Hippospongins A−F: New Furanoterpenes from a Southern Australian Marine Sponge *Hippospongia* sp.

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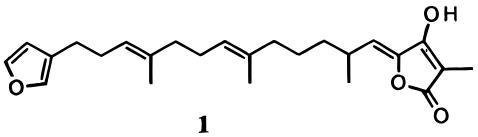
Three new C_{25} furanoterpenes, hippospongins A−C (**5**−**7**); a new C_{24} furanoterpene, hippospongin D (**8**); and two new C_{22} furanoterpenes, hippospongins E and F (**9** and **10**), were isolated from a southern Australian collection of the marine sponge *Hippospongia* sp. The hippospongins possess structural features intermediate between C_{21} furanoterpenes and their putative biosynthetic precursors, C_{25} tetronic acids. All structures were secured by detailed spectroscopic analysis.

Marine sponges are a well known source of novel furanoterpenes. It has been proposed[1] that biosynthetic manipulation of C_{25} tetronic acids such as variabilin (**1**),[2] via hydrolysis of the tetronic acid followed by keto−enol tautomerism and cleavage of the resulting 1,2-diketone, can lead to carboxylic acids such as **2**. Such carboxylic acids can then undergo oxidative modification to yield lactones and furans, such as furospongolide (**3**)[3] and anhydrofurospongin 1 (**4**).[4] In this way C_{25} tetronic acids can be viewed as biosynthetic precursors to C_{21} furanoterpenes. Although numerous examples of both these structure classes have been isolated and identified from marine sponges, no marine metabolites have been reported that possess both the bisfuranyl regiochemistry common to C_{21} furanoterpenes and a C_{25} carbon skeleton. Our investigations into the chemistry of a southern Australian species of *Hippospongia* has resulted in the isolation and identification of six new furanoterpenes, hippospongins A−F (**5**−**10**), which are speculated to be biosynthetically related to the C_{25} tetronic acids and the C_{21} furanoterpenes described above.



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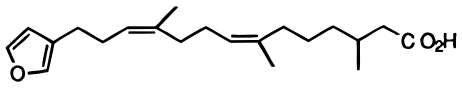

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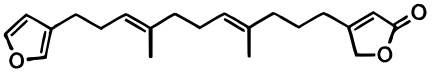

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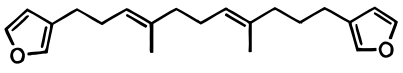

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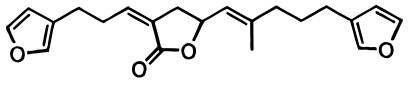

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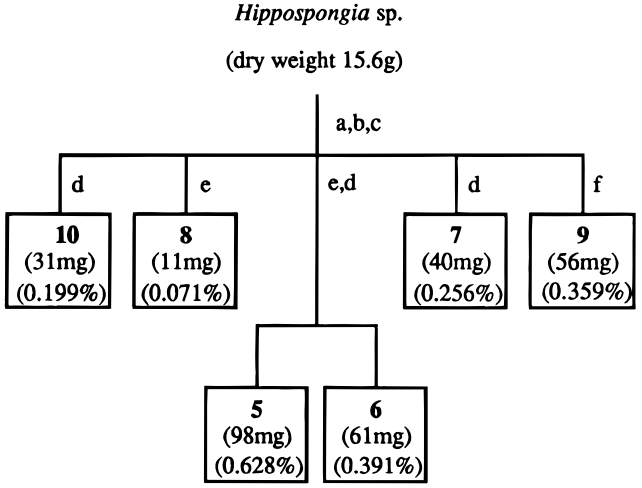
Scheme 1. Extraction and Isolation Procedure[a]



[a] Key: (a) extraction with EtOH; (b) CH_2Cl_2 solubles; (c) rapid silica filtration (petroleum spirits to EtOAc, 20% stepwise gradient); (d) silica HPLC (30% EtOAc/petroleum spirits); (e) C_{18} HPLC (5% H_2O/MeOH); (f) C_{18} HPLC (10% H_2O/MeOH).

Results and Discussion

The CH_2Cl_2-soluble fraction of the crude EtOH extract of a *Hippospongia* sp. collected from the Great Australian Bight, Australia, was found to exhibit mild antibiotic activity against *Staphylococcus aureus*. Fractionation of this material as outlined in Scheme 1 yielded six new furanoterpenes, identified as hippospongins A−F (**5**−**10**).

Hippospongin A (**5**) possessed a molecular formula ($C_{25}H_{32}O_5$ from $M^+ - H$) requiring ten double-bond equivalents (DBE). IR absorptions [3010 (br), 1765 cm^{-1}] and a deshielded ^{13}C-NMR resonance [181.4 (s) ppm, see Table 1] accounted for one DBE and two oxygen atoms as a carboxylic acid functionality, while the absence of suitably deshielded sp^3 hybridized carbon resonances ensured that the three remaining oxygen atoms were attached to sp^2 hybridized carbons. This latter observation, together with the presence of 12 "olefinic" carbon resonances, six of which were significantly deshielded (142.7, 138.8, 136.9, 155.5, 137.5, and 152.9 ppm), and seven deshielded "olefinic" proton resonances lacking measurable coupling, suggested the presence of three substituted furanyl moieties. Careful analysis of the COSY and gHMBC data for **5** revealed a sequence of correlations consistent with a structure fragment C-1 to C-21 featuring one monosubstituted

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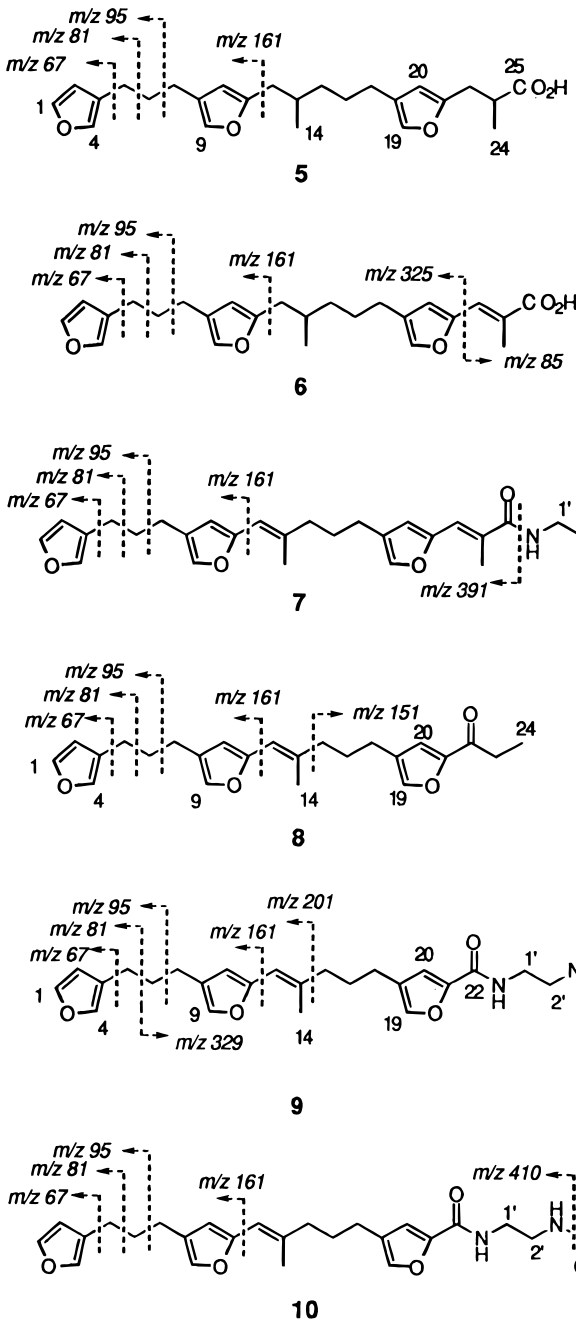


5 **6** **7** **8** **9** **10**

and two disubstituted furanyl moieties, and a secondary methyl (δ 0.88, d) attached to an asymmetric center (C-13). That C-13 was asymmetric was further evidenced from the diastereotopic nature of H_2-12 and H_2-15. Analysis of the 2D-NMR data also identified the fragment C-22 to C-25, featuring the carboxylic acid functionality and the remaining secondary methyl (δ 1.20, d). As with C-13 the asymmetric nature of C-23 was evidenced from the diastereotopic nature of the adjacent methylene (H_2-22). These two fragments, C-1 to C-21 and C-22 to C-25, accounted for the entire structure of hippospongin A (**5**), which could be assembled as shown. Mass spectral fragmentations supportive of the assigned structure were observed at *m*/*z* 67, 81, 95, and 161.

Hippospongin B (**6**) did not exhibit a molecular ion in the mass spectrum, and its molecular formula ($C_{25}H_{30}O_5$), established by consideration of the highest mass ion (*m*/*z* 325, cleavage of C-21/C-22, $C_{21}H_{25}O_3$) and NMR data, required 11 DBE. NMR analysis of hippospongin B (**6**) (Tables 2 and 3) revealed considerable

Table 1. NMR (^{1}H, 400 MHz; ^{13}C, 100 MHz; $CDCl_3$) Data for Hippospongin A (**5**)

carbon no.	^{13}C (ppm, m)	^{1}H (d, m, *J* Hz)	COSY	gHMBC
1	142.7 (d)	7.34 (s)	H-2	C-2, C-3, C-4
2	111.0 (d)	6.27 (s)	H-1	C-1, C-3, C-4, C-5
3	124.8 (s)			
4	138.8 (d)	7.21 (s)		C-1, C-2
5	24.5 (t)[a]	2.40 (m)	H_2-6	C-2, C-3, C-4, C-6
6	30.1 (t)	1.79 (m)	H_2-5	C-5, C-7
7	24.3 (t)[a]	2.40 (m)	H_2-6	C-6, C-7, C-9, C-10
8	125.3 (s)			
9	136.9 (d)	7.07 (s)		C-10
10	107.4 (d)	5.86 (s)		C-9
11	155.5 (s)			
12	35.6 (t)	2.54 (dd, 5.9, 14.8)	H-13	C-10, C-11, C-13, C-14, C-9, C-10, C-13, C-15
		2.32 (m)		
13	32.4 (d)	1.79 (m)	H_2-12, CH_3-14, H_2-15	C-11, C-12, C-14
14	19.6 (q)	0.88 (d, 6.5)	H-13	C-12, C-13
15	36.2 (t)	1.38 (m)	H_2-16, H-13	C-12, C-14, C-16, C-17
		1.20 (m)		
16	27.3 (t)	1.54 (m)	H_2-15, H_2-17	C-15, C-17
17	25.1 (t)	2.32 (m)	H_2-16	C-15, C-16, C-18, C-19
18	125.9 (s)			
19	137.5 (d)	7.05 (s)		C-18, C-21
20	108.2 (d)	5.93 (s)		C-18, C-20, C-21
21	152.9 (s)			
22	31.7 (t)	3.02 (dd, 5.8, 15.0)	H-23	C-23, C-24, C-25
		2.68 (dd, 7.3, 15.0)		
23	38.6 (d)	2.83 (m)	H_2-22, H_3-24	C-22, C-24, C-25
24	16.4 (q)	1.20 (d, 6.1)	H-23	C-22, C-23, C-25
25	181.4 (s)			

[a]Assignments within a column may be interchanged.

Table 2. ^{13}C-NMR ($CDCl_3$, 100 MHz) Data for (**6**−**10**)

carbon no.	**6**	**7**	**8**	**9**	**10**
1	142.7 (d)	142.6 (d)	142.7 (d)	142.7 (d)	142.7 (d)
2	111.0 (d)	110.9 (d)	111.0 (d)	110.9 (d)	110.9 (d)
3	124.8 (s)	124.6(s)	124.7 (s)	124.6 (s)	124.7 (s)
4	138.8 (d)	138.8 (d)	138.9 (d)	138.8 (d)	138.8 (d)
5	24.4 (t)[a]	24.3 (t)[a]	24.3 (t)[a]	24.3 (t)[a]	24.3 (t)[a]
6	30.1 (t)	30.1 (t)	29.7 (t)	30.1 (t)	30.1 (t)
7	24.2 (t)[a]	24.1 (t)[a]	24.2 (t)[a]	24.1 (t)[a]	24.2 (t)[a]
8	125.3 (s)	126.1 (s)	126.2 (s)	126.1 (s)	126.2 (s)
9	136.9 (d)	136.9 (d)	137.1 (d)	137.0 (d)	137.0 (d)
10	107.5 (d)	109.0 (d)	109.2 (d)	109.0 (d)	109.1 (d)
11	155.4 (s)	153.5 (s)	153.5 (s)	153.4 (s)	153.5 (s)
12	35.5 (t)	114.5 (d)	114.8 (d)	114.6 (d)	114.7 (d)
13	32.4 (d)	137.6 (s)	137.3 (s)	137.3 (s)	137.4 (s)
14	19.6 (q)	18.4 (q)	18.4 (q)	18.3 (q)	18.4 (q)
15	36.0 (t)	40.0 (t)	40.0 (t)	39.9 (t)	39.9 (t)
16	27.3 (t)	27.9 (t)	28.0 (t)	27.8 (t)	27.8 (t)
17	24.8 (t)	24.0 (t)[a]	23.9 (t)[a]	23.9 (t)[a]	23.9 (t)[a]
18	127.7 (s)	127.1 (s)[b]	127.5 (s)	126.1 (s)	127.6 (s)
19	141.1 (d)	140.0 (d)	142.7 (d)	140.6 (d)	140.5 (d)
20	117.3 (d)	115.4 (d)	117.7 (d)	115.6 (d)	115.6 (d)
21	151.7 (s)	151.8 (s)	152.6 (s)	147.5 (s)	147.6 (s)
22	127.8 (d)	122.4 (s)	190.3 (s)	159.5 (s)	158.6 (s)
23	123.3 (s)	126.9 (s)[b]	31.5 (t)		38.3 (t)
24	13.7 (q)	14.2 (q)	8.0 (q)		63.3 (t)
25	174.1 (s)	170.3 (s)			
1′		42.8 (t)		42.0 (t)	
2′		62.1 (t)		62.1 (t)	
$NHCOCH_3$					171.1 (s)
$NHCOCH_3$					20.9 (q)

[a,b] Assignments may be interchanged within a column. Multiplicities assigned by DEPT 90 and 135 experiments. Assignments made with reference to HMQC (**6** to **10**) and gHMBC (**6** to **9**) experiments and the assigned data for **10**.

spectroscopic similarity to hippospongin A (**5**), with both compounds possessing the same C-1 to C-22 fragment. An additional olefinic methine (δ 7.31) and olefinic methyl (δ 2.21) resonance along with the absence of both H-23, H_3-24 and H_2-22 resonances in the ^{1}H-NMR spectrum of **6** compared to **5**, clearly identified the extra

Table 3. ^{1}H NMR ($CDCl_3$, 400 MHz) Data for (**6**−**10**)[a]

proton no.	**6** δ (m, *J* Hz)	**7** δ (m,*J* Hz)	**8** δ (m, *J* Hz)	**9** δ (m, *J* Hz)	**10** δ (m, *J* Hz)
1	7.35 (s)	7.35 (s)	7.35 (s)	7.35 (s)	7.35 (br t, 1.7)
2	6.27 (s)	6.26 (s)	6.27 (s)	6.26 (s)	6.26 (s)
4	7.21 (s)	7.21 (s)	7.21 (s)	7.21 (s)	7.22 (s)
5	2.42 (m)	2.42 (m)	2.44 (m)	2.44 (m)	2.42 (m)
6	1.80 (m)	1.80 (m)	1.80 (m)	1.80 (m)	1.80 (m)
7	2.42 (m)	2.42 (m)	2.44 (m)	2.44 (m)	2.42 (m)
9	7.07 (s)	7.12 (s)	7.12 (s)	7.12 (s)	7.12 (s)
10	5.86 (s)	6.08 (s)	6.08 (s)	6.08 (s)	6.08 (s)
12_a	2.54 (dd)[b]	6.02 (s)	6.02 (s)	6.00 (s)	6.01 (s)
12_b	2.42(m)				
13	1.80 (m)				
14	0.90 (d, 6.6)	1.95 (s)	1.95 (s)	1.94 (s)	1.94 (s)
15_a	1.39 (m)	2.17 (br, 7.5)	2.17 (m)	2.15 (br, 7.0)	2.17 (br t, 7)
15_b	1.20 (m)				
16	1.59 (m)	1.75 (m)	1.80 (m)	1.75 (m)	1.75 (m)
17	2.42 (m)	2.42 (m)	2.44 (m)	2.44 (m)	2.42 (m)
19	7.31 (s)	7.25 (s)	7.35 (s)	7.21 (s)	7.22 (s)
20	6.53 (s)	6.40 (s)	7.05 (s)	7.00 (s)	7.01 (s)
22	7.50 (s)	7.13 (s)			
23			2.82 (q, 7.5)		
24	2.21 (s)	2.21 (s)	1.20 (br,7.5)		
1′		3.51 (dt)[c]		3.56 (br dt)[d]	3.67 (dt,5.7, 5.6.)
2′		3.75 (br, 5.0)		3.78 (br, 5.0)	4.23 (br t, 5)
CON*H*		6.64 (br, 5.5)		6.93 (br m)	6.64 (br t, 5.7)
NH_2		3.35 (br s)		3.20 (br s)	
				3.35 (br s)	
NHCOCH_3					2.09 (s)

[a] Assignments made with reference to HMQC (**6** to **10**) and gHMBC (**6** to **9**) experiments and the assigned data for **5**. [b] J = 6.1 and 14.8. [c] J = 4.7 and 4.8. [d] J = 5.0 and 5.0.

DBE as being a $\Delta^{22,23}$. The *E* geometry of this asymmetric double bond was established by NOESY correlations from H-20 to both H-22 and H_3-24. Mass spectral fragmentations supportive of the assigned structure were observed at *m*/*z* 67, 81, 85, 95, 161, and 325, while an overlapping sequence of COSY and gHMBC correlations were observed from C-1 to C-25.

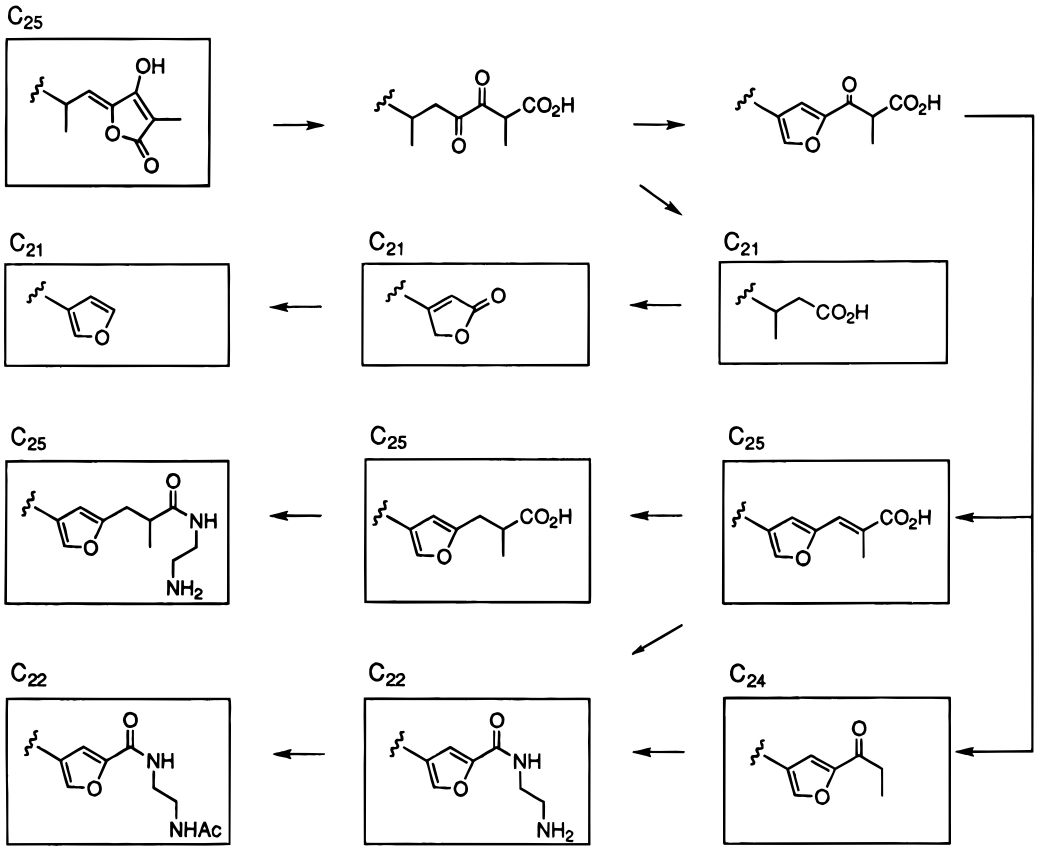
Hippospongin C (**7**) possessed a molecular formula $C_{27}H_{34}N_2O_4$, requiring 12 DBE. NMR analysis of hippospongin C (**7**) (Tables 2 and 3) revealed considerable spectroscopic similarity to hippospongin B (**6**), with one significant difference being that hippospongin C (**7**) was achiral and incorporated a $\Delta^{12,13}$ (^{1}H : δ 6.02, s; ^{13}C : 137.6, s and 114.3 ppm, d) in place of a secondary methyl. The shielded nature of the ^{13}C-NMR chemical shift for C-14 (18.4 ppm) was taken to imply an *E* geometry about the C-12 to C-13 double bond. IR absorptions (3340 and 1659 cm^{-1}) together with a D_2O exchangeable ^{1}H-NMR resonance (δ 6.64, bt, 1H) coupled to a deshielded methylene (δ 3.51, dt) and exhibiting an HMBC correlation to the carbonyl carbon C-25 (170.3 ppm), was taken as evidence for a primary amide functionality. Correlations between the deshielded methylene (δ 3.51, dt) to another methylene (δ 3.75, br t) further correlated to an NH_2 (δ 3.35, br s) defined the terminus to hippospongin C (**7**) as a 1,2-diaminoethyl unit. An *E* geometry was assigned about $\Delta^{22,23}$ in **7** on the basis of the close comparision in the ^{13}C-NMR shift for C-24 (14.2 ppm) with that recorded for **6** (13.7 ppm). Mass spectral fragmentations supportive of the assigned structure were observed at *m*/*z* 67, 81, 85, 95, 161, and 391, while an overlapping sequence of COSY and gHMBC correlations were observed from C-1 to C-21, and from C-22 through the amide linkage to C-2′.

Hippospongin D (**8**) possessed a molecular formula $C_{24}H_{28}O_4$ requiring 11 DBE. NMR comparisons of hippospongin D (**8**) (Tables 2 and 3), together with analysis of COSY and gHMBC data, revealed a C-1 to C-21 fragment common with hippospongin C (**7**). Unlike hippospongins A−C (**5**-**7**), hippospongin D (**8**) did not possess D_2O-exchangeable ^{1}H NMR resonances nor absorptions in the IR spectrum characteristic of either NH or COOH functionalities. It did, however, exhibit an IR absorption (1765 cm^{-1}) along with a ^{13}C NMR resonance [190.3 (s) ppm] consistent with a ketone. Additional NMR resonances for an ethyl moiety (δ 2.82, q, J = 7.5 Hz; δ 1.20, t, J = 7.5 Hz) correlated through gHMBC analysis to a carbonyl carbon (C-22) defined the total structure for **8** as shown. Mass spectral fragmentations supportive of the assigned structure were observed at *m*/*z* 67, 81, 85, 95, 151, and 161.

Hippospongin E (**9**) possessed a molecular formula $C_{24}H_{30}N_2O_4$ requiring 11 DBE. Comparison of NMR data (Tables 2 and 3) for hippospongin E (**9**) with that for hippospongin D (**8**) revealed a common C-1 to C-18 fragment. IR absorptions (3328 and 1650 cm-1), together with D_2O-exchangeable ^{1}H-NMR resonances (δ 6.93, NH and δ 3.35/3.20, NH_2) and mutually coupled deshielded methylenes (δ 3.56 and 3.78), clearly identified the same primary amide functionality in **9** as observed in hippospongin C (**7**). Mass spectral fragmentations supportive of the assigned structure were observed at *m*/*z* 67, 81, 85, 95, 161, 201, and 329.

Hippospongin F (**10**) was readily identified as an acetylated derivative of hippospongin E (**9**). NMR comparison (Tables 2 and 3) between **9** and **10** revealed an excellent match for the structure fragment C-1 to C-22. The appearance of an acetate resonance (δ 2.09) in the ^{1}H NMR spectrum of **10**, together with deshielding of the ethyl amine methylenes in **10** (C-1′ δ 3.67 and C-2′ δ 4.23) compared to **9** (C-1′ δ 3.56 and C-2′ δ 3.78), was indicative of a C-2′-NHAc functionality. Overlapping COSY and gHMBC correlations were observed from C-1 through C-22 and on to C-2′−NHCOCH_3. Mass spectral fragmentations supportive of the assigned structure were observed at *m*/*z* 67, 81, 95, 161, and 410.

Scheme 2. Possible Biosynthetic Relationships



As mentioned in the introduction to this report, the hippospongins A to F (**5**−**10**) possess structural features characteristic of both C_{25} tetronic acids and C_{21} furanoterpenes. Both C_{25} tetronic acids and the hippospongins possess an acyclic carbon skeleton featuring a β-furanyl terminus, and, although the hippospongins do not feature a tetronic acid terminus, hippospongins A and B (**5** and **6**) incorporate a carboxylic acid, while hippospongins C to F (**7** to **10**) are simple biosynthetic derivatives (amide **7**, decarboxylated ketone **8**, degraded amides **9** and **10**). Marine C_{21} furanoterpenes on the other hand are typically characterized by an acyclic carbon skeleton terminated by β-furanyl functionalities. Commonly oxygenated at the central carbon, some C_{21} furanoterpenes are known to incorporate a third heterocyclic ring, such as is the case for nitenin (**11**). This oxygenation pattern is common to that exhibited by the hippospongins A to F (**5**-**10**). Indeed, hydrolysis of the amides hippospongins E and F (**9** and **10**) followed by decarboxylation would lead to a close structural analogue of nitenin (**11**).[5]

The hippospongins A to F (**5**-**10**) are new marine natural products that possess a hitherto unknown trisfuranyl regiochemistry, with carbon skeletons intermediate between C_{25} tetronic acids and C_{21} furanoterpenes. Hippospongins C (**7**), E (**9**), and F (**10**) also incorporate unusual amide linkages to 1,2-diaminoethane. It is speculated that hippospongins A to F (**5**−**10**) are biosynthetically related to C_{25} tetronic acids and C_{21} furanoterpenes, as indicated in Scheme 2.

Only hippospongin A (**5**) was found to be a mild antibiotic, inhibiting the growth of *Staphylococcus aureus* at concentrations of ca. 200 μg/disk in a standard agar plate assay. The stereochemistry about the chiral centers in hippospongins A and B (**5** and **6**) remain undetermined.

Experimental Section

General Experimental Procedures. These are reported elsewhere.[6]

Collection, Extraction, and Isolation. A fresh specimen of *Hippospongia* sp. (Museum of Victoria registry no. F77036) was collected by epibenthic sled during a cruise on the *RV Franklin* in the Great Australian Bight (depth 210 m, 34° 47.1′ S; 124° 32.2′ E). *Hippospongia* sp. (order, Dictyoceratida; family, Spongiidae) is a thickly stalked, massive to club-shaped sponge; quite compressible but fibrous and very difficult to tear; and sandy-beige both in life and preserved in EtOH. The surface of the sponge is regularly conulose; conules are bifurcate/trifurcate, spaced 3−5 mm apart and joined by a glossy, transparent membrane. Oscular apertures are of 3−5-mm diameter, sunken between conules with a prominent membranous lip, and tend to be grouped apically. The ectosome consists of a thin tangential layer of foreign spicules bound by primary fiber spongin that overlies the cavernous subectosomal region. The choanosome is a mass of vermiform secondary fibers of 25−32-μm diameter, branching, anastomozing, and clear of coring material. Primary fibers are reduced, fasciculate, ascending in support of conules and cored with fine spicular detritus. Interstitial collagen is light and spicular detritus is scattered lightly throughout. There are no native spicules present in the skeleton.

Shortly after collection, the specimen was frozen for transport, then diced and stored in EtOH at −20 °C. The decanted EtOH extract was subsequently concen-

trated under reduced pressure and partitioned as outlined in Scheme 1 to yield the pure compounds in order of increasing polarity: hippospongin D (**8**) (11 mg, 0.1%), hippospongin A (**5**) (98 mg, 0.6%), hippospongin B (**6**) (61 mg, 0.1%), hippospongin F (**10**) (31 mg, 0.2%), hippospongin C (**7**) (40 mg, 0.3%), hippospongin E (**9**) (56 mg, 0.4%)

Hippospongin A (5): stable pale-yellow oil; $[\alpha]_D$ +0.4° (*c* 0.9, $CHCl_3$); UV (EtOH) λ max (log ϵ) 218 (4.54) nm; IR (film) ν max 3010 (br), 1765, 1705, 1679, 1458 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz), see Table 1; ^{13}C NMR ($CDCl_3$, 100 MHz), see Table 1; EIMS (70 eV) *m/z* [M^+−H] 411 (2), 327 (1), 275 (8), 233 (9), 220 (13), 175 (49), 161 (33), 136 (40), 109 (34), 95 (60), 91 (67), 81 (68), 69 (92), 67 (63), 53 (100); HREIMS *m/z* 411.2155; calcd for $C_{25}H_{31}O_5$ 411.2171.

Hippospongin B (6): stable pale-yellow oil; $[\alpha]_D$ −5.1° (*c* 0.9, $CHCl_3$); UV (EtOH) λ max (log ϵ) 308 (4.38), 215 (4.17) nm; IR (film) ν max 3010 (br), 1679, 1630, 1501, 1414, 1268 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz), see Table 3. ^{13}C NMR ($CDCl_3$, 100 MHz), see Table 2; EIMS (70 eV) *m/z* 372 (28), [$M^+ - C_4H_5O_2$] 325 (7), 282 (27), 256 (13), 238 (14), 217 (18), 190 (21), 175 (4), 146 (49), 120 (26), 109 (42), 95 (29), 85 (100), 81 (2), 73 (81), 67 (2), 59 (42); HREIMS *m/z* 325.1786; calcd for $C_{21}H_{25}O_3$ 325.1804.

Hippospongin C (7): moderately stable pale-yellow oil; UV (EtOH) λ max (log ϵ) 303 (4.34), 287 (4.39), 276 (4.39), 206 (4.19) nm; IR (film) ν max 3340, 1659, 1620, 1542, 1443, 1300 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz), see Table 3; ^{13}C NMR ($CDCl_3$, 100 MHz), see Table 2; EIMS (70 eV) *m/z* [M^+] 450 (20), 391 (5), 371 (9), 262 (15), 242 (38), 209 (56), 161 (23), 148 (100), 133 (31), 95 (63), 91 (68), 81 (56), 67 (26), 51 (29); HREIMS *m/z* 450.2491; calcd for $C_{27}H_{34}N_2O_4$ 450.2518.

Hippospongin D (8): stable pale-yellow oil; UV (EtOH) λ max (log ϵ) 277 (4.14), 214 (3.87) nm; IR (film) ν max 1765, 1669, 1501, 1456, 1385, 1022 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz), see Table 3; ^{13}C NMR ($CDCl_3$, 100 MHz), see Table 2; EIMS (70 eV) *m/z* [M^+] 380 (1), 323 (1), 233 (8), 191 (24), 179 (14), 161 (50), 151 (28), 135 (39), 95 (51), 83 (96), 81 (43), 67 (35), 56 (100); HREIMS *m/z* 380.1995; calcd for $C_{27}H_{34}N_2O_4$ 380.1987.

Hippospongin E (9): moderately stable pale-yellow oil; UV (EtOH) λ max (log ϵ) 279 (3.95) nm; IR (film) ν max 3328, 1650, 1556, 1502, 1420, 1305 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz), see Table 3, ^{13}C NMR ($CDCl_3$, 100 MHz), see Table 2; EIMS (70 eV) *m/z* [M^+] 410 (42), 329 (26), 316 (15), 263 (16), 222 (17), 179 (25), 161 (13), 148 (100), 135 (34), 95 (55), 91 (42), 81 (56), 67 (24), 51 (37); HREIMS *m/z* 410.2217; calcd for $C_{24}H_{30}N_2O_4$ 410.2205.

Hippospongin F (10): stable colorless, pale yellow oil; UV (EtOH) λ max (log ϵ) 265 (4.02) nm; IR (film) ν max 3351, 1835, 1735, 1647, 1545, 1233, 1048 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz), see Table 3; ^{13}C NMR ($CDCl_3$, 100 MHz), see Table 2; EIMS (70 eV) *m/z* [M^+ − Ac + H] 410 (5), 329 (4), 280 (11), 263 (12), 224 (16), 210 (6), 179 (100), 161 (26), 148 (20), 135 (43), 95 (47), 91 (35), 81 (50), 67 (32), 51 (49); HREIMS *m/z* 410.2233; calcd for $C_{24}H_{31}N_2O_4$ 410.2205.

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References and Notes

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