gonoi, J. Fromont and J. Kobayashi, *Tetrahedron Lett.*, 2013, **54**, 3794–3796.
700 N. Tanaka, T. Kusama, A. Takahashi-Nakaguchi, T. Gonoi, J. Fromont and J. Kobayashi, *Org. Lett.*, 2013, **15**, 3262–3265.
701 E. A. Santalova, V. A. Denisenko and P. S. Dmitrenok, *Chem. Nat. Compd.*, 2013, **49**, 75–78.
702 K. Hirano, T. Kubota, M. Tsuda, K. Watanabe, J. Fromont and J. Kobayashi, *Tetrahedron*, 2000, **56**, 8107–8110.
703 S. Saha, C. V. R. Reddy, T. Chiranjeevi, U. Addepally, T. S. C. Rao and B. Patro, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 1013–1016.
704 T. D. Tran, N. B. Pham, G. Fechner, J. N. A. Hooper and R. J. Quinn, *J. Nat. Prod.*, 2013, **76**, 516–523.
705 Y.-J. Lee, S. Han, H.-S. Lee, J. S. Kang, J. Yun, C. J. Sim, H. J. Shin and J. S. Lee, *J. Nat. Prod.*, 2013, **76**, 1731–1736.
706 H. Niemann, W. Lin, W. E. G. Müller, M. Kubbutat, D. Lai and P. Proksch, *J. Nat. Prod.*, 2013, **76**, 121–125.
707 K. Kunze, H. Niemann, S. Ueberlein, R. Schulze, H. Ehrlich, E. Brunner, P. Proksch and K.-H. van Pée, *Mar. Drugs*, 2013, **11**, 1271–1287.
708 F. Yang, R.-H. Ji, J. Li, J.-H. Gan and H.-W. Lin, *Nat. Prod. Commun.*, 2013, **8**, 1713–1714.
709 Z.-B. Zhao, J.-Z. Sun, S.-C. Mao and Y.-W. Guo, *J. Asian Nat. Prod. Res.*, 2013, **15**, 198–202.
710 A. N. E.-S. Hamed, W. Wätjen, R. Schmitz, Y. Chovolou, R. Edrada-Ebel, D. T. A. Youssef, M. S. Kamel and P. Proksch, *Nat. Prod. Commun.*, 2013, **8**, 289–292.
711 L. Du, Y.-D. Zhou and D. G. Nagle, *J. Nat. Prod.*, 2013, **76**, 1175–1181.
712 A. E. Wright, S. A. Rueth and S. S. Cross, *J. Nat. Prod.*, 1991, **54**, 1108–1111.
713 T. Kamishima, T. Kikuchi and T. Katoh, *Eur. J. Org. Chem.*, 2013, **21**, 4558–4563.

714 W.-H. Jiao, X.-J. Huang, J.-S. Yang, F. Yang, S.-J. Piao, H. Gao, J. Li, W.-C. Ye, X.-S. Yao, W.-S. Chen and H.-W. Lin, *Org. Lett.*, 2012, **14**, 202–205.

715 B. Schmalzbauer, J. Herrmann, R. Muller and D. Menche, *Org. Lett.*, 2013, **15**, 964–967.

716 A. Yegdaneh, S. Putchakarn, S. Yuenyongsawad, A. Ghannadi and A. Plubrukarn, *Nat. Prod. Commun.*, 2013, **8**, 1355–1357.

717 W. Balansa, R. Islam, D. F. Gilbert, F. Fontaine, X. Xiao, H. Zhang, A. M. Piggott, J. W. Lynch and R. J. Capon, *Bioorg. Med. Chem.*, 2013, **21**, 4420–4425.

718 H. Yamazaki, T. Nakazawa, D. A. Sumilat, O. Takahashi, K. Ukai, S. Takahashi and M. Namikoshi, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 2151–2154.

719 H.-S. Park, S. Y. Park, C. J. Sim and J.-R. Rho, *Chem. Pharm. Bull.*, 2008, **56**, 1198–1200.

720 H. Zhang, J. M. Major, R. J. Lewis and R. J. Capon, *Org. Biomol. Chem.*, 2008, **6**, 3811–3815.

721 S.-H. Lee, J.-E. Jeon, C.-H. Ahn, S.-C. Chung, J. Shin and K.-B. Oh, *Appl. Microbiol. Biotechnol.*, 2013, **97**, 3141–3148.

722 G. R. Pettit, Y. Tang, Q. Zhang, G. T. Bourne, C. A. Arm, J. E. Leet, J. C. Knight, R. K. Pettit, J.-C. Chapuis, D. L. Doubek, F. J. Ward, C. Weber and J. N. A. Hooper, *J. Nat. Prod.*, 2013, **76**, 420–424.

723 A. Patra, C. W. J. Chang, P. J. Scheuer, G. D. van Duyne, G. K. Matsumoto and J. Clardy, *J. Am. Chem. Soc.*, 1984, **106**, 7981–7983.

724 I. T. Sandoval, E. J. Manos, R. M. Van Wagoner, R. G. C. Delacruz, K. Edes, D. R. Winge, C. M. Ireland and D. A. Jones, *Chem. Biol.*, 2013, **20**, 753–763.

725 D. Green, I. Goldberg, Z. Stein, M. Ilan and Y. Kashman, *Nat. Prod. Lett.*, 1992, **1**, 193–199.

726 J. Peng, K. Walsh, V. Weedman, J. D. Bergthold, J. Lynch, K. L. Lieu, I. A. Braude, M. Kelly and M. T. Hamann, *Tetrahedron*, 2002, **58**, 7809–7819.

727 C. Wang, D. Wang and S. Gao, *Org. Lett.*, 2013, **15**, 4402–4405.

728 A. J. Singh, J. D. Dattelbaum, J. J. Field, Z. Smart, E. F. Woolly, J. M. Barber, R. Heathcott, J. H. Miller and P. T. Northcote, *Org. Biomol. Chem.*, 2013, **11**, 8041–8051.

729 E. Avilés, A. D. Rodríguez and J. Vicente, *J. Org. Chem.*, 2013, **78**, 11294–11301.

730 N. X. Nhiem, N. V. Quang, C. V. Minh, D. T. T. Hang, H. L. T. Anh, B. H. Tai, P. H. Yen, N. T. Hoai, D. C. Thung and P. V. Kiem, *Nat. Prod. Commun.*, 2013, **8**, 1209–1212.

731 J.-E. Jeon, L. Liao, H. Kim, C. J. Sim, D.-C. Oh, K.-B. Oh and J. Shin, *J. Nat. Prod.*, 2013, **76**, 1679–1685.

732 F. Lefranc, G. Nuzzo, N. A. Hamdy, I. Fakhr, L. M. Y. Banuls, G. Van Goietsenoven, G. Villani, V. Mathieu, R. van Soest, R. Kiss and M. L. Ciavatta, *J. Nat. Prod.*, 2013, **76**, 1541–1547.

733 C. Audoin, D. Bonhomme, J. Ivanisevic, M. de la Cruz, B. Cautain, M. C. Monteiro, F. Reyes, L. Rios, T. Perez and O. P. Thomas, *Mar. Drugs*, 2013, **11**, 1477–1489.

734 J. Li, L. Du, M. Kelly, Y.-D. Zhou and D. G. Nagle, *J. Nat. Prod.*, 2013, **76**, 1492–1497.

735 J. Daoust, M. Chen, M. Wang, D. E. Williams, M. A. G. Chavez, Y. A. Wang, C. E. Merchant, A. Fontana, T. J. Kieffer and R. J. Andersen, *J. Org. Chem.*, 2013, **78**, 8267–8273.

736 W. Balansa, R. Islam, F. Fontaine, A. M. Piggott, H. Zhang, X. Xiao, T. L. Webb, D. F. Gilbert, J. W. Lynch and R. J. Capon, *Org. Biomol. Chem.*, 2013, **11**, 4695–4701.

737 W. Wang, B. Mun, Y. Lee, M. V. Reddy, Y. Park, J. Lee, H. Kim, D. Hahn, J. Chin, M. Ekins, S.-J. Nam and H. Kang, *J. Nat. Prod.*, 2013, **76**, 170–177.

738 Y.-M. Fuh, M.-C. Lu, C.-H. Lee and J.-H. Su, *Nat. Prod. Commun.*, 2013, **8**, 571–572.

739 D. Hahn, D. H. Won, B. Mun, H. Kim, C. Han, W. Wang, T. Chun, S. Park, D. Yoon, H. Choi, S.-J. Nam, M. Ekins, J. Chin and H. Kang, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 2336–2339.

740 L. Harinantenaina, P. J. Brodie, J. Maharavo, G. Bakary, K. TenDyke, Y. Shen and D. G. I. Kingston, *Bioorg. Med. Chem.*, 2013, **21**, 2912–2917.

741 L. P. P. Cano, S. A. Bartolotta, N. A. Casanova, G. E. Siless, E. Portmann, L. Schejter, J. A. Palermo and M. A. Carballo, *Steroids*, 2013, **78**, 982–986.

742 T.-R. Su, K.-J. Liang, M.-Y. Chiang, M.-C. Lu, Y.-J. Wu and J.-H. Su, *Nat. Prod. Commun.*, 2013, **8**, 1535–1536.

743 Z.-B. Cheng, H. Xiao, C.-Q. Fan, Y.-N. Lu, G. Zhang and S. Yin, *Steroids*, 2013, **78**, 1353–1358.

744 X. C. Nguyen, A. Longeon, V. C. Pham, F. Urvois, C. Bressy, T. T. V. Trinh, H. N. Nguyen, V. K. Phan, V. M. Chau, J.-F. Briand and M.-L. Bourguet–Kondracki, *J. Nat. Prod.*, 2013, **76**, 1313–1318.

745 R. A. Keyzers, J. Daoust, M. T. Davies-Coleman, R. van Soest, A. Balgi, E. Donohue, M. Roberge and R. J. Andersen, *Org. Lett.*, 2008, **10**, 2959–2962.

746 R. Forestieri, E. Donohue, A. Balgi, M. Roberge and R. J. Andersen, *Org. Lett.*, 2013, **15**, 3918–3921.

747 Z. Lu, M. Koch, M. K. Harper, T. K. Matainaho, L. R. Barrows, R. M. Van Wagoner and C. M. Ireland, *J. Nat. Prod.*, 2013, **76**, 2150–2152.

748 D.-Q. Xue, S.-C. Mao, X.-Q. Yu and Y.-W. Guo, *Biochem. Syst. Ecol.*, 2013, **49**, 101–106.

749 S. S. Afiyatullov, A. I. Kalinovsky, A. S. Antonov, L. P. Ponomarenko, P. S. Dmitrenok, D. L. Aminin, V. B. Krasokhin, V. M. Nosova and A. V. Kisin, *J. Nat. Prod.*, 2007, **70**, 1871–1877.

750 S. A. Kolesnikova, E. G. Lyakhova, A. I. Kalinovsky, M. A. Pushilin, S. S. Afiyatullov, E. A. Yurchenko, S. A. Dyshlovoy, C. V. Minh and V. A. Stonik, *J. Nat. Prod.*, 2013, **76**, 1746–1752.

751 J. Colorado, D. Muñoz, D. Marquez, M. E. Marquez, J. Lopez, O. P. Thomas and A. Martinez, *Molecules*, 2013, **18**, 2598–2610.

752 S. Ahmed, A. Ibrahim and A. S. Arafa, *Tetrahedron Lett.*, 2013, **54**, 2377–2381.

753 R. Huang, Y. Peng, X. Zhou, M. Fu, S. Tian and Y. Liu, *Nat. Prod. Res.*, 2013, **27**, 319–322.

754 N. Cachet, L. Loffredo, O. O. Vicente and O. P. Thomas, *Phytochem. Lett.*, 2013, **6**, 205–208.

755 S.-H. Qi, G.-C. Su, Y.-F. Wang, Q.-Y. Liu and C.-H. Gao, *Chem. Pharm. Bull.*, 2009, **57**, 87–88.
756 S.-H. Qi, G.-C. Su, Y.-F. Wang, Q.-Y. Liu and C.-H. Gao, *Chem. Pharm. Bull.*, 2013, **61**, 887.
757 A. Berndt, M. Gruner, A. W. Schmidt and H.-J. Knölker, *Synlett*, 2013, **24**, 2102–2106.
758 S. Kodani, K. Sato, T. Higuchi, B. E. Casareto and Y. Suzuki, *Nat. Prod. Res.*, 2013, **27**, 1859–1862.
759 H.-M. Chung, J.-H. Su, T.-L. Hwang, J.-J. Li, J.-J. Chen, Y.-H. Chen, Y.-C. Chang, Y.-D. Su, Y.-H. Chen, L.-S. Fang, J.-H. Sheu, W.-H. Wang and P.-J. Sung, *Tetrahedron*, 2013, **69**, 2740–2744.
760 H.-M. Chung, W.-H. Wang, T.-L. Hwang, Y.-C. Wu and P.-J. Sung, *Nat. Prod. Commun.*, 2013, **8**, 1037–1040.
761 D. Chen, W. Chen, D. Liu, L. van Ofwegen, P. Proksch and W. Lin, *J. Nat. Prod.*, 2013, **76**, 1753–1763.
762 Y.-J. Xio, J.-H. Su, B.-W. Chen, Y.-J. Tseng, Y.-C. Wu and J.-H. Sheu, *Mar. Drugs*, 2013, **11**, 3735–3741.
763 Y.-J. Tseng, Y.-S. Lee, S.-K. Wang, J.-H. Sheu and C.-Y. Duh, *Mar. Drugs*, 2013, **11**, 2501–2509.
764 B. Yang, S. Liao, X. Lin, J. Wang, J. Liu, X. Zhou, X. Yang and Y. Liu, *Mar. Drugs*, 2013, **11**, 4741–4750.
765 E. R. Wagner, R. D. Moss, R. M. Brooker, J. P. Heeschen, W. J. Potts and M. L. Dilling, *Tetrahedron Lett.*, 1965, 4233–4239.
766 P. Georgantea, E. Ioannou, C. Vagias and V. Roussis, *Tetrahedron Lett.*, 2013, **54**, 6920–6922.
767 Y.-F. Lin, C.-Y. Kuo, Z.-H. Wen, Y.-Y. Lin, W.-H. Wang, J.-H. Su, J.-H. Sheu and P.-J. Sung, *Molecules*, 2013, **18**, 8160–8167.
768 L. Li, C.-Y. Wang, C.-L. Shao, L. Han, X.-P. Sun, J. Zhao, Y.-W. Guo, H. Huang and H.-S. Guan, *J. Asian Nat. Prod. Res.*, 2009, **11**, 851–855.
769 N. P. Thao, N. H. Nam, N. X. Cuong, T. H. Quang, P. T. Tung, L. D. Dat, D. Chae, S. Kim, Y.-S. Koh, P. V. Kiem, C. V. Minh and Y. H. Kim, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 228–231.
770 H.-Y. Fang, C.-H. Hsu, C.-H. Chao, Z.-H. Wen, Y.-C. Wu, C.-F. Dai and J.-H. Sheu, *Mar. Drugs*, 2013, **11**, 1853–1865.
771 T.-C. Tsai, Y.-J. Wu, J.-H. Su, W.-T. Lin and Y.-S. Lin, *Mar. Drugs*, 2013, **11**, 114–123.
772 K.-H. Chen, C.-F. Dai, M.-C. Lu, J.-J. Li, J.-J. Chen, Y.-C. Chang, Y.-D. Su, W.-H. Wang and P.-J. Sung, *Mar. Drugs*, 2013, **11**, 3372–3380.
773 L.-C. Hu, J.-H. Su, M. Y.-N. Chiang, M.-C. Lu, T.-L. Hwang, Y.-H. Chen, W.-P. Hu, N.-C. Lin, W.-H. Wang, L.-S. Fang, Y.-H. Kuo and P.-J. Sung, *Mar. Drugs*, 2013, **11**, 1999–2012.
774 A. Ma, Z. Deng, L. van Ofwegen, M. Bayer, P. Proksch and W. Lin, *J. Nat. Prod.*, 2008, **71**, 1152–1160.
775 C.-C. Su, B.-S. Wong, C. Chin, Y.-J. Wu and J.-H. Su, *Int. J. Mol. Sci.*, 2013, **14**, 4317–4325.
776 Y.-S. Lin, C.-H. Chen, C.-C. Liaw, Y.-C. Chen, Y.-H. Kuo and Y.-C. Shen, *Tetrahedron*, 2009, **65**, 9157–9164.
777 L.-C. Hu, W.-H. Yen, J.-H. Su, M. Y.-N. Chiang, Z.-H. Wen, W.-F. Chen, T.-J. Lu, Y.-W. Chang, Y.-H. Chen, W.-H. Wang, Y.-C. Wu and P.-J. Sung, *Mar. Drugs*, 2013, **11**, 2154–2167.
778 W.-H. Yen, Y.-D. Su, Y.-C. Chang, Y.-H. Chen, Y.-H. Chen, C.-F. Dai, Z.-H. Wen, J.-H. Su and P.-J. Sung, *Tetrahedron Lett.*, 2013, **54**, 2267–2270.
779 H.-F. Lin, H.-J. Su, N.-L. Lee and J.-H. Su, *Nat. Prod. Commun.*, 2013, **8**, 1363–1364.
780 D. Lai, Z. Geng, Z. Deng, L. van Ofwegen, P. Proksch and W. Lin, *J. Agric. Food Chem.*, 2013, **61**, 4585–4592.
781 J. Yin, M. Zhao, M. Ma, Y. Xu, Z. Xiang, Y. Cai, J. Dong, X. Lei, K. Huang and P. Yan, *Mar. Drugs*, 2013, **11**, 455–465.
782 M. Zhao, X. Li, F. Zhao, S. Cheng, Z. Xiang, J. Dong, K. Huang and P. Yan, *Chem. Pharm. Bull.*, 2013, **61**, 1323–1328.
783 M. Zhao, J. Yin, W. Jiang, M. Ma, X. Lei, Z. Xiang, J. Dong, K. Huang and P. Yan, *Mar. Drugs*, 2013, **11**, 1162–1172.
784 C. B. Rao, C. Satyanarayana, D. S. Rao, D. V. Rao, E. Fahy and D. J. Faulkner, *J. Nat. Prod.*, 1993, **56**, 2003–2007.
785 F. Cao, J. Zhou, K.-X. Xu, M.-Q. Zhang and C.-Y. Wang, *Nat. Prod. Commun.*, 2013, **8**, 1675–1678.
786 S.-K. Wang, M.-K. Hsieh and C.-Y. Duh, *Mar. Drugs*, 2013, **11**, 4318–4327.
787 Z. Xi, W. Bie, W. Chen, D. Liu, L. van Ofwegen, P. Proksch and W. Lin, *Mar. Drugs*, 2013, **11**, 3186–3196.
788 R. F. Abou El-Ezz, S. A. Ahmed, M. M. Radwan, N. A. Ayoub, M. S. Afifi, S. A. Ross, P. T. Szymanski, H. Fahmy and S. I. Khalifa, *Tetrahedron Lett.*, 2013, **54**, 989–992.
789 C.-X. Zhang, X.-X. He, J. Zhang, Q. Guo, L.-F. Lei, J.-Y. Su and L.-M. Zeng, *Nat. Prod. Res.*, 2013, **27**, 782–786.
790 Z. Xi, W. Bie, W. Chen, D. Liu, L. van Ofwegen, P. Proksch and W. Lin, *Helv. Chim. Acta*, 2013, **96**, 2218–2227.
791 P. C. Yan, Y. Lv, L. van Ofwegen, P. Proksch and W. Lin, *Org. Lett.*, 2010, **12**, 2484–2487.
792 P. Yan, Z. Deng, L. van Ofwegen, P. Proksch and W. Lin, *Mar. Drugs*, 2010, **8**, 2837–2848.
793 P. Yan, Z. Deng, L. van Ofwegen, P. Proksch and W. Lin, *Chem. Pharm. Bull.*, 2010, **58**, 1591–1595.
794 L.-M. Zeng, W.-J. Lan, J.-Y. Su, G.-W. Zhang, X.-L. Feng, Y.-J. Liang and X.-P. Yang, *J. Nat. Prod.*, 2004, **67**, 1915–1918.
795 P. Yan, Z. Deng, L. van Ofwegen, P. Proksch and W. Lin, *Chem. Biodiversity*, 2011, **8**, 1724–1734.
796 X.-H. Yan, M. Gavagnin, G. Cimino and Y.-W. Guo, *Tetrahedron Lett.*, 2007, **48**, 5313–5316.
797 R. Jia, T. Kurtan, A. Mandi, X.-H. Yan, W. Zhang and Y.-W. Guo, *J. Org. Chem.*, 2013, **78**, 3113–3119.
798 W.-J. Lan, S.-L. Wang and H.-J. Li, *Nat. Prod. Commun.*, 2009, **4**, 1193–1196.
799 Y.-F. Li, L.-L. He, H.-L. Liu, L.-F. Liang, H.-B. Zhang and Y.-W. Guo, *J. Asian Nat. Prod. Res.*, 2013, **15**, 566–573.
800 P. Yan, Z. Deng, L. van Ofwegen, P. Proksch and W. Lin, *Chem. Pharm. Bull.*, 2010, **58**, 1591–1595.
801 M.-E. F. Hegazy, T. A. Mohamed, F. F. Abdel-Latif, M. S. Alsaid, A. A. Shahat and P. W. Pare, *Phytochem. Lett.*, 2013, **6**, 383–386.
802 L.-F. Liang, T. Kurtan, A. Mandi, L.-G. Yao, J. Li, W. Zhang and Y.-W. Guo, *Org. Lett.*, 2013, **15**, 274–277.
803 L.-F. Liang, L.-X. Gao, J. Li, O. Taglialatela-Scafati and Y.-W. Guo, *Bioorg. Med. Chem.*, 2013, **21**, 5076–5080.

804 L.-F. Liang, L.-F. Lan, O. Taglialatela-Scafati and Y.-W. Guo, *Tetrahedron*, 2013, **69**, 7381–7386.
805 C. Zhang, J. Li, J. Su, Y. Liang, X. Yang, K. Zheng and L. Zeng, *J. Nat. Prod.*, 2006, **69**, 1476–1480.
806 J. A. Toth, B. J. Burreson, P. J. Scheuer, J. Finer-Moore and J. Clardy, *Tetrahedron*, 1980, **36**, 1307–1309.
807 R. Jia, Y.-W. Guo, E. Mollo and G. Cimino, *Helv. Chim. Acta*, 2005, **88**, 1028–1033.
808 C. Li, M. Jiang, M.-P. La, T.-J. Li, H. Tang, P. Sun, B.-S. Liu, Y.-H. Yi, Z. Liu and W. Zhang, *Mar. Drugs*, 2013, **11**, 1565–1582.
809 J.-F. Sun, Z. Han, X.-F. Zhou, B. Yang, X. Lin, J. Liu, Y. Peng, X.-W. Yang and Y. Liu, *Tetrahedron*, 2013, **69**, 871–880.
810 C.-C. Liaw, Y.-C. Lin, Y.-S. Lin, C.-H. Chen, T.-L. Hwang and Y.-C. Shen, *Mar. Drugs*, 2013, **11**, 2042–2053.
811 B.-W. Chen, S.-Y. Wang, C.-Y. Huang, S.-L. Chen, Y.-C. Wu and J.-H. Sheu, *Tetrahedron*, 2013, **69**, 2296–2301.
812 Y.-S. Cai, L.-G. Yao, A. Di Pascale, C. Irace, E. Mollo, O. Taglialatela-Scafati and Y.-W. Guo, *Tetrahedron*, 2013, **69**, 2214–2219.
813 T. Miyamoto, K. Yamada, N. Ikeda, T. Komori and R. Higuchi, *J. Nat. Prod.*, 1994, **57**, 1212–1219.
814 C.-J. Tai, J.-H. Su, C.-Y. Huang, M.-S. Huang, Z.-H. Wen, C.-F. Dai and J.-H. Sheu, *Mar. Drugs*, 2013, **11**, 788–799.
815 Y.-N. Lee, C.-J. Tai, T.-L. Hwang and J.-H. Sheu, *Mar. Drugs*, 2013, **11**, 2741–2750.
816 M. Ochi, K. Yamada, K. Kataoka, H. Kotsuki and K. Shibata, *Chem. Lett.*, 1992, 155–158.
817 T.-H. Chen, M.-C. Lu, Y.-C. Chang, Y.-D. Su, Y.-H. Chen, N.-C. Lin, L.-S. Fang, Y.-C. Wu and P.-J. Sung, *Mar. Drugs*, 2013, **11**, 4585–4593.
818 F.-Y. Shih, T.-H. Chen, M.-C. Lu, W.-F. Chen, Z.-H. Wen, Y.-H. Kuo and P.-J. Sung, *Int. J. Mol. Sci.*, 2013, **14**, 21781–21789.
819 M.-C. Lin, B.-W. Chen, C.-Y. Huang, C.-F. Dai, T.-L. Hwang and J.-H. Sheu, *J. Nat. Prod.*, 2013, **76**, 1661–1667.
820 T.-T. Li, X.-L. Tang, C.-L. Chen, X.-W. Zhang, R.-C. Wu, H.-Y. Zhu, P.-L. Li and G.-Q. Li, *Helv. Chim. Acta*, 2013, **96**, 1188–1196.
821 Y.-J. Tseng, S.-K. Wang and C.-Y. Duh, *Mar. Drugs*, 2013, **11**, 3288–3296.
822 G. Zhang, X. Tang, C. Cheng, K. Gong, X. Zhang, H. Zhu, R. Wu, P. Li and G. Li, *Steroids*, 2013, **78**, 845–850.
823 H.-Y. Zhao, C.-L. Shao, Z.-Y. Li, L. Han, F. Cao and C.-Y. Wang, *Molecules*, 2013, **18**, 3458–3466.
824 K.-K. Gong, X.-L. Tang, G. Zhang, C.-L. Cheng, X.-W. Zhang, P.-L. Li and G.-Q. Li, *Mar. Drugs*, 2013, **11**, 4788–4798.
825 L.-L. Sun, C.-L. Shao, H. Hang, Z.-Y. Guo, Q. Xing and C.-Y. Wang, *Nat. Prod. Res.*, 2013, **27**, 1159–1166.
826 M. Shaaban, K. A. Shaaban and M. A. Ghani, *Steroids*, 2013, **78**, 866–873.
827 A. Umeyama, N. Shoji, M. Ozeki and S. Arihara, *J. Nat. Prod.*, 1996, **59**, 894–895.
828 A. I. Elshamy, A. F. Abdel-Razik, M. I. Nassar, T. K. Mohamed, M. A. Ibrahim and S. M. El-Kousy, *Nat. Prod. Res.*, 2013, **27**, 1250–1254.
829 M. Shaaban, M. A. Ghani and K. A. Shaaban, *Z. Naturforsch., B: J. Chem. Sci.*, 2013, **68**, 939–945.
830 P. Wang, H. Tang, B.-S. Liu, T.-J. Li, P. Sun, W. Zhu, Y.-P. Luo and W. Zhang, *Steroids*, 2013, **78**, 951–958.
831 T.-F. Liu, X. Lu, H. Tang, M.-M. Zhang, P. Wang, P. Sun, Z.-Y. Liu, Z.-L. Wang, L. Li, Y.-C. Rui, T.-J. Li and W. Zhang, *Steroids*, 2013, **78**, 108–114.
832 L.-F. Liang, X.-J. Wang, H.-Y. Zhang, H.-L. Liu, J. Li, L.-F. Lan, W. Zhang and Y.-W. Guo, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 1334–1337.
833 S.-K. Wang, S.-Y. Puu and C.-Y. Duh, *Mar. Drugs*, 2013, **11**, 571–580.
834 Z. Wang, H. Tang, P. Wang, W. Gong, M. Xue, H. Zhang, T. Liu, B. Liu, Y. Yi and W. Zhang, *Mar. Drugs*, 2013, **11**, 775–787.
835 N. P. Thao, N. H. Nam, N. X. Cuong, B. H. Tai, T. H. Quang, N. T. T. Ngan, B. T. T. Luyen, S. Y. Yang, C. H. Choi, S. Kim, D. Chae, Y.-S. Koh, P. V. Kiem, C. V. Minh and Y. H. Kim, *Bull. Korean Chem. Soc.*, 2013, **34**, 949–952.
836 L.-L. Sun, X.-M. Fu, X.-B. Li, Q. Xing and C.-Y. Wang, *Nat. Prod. Res.*, 2013, **27**, 2006–2011.
837 W.-H. Yen, W.-F. Chen, C.-H. Cheng, C.-F. Dai, M.-C. Lu, J.-H. Su, Y.-D. Su, Y.-H. Chen, Y.-C. Chang, Y.-H. Chen, J.-H. Sheu, C.-S. Lin, Z.-H. Wen and P.-J. Sung, *Molecules*, 2013, **18**, 2895–2903.
838 J. Zhang, X.-J. Liao, K.-L. Wang, Z. Deng and S.-H. Xu, *Steroids*, 2013, **78**, 396–400.
839 C.-H. Chao, Y.-C. Wu, Z.-H. Wen and J.-H. Sheu, *Mar. Drugs*, 2013, **11**, 136–145.
840 C.-Y. Huang, C.-C. Liaw, B.-W. Chen, P.-C. Chen, J.-H. Su, P.-J. Sung, C.-F. Dai, M. Y. Chiang and J.-H. Sheu, *J. Nat. Prod.*, 2013, **76**, 1902–1908.
841 J. Zhang, L.-C. Li, K.-L. Wang, X.-J. Liao, Z. Deng and S.-H. Xu, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 1079–1082.
842 M. Jiang, P. Sun, H. Tang, B.-S. Liu, T.-J. Li, C. Li and W. Zhang, *J. Nat. Prod.*, 2013, **76**, 764–768.
843 S. Qi, S. Zhang, J. Huang, Z. Xiao, J. Wu and Q. Li, *Magn. Reson. Chem.*, 2005, **43**, 266–268.
844 C.-H. Chao, C.-H. Hsieh, S.-P. Chen, C.-K. Lu, C.-F. Dai and J.-H. Sheu, *Tetrahedron Lett.*, 2006, **47**, 5889–5891.
845 K. Ota and H. Miyaoka, *Chem. Commun.*, 2013, **49**, 8148–8150.
846 H. Takamura, K. Iwamoto, E. Nakao and I. Kadota, *Org. Lett.*, 2013, **15**, 1108–1111.
847 J. S. Clark, R. Berger, S. T. Hayes, H. M. Senn, L. J. Farrugia, L. H. Thomas, A. J. Morrison and L. Gobbi, *J. Org. Chem.*, 2013, **78**, 673–696.
848 M. J. Palframan and G. Pattenden, *Tetrahedron Lett.*, 2013, **54**, 6822–6825.
849 M. J. Palframan and G. Pattenden, *Tetrahedron Lett.*, 2013, **54**, 324–328.
850 H. Kikuchi, Y. Tsukitani, Y. Yamada, K. Iguchi, S. A. Drexler and J. Clardy, *Tetrahedron Lett.*, 1982, **23**, 1063–1066.
851 H.-P. Lee, S.-Y. Huang, Y.-Y. Lin, H.-M. Wang, Y.-H. Jean, S.-F. Wu, C.-Y. Duh and Z.-H. Wen, *Mar. Drugs*, 2013, **11**, 99–113.

852 W.-H. Yen, L.-C. Hu, J.-H. Su, M.-C. Lu, W.-H. Twan, S.-Y. Yang, Y.-C. Kuo, C.-F. Weng, C.-H. Lee, Y.-H. Kuo and P.-J. Sung, *Molecules*, 2012, **17**, 14058–14066.
853 K.-J. Huang, Y.-C. Chen, M. El-Shazly, Y.-C. Du, J.-H. Su, C.-W. Tsao, W.-H. Yen, W.-B. Chang, Y.-D. Su, Y.-T. Yeh and M.-C. Lu, *Molecules*, 2013, **18**, 2924–2933.
854 Y. Kashman, M. Bodner, Y. Loya and Y. Benayahu, *Isr. J. Chem.*, 1977, **16**, 1–3.
855 W.-L. Hsu, S.-J. Chiu, Y.-T. Tsai, C.-M. Chang, J.-Y. Wang, E. T. Wang, M.-F. Hou, C.-Y. Huang, J.-H. Sheu and W.-C. Chang, *Molecules*, 2013, **18**, 7023–7034.
856 C.-Y. Kao, J.-H. Su, M.-C. Lu, T.-L. Hwang, W.-H. Wang, J.-J. Chen, J.-H. Sheu, Y.-H. Kuo, C.-F. Weng, L.-S. Fang, Z.-H. Wen and P.-J. Sung, *Mar. Drugs*, 2011, **9**, 1319–1331.
857 C.-Y. Lin, M.-C. Lu, J.-H. Su, C.-L. Chu, D. Shiuan, C.-F. Weng, P.-J. Sung and K.-J. Huang, *Mar. Drugs*, 2013, **11**, 1336–1350.
858 S. A. Look, W. Fenical, G. K. Matsumoto and J. Clardy, *J. Org. Chem.*, 1986, **51**, 5140–5145.
859 D. R. Day, S. Jabaiah, R. S. Jacobs and R. D. Little, *Mar. Drugs*, 2013, **11**, 3258–3271.
860 T. Higa, J. Tanaka, Y. Tsukitani and H. Kikuchi, *Chem. Lett.*, 1981, 1647–1650.
861 C. Ishikawa, J. Tanaka, H. Katano, M. Senba and N. Mori, *Mar. Drugs*, 2013, **11**, 3410–3424.
862 C. Schneider, M. L. Manier, D. L. Hachey and A. R. Brash, *Lipids*, 2002, **37**, 217–221.
863 E. Reina, F. A. Ramos, L. Castellanos, M. Aragon and L. F. Ospina, *J. Pharm. Pharmacol.*, 2013, **65**, 1643–1652.
864 S.-L. Wu, J.-H. Su, C.-Y. Huang, C. J. Tai, P.-J. Sung, C.-C. Liaw and J.-H. Sheu, *Mar. Drugs*, 2012, **10**, 1203–1211.
865 B.-W. Chen, Y.-C. Wu, M. Y. Chiang, J.-H. Su, W.-H. Wang, T.-Y. Fan and J.-H. Sheu, *Tetrahedron*, 2009, **65**, 7016–7022.
866 Y.-H. Chen, T.-L. Hwang, Y.-D. Su, Y.-C. Chang, P.-H. Hong, L.-C. Hu, W.-H. Yen, H.-Y. Hsu, S.-J. Huang, Y.-H. Kuo and P.-J. Sung, *Chem. Pharm. Bull.*, 2012, **60**, 160–163.
867 S.-L. Wu, J.-H. Su, C.-Y. Huang, C.-J. Tai, P.-J. Sung, C.-C. Liaw and J.-H. Sheu, *Mar. Drugs*, 2013, **11**, 5087–5088.
868 M. R. Prinsep and M. Dumté, *Nat. Prod. Commun.*, 2013, **8**, 693–694.
869 A. R. Carroll, S. Duffy, M. Sykes and V. M. Avery, *Org. Biomol. Chem.*, 2011, **9**, 604–609.
870 F. A. Khan and S. Ahmad, *Tetrahedron Lett.*, 2013, **54**, 2996–2998.
871 Y. Kamano, H. Zhang, Y. Ichihara, H. Kizu, K. Komiyama and G. R. Pettit, *Tetrahedron Lett.*, 1995, **36**, 2783–2784.
872 G. S. M. Figueiredo, R. S. Zardo, B. V. Silva, F. A. Violante, A. C. Pinto and P. D. Fernandes, *Pharmacol., Biochem. Behav.*, 2013, **103**, 431–439.
873 K. Konoki, T. Onoda, R. Watanabe, Y. Cho, S. Kaga, T. Suzuki and M. Yotsu-Yamashita, *Mar. Drugs*, 2013, **11**, 300–315.
874 H. Kawashima, M. Ohnishi and S. Ogawa, *J. Oleo Sci.*, 2013, **62**, 465–470.
875 E. Villaverde-de-Sáa, C. Valls-Cantenys, J. B. Quintana, R. Rodil and R. Cela, *J. Chromatogr. A*, 2013, 85–94.
876 M. Carbone, M. L. Ciavatta, J.-R. Wang, I. Cirillo, V. Mathieu, R. Kiss, E. Mollo, Y.-W. Guo and M. Gavagnin, *J. Nat. Prod.*, 2013, **76**, 2065–2073.
877 C. M. Ireland, J. E. Biskupiak, G. J. Hite, M. Rapposch, P. J. Scheuer and J. R. Ruble, *J. Org. Chem.*, 1984, **49**, 559–561.
878 S. Jaisamut, S. Prabpai, C. Tancharoen, S. Yuenyongsawad, S. Hannongbua, P. Kongsaeree and A. Plubrukarn, *J. Nat. Prod.*, 2013, **76**, 2158–2161.
879 K. C. Tan, T. Wakimoto, K. Takada, T. Ohtsuki, N. Uchiyama, Y. Goda and I. Abe, *J. Nat. Prod.*, 2013, **76**, 1388–1391.
880 S. Smith and G. M. Timms, *J. Chem. Soc.*, 1937, 396–401.
881 T. Wakimoto, K. C. Tan and I. Abe, *Toxicon*, 2013, **72**, 1–4.
882 M. Carbone, C. Muniain, F. Castelluccio, O. Iannicelli and M. Gavagnin, *Biochem. Syst. Ecol.*, 2013, **49**, 172–175.
883 K. E. Clark, A. Capper, G. Della Togna, V. J. Paul, L. I. Romero, T. Johns, L. Cubilla-Rios and T. L. Capson, *Nat. Prod. Commun.*, 2013, **8**, 1537–1540.
884 I. W. Mudianta, V. L. Challinor, A. E. Winters, K. L. Cheney, J. J. De Voss and M. J. Garson, *Beilstein J. Org. Chem.*, 2013, **9**, 2925–2933.
885 P. Ciminiello, C. Dell'Aversano, E. Fattorusso, M. Forino, S. Magno, S. Ianaro and M. Di Rosa, *Eur. J. Org. Chem.*, 2001, 49–53.
886 P. Ciminiello, C. Dell'Aversano, E. Fattorusso, M. Forino, S. Magno, F. U. Santelia, V. I. Moutsos, E. N. Pitsinos and E. A. Couladouros, *Tetrahedron*, 2006, **62**, 7738–7743.
887 D. H. Dethe and A. Ranjan, *RSC Adv.*, 2013, **3**, 23692–23703.
888 Y. Nakao, W. Y. Yoshida, Y. Takada, J. Kimura, L. Yang, S. L. Mooberry and P. L. Scheuer, *J. Nat. Prod.*, 2004, **67**, 1332–1340.
889 Y. Takada, M. Umehara, Y. Nakao and J. Kimura, *Tetrahedron Lett.*, 2008, **49**, 1163–1165.
890 M. Umehara, T. Negishi, Y. Maehara, Y. Nakao and J. Kimura, *Tetrahedron*, 2013, **69**, 3045–3053.
891 Y. Kato and P. J. Scheuer, *J. Am. Chem. Soc.*, 1974, **96**, 2245–2246.
892 Y. Hanaki, M. Kikumori, S. Ueno, H. Tokuda, N. Suzuki and K. Irie, *Tetrahedron*, 2013, **69**, 7636–7645.
893 D. S. Dalisay, E. W. Rogers, A. S. Edison and T. F. Molinski, *J. Nat. Prod.*, 2009, **72**, 732–738.
894 W. Tantisantisom, D. M. Ramsey and S. R. McAlpine, *Org. Lett.*, 2013, **15**, 4638–4641.
895 M. T. Hamann and P. J. Scheuer, *J. Am. Chem. Soc.*, 1993, **115**, 5825–5826.
896 R. Salazar, H. Cortés-Funes, E. Casado, B. Pardo, A. López-Martín, C. Cuadra, J. Tabernero, C. Coronado, M. Garciá, A. S. Matos-Pita, B. Miguel-Lillo, M. Cullell-Young, J. L. Iglesias Dios and L. Paz-Ares, *Cancer Chemother. Pharmacol.*, 2013, **72**, 75–83.
897 M. Serova, A. de Gramont, I. Bieche, M. E. Riveiro, C. M. Galmarini, M. Aracil, J. Jimeno, S. Faivre and E. Raymond, *Mar. Drugs*, 2013, **11**, 944–959.
898 K. V. Rao, M.-K. Na, J. C. Cook, J. Peng, R. Matsumoto and M. T. Hamman, *J. Nat. Prod.*, 2008, **71**, 772–778.

899 M. A. Albadry, K. M. Elokely, B. Wang, J. J. Bowling, M. F. Abdelwahab, M. H. Hossein, R. J. Doerksen and M. T. Hamann, *J. Nat. Prod.*, 2013, **76**, 178–185.
900 The error has been noted by the lead author and a correction will be forthcoming (M. Hamann, pers. commun.).
901 K. Yamada, M. Ojika, T. Ishigaki, Y. Yoshida, H. Ekimoto and M. Arakawa, *J. Am. Chem. Soc.*, 1993, **115**, 11020–11021.
902 M. Kita, Y. Hirayama, K. Yoneda, K. Yamagishi, T. Chinen, T. Usui, E. Sumiya, M. Uesugi and H. Kigoshi, *J. Am. Chem. Soc.*, 2013, **135**, 18089–18095.
903 M. Ojika, H. Kigoshi, Y. Yoshida, T. Ishigaki, M. Nisiwaki, I. Tsukada, M. Arakawa, H. Ekimoto and K. Yamada, *Tetrahedron*, 2007, **63**, 3138–3167.
904 O. Ohno, M. Morita, K. Kitamura, T. Teruya, K. Yoneda, M. Kita, H. Kigoshi and K. Suenaga, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 1467–1471.
905 Y. Nakamura, H. Kato, T. Nishikawa, N. Iwasaki, Y. Suwa, H. Rotinsulu, F. Losung, W. Maarisit, R. E. P. Mangindaan, H. Morioka, H. Yokosawa and S. Tsukamoto, *Org. Lett.*, 2013, **15**, 322–325.
906 C.-D. Pham, H. Weber, R. Hartmann, V. Wray, W. Lin, D. Lai and P. Proksch, *Org. Lett.*, 2013, **15**, 2230–2233.
907 K. E. Rudolph, M. S. Liberio, R. A. Davis and A. R. Carroll, *Org. Biomol. Chem.*, 2013, **11**, 261–270.
908 J. L. Li, E. La Kim, H. Wang, J. Hong, S. Shin, C.-K. Lee and J. H. Jung, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 4701–4704.
909 M. Menna, A. Aiello, F. D'Aniello, C. Imperatore, P. Luciano, R. Vitalone, C. Irace and R. Santamaria, *Eur. J. Org. Chem.*, 2013, 3241–3246.
910 N. Bontemps, F. Gattacceca, C. Long, O. P. Thomas and B. Banaigs, *J. Nat. Prod.*, 2013, **76**, 1801–1805.
911 B. R. Copp, J. Tompa, A. Tahir and C. M. Ireland, *J. Org. Chem.*, 1998, **63**, 8024–8026.
912 H. K. H. Fong and B. R. Copp, *Mar. Drugs*, 2013, **11**, 274–299.
913 N. Matsumori, Y. Hiradate, H. Shibata, T. Oishi, S. Shimma, M. Toyoda, F. Hayashi, M. Yoshida, M. Murata and M. Morisawa, *Org. Lett.*, 2013, **15**, 294–297.
914 M. Yoshida, M. Murata, K. Inaba and M. Morisawa, *Proc. Natl. Acad. Sci. U. S. A.*, 2002, **99**, 14831–14836.
915 T. V. K. Reddy, B. L. A. P. Devi, R. B. N. Prasad, P. Sujitha and C. G. Kumar, *Eur. J. Med. Chem.*, 2013, **67**, 384–389.
916 A. Aiello, E. Fattorusso, A. Giordano, M. Menna, C. Navarrete and E. Muñoz, *Tetrahedron*, 2009, **65**, 4384–4388.
917 J. N. Kumar, P. R. Reddy, B. Das, C. G. Kumar and P. Sujitha, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 5192–5194.
918 J. N. Kumar and B. Das, *Tetrahedron Lett.*, 2013, **54**, 3865–3867.
919 M. L. Ciavatta, E. Manzo, G. Nuzzo, G. Villani, M. Varcamonti and M. Gavagnin, *Tetrahedron*, 2010, **66**, 7533–7538.
920 T. B. Parsons, N. Spencer, C. W. Tsang and R. S. Grainger, *Chem. Commun.*, 2013, **49**, 2296–2298.
921 D. R. Appleton and B. R. Copp, *Tetrahedron Lett.*, 2003, **44**, 8963–8965.
922 K. Takamura, H. Matsuo, A. Tanaka, J. Tanaka, T. Fukuda, F. Ishibashi and M. Iwao, *Tetrahedron*, 2013, **69**, 2782–2788.
923 W. Y. Yoshida, K. K. Lee, A. R. Carroll and P. J. Scheuer, *Helv. Chim. Acta*, 1992, **75**, 1721–1725.
924 H. Jin, P. Zhang, K. Bijian, S. Ren, S. Wan, M. A. Alaoui-Jamali and T. Jiang, *Mar. Drugs*, 2013, **11**, 1427–1439.
925 T. H. Trieu, J. Dong, Q. Zhang, B. Zheng, T.-Z. Meng, X. Lu and X.-X. Shi, *Eur. J. Org. Chem.*, 2013, 3271–3277.
926 J. D. Panarese and S. P. Waters, *Org. Biomol. Chem.*, 2013, **11**, 3428–3431.
927 W. Wang, S.-J. Nam, B.-C. Lee and H. Kang, *J. Nat. Prod.*, 2008, **71**, 163–166.
928 L. Peng, F.-M. Zhang, B.-M. Yang, X.-B. Zhang, W.-X. Liu, S.-Y. Zhang and Y.-Q. Tu, *Tetrahedron Lett.*, 2013, **54**, 6514–6516.
929 H. Fuwa, K. Sekine and M. Sasaki, *Org. Lett.*, 2013, **15**, 3970–3973.
930 B. C. M. Potts, D. J. Faulkner, J. A. Chan, G. C. Simolike, P. Offen, M. E. Hemling and T. A. Francis, *J. Am. Chem. Soc.*, 1991, **113**, 6321–6322.
931 A. N. Pearce, E. W. Chia, M. V. Berridge, E. W. Maas, M. J. Page, J. L. Harper, V. L. Webb and B. R. Copp, *Tetrahedron*, 2008, **64**, 5748–5755.
932 L. P. P. Liew, M. Kaiser and B. R. Copp, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 452–454.
933 A. N. Pearce, E. W. Chia, M. V. Berridge, G. R. Clark, J. L. Harper, L. Larsen, E. W. Maas, M. J. Page, N. B. Perry, V. L. Webb and B. R. Copp, *J. Nat. Prod.*, 2007, **70**, 936–940.
934 C. F. C. Lam, N. Pearce, S. H. Tan, M. Kaiser and B. R. Copp, *Mar. Drugs*, 2013, **11**, 3472–3499.
935 A. M. Seldes, M. F. Rodriguez Brasco, L. Hernandez Franco and J. A. Palermo, *Nat. Prod. Res.*, 2007, **21**, 555–563.
936 S. B. Bharate, R. R. Yadav, S. I. Khan, B. L. Tekwani, M. R. Jacob, I. A. Khan and R. A. Vishwakarma, *MedChemComm*, 2013, **4**, 1042–1048.
937 M. J. McKay, A. R. Carroll and R. J. Quinn, *J. Nat. Prod.*, 2005, **68**, 1776–1778.
938 A. K. Pandey, R. Sharma, R. Shivahare, A. Arora, N. Rastogi, S. Gupta and P. M. S. Chauhan, *J. Org. Chem.*, 2013, **78**, 1534–1546.
939 J. Kobayashi, J.-F. Cheng, Y. Kikuchi, M. Ishibashi, S. Yamamura, Y. Ohizumi, T. Ohta and S. Nozoe, *Tetrahedron Lett.*, 1990, **31**, 4617–4620.
940 L. V. Frolova, I. V. Magedov, A. E. Romero, M. Karki, I. Otero, K. Hayden, N. M. Evdokimov, L. M. Y. Banuls, S. K. Rastogi, W. R. Smith, S.-L. Lu, R. Kiss, C. B. Shuster, E. Hamel, T. Betancourt, S. Rogelj and A. Kornienko, *J. Med. Chem.*, 2013, **56**, 6886–6900.
941 H. Kang and W. Fenical, *J. Org. Chem.*, 1997, **62**, 3254–3262.
942 J. W. Bin, I. L. K. Wong, X. Hu, Z. X. Yu, L. F. Xing, T. Jiang, L. M. C. Chow and W. S. Biao, *J. Med. Chem.*, 2013, **56**, 9057–9070.
943 T. H. Won, J.-e. Jeon, S.-H. Kim, S.-H. Lee, B.-J. Rho, D.-C. Oh, K.-B. Oh and J. Shin, *J. Nat. Prod.*, 2012, **75**, 2055–2061.

944 C.-H. Ahn, T. H. Won, H. Kim, J. Shin and K.-B. Oh, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 4099–4101.
945 K. Suwanborirux, K. Charupant, S. Amnuoypol, A. Kubo and N. Saito, *J. Nat. Prod.*, 2002, **65**, 935–937.
946 M. Tsujimoto, W. Lowtangkitcharoen, N. Mori, W. Pangkruang, P. Putongking, K. Suwanborirux and N. Saito, *Chem. Pharm. Bull.*, 2013, **61**, 1052–1064.
947 J. Sikorska, A. M. Hau, C. Anklin, S. Parker-Nance, M. T. Davies-Coleman, J. E. Ishmael and K. L. McPhail, *J. Org. Chem.*, 2013, **78**, 2812.
948 J. L. Li, B. Xiao, M. Park, E. S. Yoo, S. Shin, J. Hong, H. Y. Chung, H. S. Kim and J. H. Jung, *J. Nat. Prod.*, 2013, **76**, 815.
949 G.-Y. Zhang, H.-H. Ren, Y.-B. Zhang, L.-Q. Ma, Y.-L. Yang and S. Wang, *Biochem. Syst. Ecol.*, 2013, **51**, 203–206.
950 N. P. Thao, N. X. Cuong, B. T. T. Luyen, N. H. Nam, P. V. Cuong, N. V. Thanh, N. X. Nhiem, T. T. H. Hanh, E.-J. Kim, H.-K. Kang, P. V. Kiem, C. V. Minh and Y. H. Kim, *Chem. Pharm. Bull.*, 2013, **61**, 1044–1051.
951 N. P. Thao, N. X. Cuong, B. T. T. Luyen, T. H. Quang, T. T. H. Hanh, S. Kim, Y.-S. Koh, N. H. Nam, P. V. Kiem, C. V. Minh and Y. H. Kim, *Mar. Drugs*, 2013, **11**, 2917–2926.
952 R. S. Popov, N. V. Ivanchina, A. A. Kicha, T. B. Malyarenko, A. I. Kalinovskii and P. S. Dmitrenok, *Chem. Nat. Compd.*, 2013, **49**, 286–290.
953 Z. Li, G. Chen, X. Lu, H. Wang, B. Feng and Y. Pei, *Nat. Prod. Res.*, 2013, **27**, 1816–1822.
954 Z.-R. Zou, Y.-H. Yi, H.-M. Wu, J.-H. Wu, C.-C. Liaw and H.-K. Lee, *J. Nat. Prod.*, 2003, **66**, 1055–1060.
955 A. S. Silchenko, A. I. Kalinovsky, S. A. Avilov, P. V. Andryjaschenko, P. S. Dmitrenok, E. A. Martyyas, V. I. Kalinin, P. Jayasandhya, G. C. Rajan and K. P. Padmakumar, *Nat. Prod. Commun.*, 2013, **8**, 301–310.
956 A. S. Silchenko, A. I. Kalinovsky, S. A. Avilov, P. V. Andryjashchenko, P. S. Dmitrenok, V. I. Kalinin, S. Taboada and C. Avila, *Biochem. Syst. Ecol.*, 2013, **51**, 45–49.
957 A. S. Silchenko, A. I. Kalinovsky, S. A. Avilov, P. V. Andryjashchenko, P. S. Dmitrenok, E. A. Martyyas and V. I. Kalinin, *Nat. Prod. Commun.*, 2013, **8**, 1053–1058.
958 A. S. Silchenko, A. I. Kalinovsky, S. A. Avilov, P. V. Andryjaschenko, P. S. Dmitrenok, E. A. Yurchenko, I. Y. Dolmatov, V. I. Kalinin and V. A. Stonik, *Nat. Prod. Commun.*, 2013, **8**, 1527–1534.
959 N. P. Thao, N. X. Cuong, B. T. T. Luyen, N. V. Thanh, N. X. Nhiem, Y.-S. Koh, B. M. Ly, N. H. Nam, P. V. Kiem, C. V. Minh and Y. H. Kim, *J. Nat. Prod.*, 2013, **76**, 1764–1770.
960 N. P. Thao, L. D. Dat, N. T. Ngoc, V. A. Tu, T. T. H. Hanh, P. T. T. Huong, N. X. Nhiem, B. H. Tai, N. X. Cuong, N. H. Nam, P. V. Cuong, S. Y. Yang, S. Kim, D. Chae, Y.-S. Koh, P. V. Kiem, C. V. Minh and Y. H. Kim, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 1823–1827.
961 S. De Marino, M. Iorizzi, F. Zollo, C. D. Amsler, S. P. Greer and J. B. McClintock, *Eur. J. Org. Chem.*, 2000, 4093–4098.
962 G. Xiao and B. Yu, *Chem.–Eur. J.*, 2013, 7708–7712.
963 N. V. Palyanova, T. M. Pankova, M. V. Starostina, A. A. Kicha, N. V. Ivanchina and V. A. Stonik, *Mar. Drugs*, 2013, **11**, 1440–1455.
964 F.-J. Wu, Y. Xue, Q.-J. Tang, J. Xu, L. Du, C.-H. Xue, K. Takahashi and Y.-M. Wang, *J. Oleo Sci.*, 2013, **62**, 717–727.
965 J. S. Yoo, T. Park, G. Bang, C. Lee, J.-R. Rho and Y. H. Kim, *J. Mass Spectrom.*, 2013, **48**, 164–171.
966 N. V. Ivanchina, A. A. Kicha, T. V. Malyarenko, A. I. Kalinovsky, P. S. Dmitrenok and V. A. Stonik, *Steroids*, 2013, **78**, 1183–1191.
967 H. Nan, H. Lin, Z. Qian and H. Yin, *Heterocycles*, 2013, **87**, 1093–1098.
968 H. Wang, M.-Y. Li, T. Satyanandamurty and J. Wu, *Planta Med.*, 2013, **79**, 666–672.
969 M. G. Ponnapalli, M. Ankireddy, S. C. V. A. R. Annam, S. Ravirala, S. Sukki and V. R. Tuniki, *Tetrahedron Lett.*, 2013, **54**, 2942–2945.
970 C.-L. Cheng, Z.-Z. Wang, P.-L. Li, X.-W. Zhang, R.-C. Wu, H.-Y. Zhu, X.-L. Tang and G.-Q. Li, *Chin. Chem. Lett.*, 2013, **24**, 1080–1082.
971 H. Chen, J. Zhang, M.-Y. Li, T. Satyanandamurty and J. Wu, *Chem. Biodiversity*, 2013, **10**, 612–620.
972 Y.-B. Wu, Z.-Y. Ni, C.-H. Huo, J. Su, M. Dong, F. Sauriol, Q.-W. Shi, Y.-C. Gu and H. Kiyota, *Biosci., Biotechnol., Biochem.*, 2013, **77**, 736–740.
973 K. Toume, K. Kamiya, M. A. Arai, N. Mori, S. K. Sadhu, F. Ahmed and M. Ishibashi, *Org. Lett.*, 2013, **15**, 6106–6109.
974 J. Li, M.-Y. Li, T. Bruhn, F. Z. Katele, Q. Xiao, P. Pedpradab, J. Wu and G. Bringmann, *Org. Lett.*, 2013, **15**, 3682–3685.
975 J. Li, M.-Y. Li, Q. Xiao, P. Pedpradab and J. Wu, *Phytochem. Lett.*, 2013, **6**, 482–485.
976 S. Homhual, H.-J. Zhang, N. Bunyapraphatsara, T. P. Kondratyuk, B. D. Santarsiero, A. D. Mesecar, A. Herunsalee, W. Chaukul, J. M. Pezzuto and H. H. S. Fong, *Planta Med.*, 2006, **72**, 255–260.
977 J. Chen, C.-S. Jiang, W.-Q. Ma, L.-X. Gao, J.-X. Gong, J.-Y. Li, J. Li and Y.-W. Guo, *Bioorg. Med. Chem. Lett.*, 2013, **23**, 5061–5065.
978 K. Li, C. O. Brant, M. Huertas, S. K. Hur and W. Li, *Org. Lett.*, 2013, **15**, 5924–5927.
979 M. Adachi, T. Imazu, M. Isobe and T. Nishikawa, *J. Org. Chem.*, 2013, **78**, 1699–1705.
980 M. Yotsu-Yamashita, Y. Abe, Y. Kudo, R. Ritson-Williams, V. J. Paul, K. Konoki, Y. Cho, M. Adachi, T. Imazu, T. Nishikawa and M. Isobe, *Mar. Drugs*, 2013, **11**, 2799–2813.
981 Y. L. Mak, J. J. Wu, W. H. Chan, M. B. Murphy, J. C. W. Lam, L. L. Chan and P. K. S. Lam, *Anal. Bioanal. Chem.*, 2013, **405**, 3331–3340.
982 http://www.marinespecies.org, accessed June 2014.