Structures and Reactivities of New Dolabellane Diterpenoids from the Caribbean Gorgonian *Eunicea laciniata*

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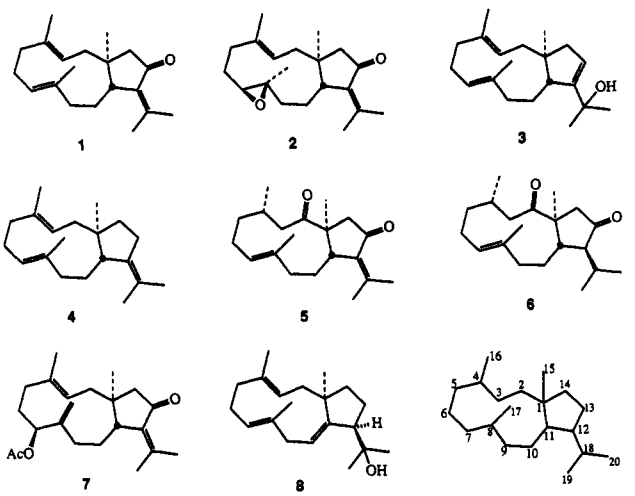
Five new diterpenoids of the dolabellane class (3-7) have been isolated from the Caribbean gorgonian *Eunicea laciniata* Duchassaing and Michelotti. The structures of these metabolites were defined by combined spectra and chemical methods. The conformation and reactivity of the 11-membered ring of the dolabellanes was investigated by ^{1}H NMR nuclear Overhauser enhancement difference spectroscopy (NOEDS) and by selected chemical transformations involving transannular cyclizations.

Gorgonian octocorals, the marine sea whips and sea fans (Phylum Cnidaria), are recognized as a prolific source of biologically active and structurally unique secondary metabolites.[1,2] Animals of the tropical Atlantic genus *Eunicea* are particularly rich in cembrane diterpenoids, and this fact has been well-known since the late 1960s.[3] Subsequent chemical studies of *Eunicea* species have been few, however, apparently due to difficulties in making homogeneous collections. The genus *Eunicea* is taxonomically complex with many species varying only slightly in form and color.[4] As part of a chemotaxonomic approach to this problem,[5] we have comprehensively investigated the genus *Eunicea* in the Caribbean Sea and reported upon the presence of new classes of secondary metabolites.[6-9] In an earlier paper, we described the structures of the new dolabellane class diterpenoids 1 and 2 from *Eunicea calyculata*.[6] Here, we wish to report the isolation of five new dolabellane diterpenoids (3-7; Chart I) and to clarify the source of this class of compounds not as the previously reported *E. calyculata*, but as *E. laciniata* Duchassaing and Michelotti.[10]

Diterpenoids of the bicyclic dolabellane class were originally isolated from the herbivorous sea hare *Dolabella californica*.[11,12] Subsequently, similar metabolites were found in its preferred diet, brown algae of the family Dictyotaceae.[13] A recent report describes the structure of a dolabellane metabolite, palominol (8), from *E. calyculata* and *E. laciniata*.[14] In this paper, we show that the structure of palominol should be revised to that of dolabellane 3.

Chart I



E. laciniata was collected in 1986 as part of an expedition to the Tobago Cays in the eastern Caribbean Sea. Freshly collected animals were stored frozen and subsequently exhaustively extracted with dichloromethane. The dolabellane diterpenoids 1 and 3-7 were purified by vacuum flash silica gel chromatography of the crude extract followed by HPLC separation of the relatively nonpolar fractions.

Dolabellane 1, a previously described compound, was isolated as an oil (1.5 g, 12% of the extract). High-resolution mass and proton and carbon NMR spectral data and optical rotations were identical with those reported.[6]

Dolabellane 3 was isolated as a white solid (mp 52-53 °C, 0.15 g, 1.2% of the extract) that was analyzed for $C_{20}H_{32}O$ by high-resolution mass and ^{13}C NMR spectral

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Table I. ^{13}C NMR Assignments for Synthetic and Natural Diterpenoids[a]

no.	1	3	4	5	6	7	9	10	12	13	14	15
1	40.9 C	47.4 C	48.4 C	50.4 C	52.3 C	40.4 C	47.8 C	46.4 C	52.3 C	52.4 C	48.5 C	48.5 C
2	40.1 CH_2	40.7 CH_2	40.2 CH_2	214.8 C	213.2 C	40.8 CH_2	40.0 CH_2	40.7 CH_2	212.5 C	216.0 C	73.1 C	75.2 C
3	124.8 CH	125.3 CH	125.9 CH	44.4 CH_2	44.6 CH_2	124.2 CH	125.9 CH	125.6 CH	44.5 CH_2	55.9 CH	41.4 CH_2	42.3 CH_2
4	135.4 C	134.5 C	134.7 C	27.3 CH	27.8 CH	136.5 C	134.8 C	135.0 C	27.6 CH	40.8 CH	27.5 CH[c]	28.6 CH[c]
5	38.1 CH_2[d]	38.1 CH_2[d]	38.2 CH_2[d]	31.2 CH_2	32.0 CH_2	37.6 CH_2	38.1 CH_2[d]	38.2 CH_2[d]	28.7 CH_2	34.7 CH_2	34.5 CH_2	34.5 CH_2
6	24.2 CH_2	24.4 CH_2	24.3 CH_2	23.2 CH_2	24.2 CH_2	32.3 CH_2	24.3 CH_2	24.3 CH_2	23.1 CH_2	28.9 CH_2	28.1 CH_2	26.4 CH_2
7	130.3 CH	128.6 CH	129.3 CH	130.6 CH	130.2 CH	76.1 CH	129.5 CH	129.5 CH	64.7 CH	55.2 CH	48.3 CH	53.6 CH
8	131.4 C	133.3 C	132.4 C	131.7 C	132.1 C	149.7 C	132.1 C	132.2 C	61.5 C	75.7 C	150.3 C	76.2 C[b]
9	39.8 CH_2[d]	40.0 CH_2[d]	39.9 CH_2[d]	40.0 CH_2	39.3 CH_2	34.3 CH_2	39.8 CH_2[d]	39.9 CH_2[d]	41.3 CH_2	47.4 CH_2	36.1 CH_2	44.5 CH_2
10	27.9 CH_2	26.1 CH_2	27.9 CH_2	27.8 CH_2	28.7 CH_2	30.6 CH_2	27.9 CH_2	29.0 CH_2	24.8 CH_2	23.2 CH_2	27.1 CH_2	23.3 CH_2
11	41.4 CH	46.0 CH	42.0 CH	48.8 CH	46.7 CH	43.5 CH	42.9 CH	42.0 CH	51.3 CH	51.9 CH	38.3 CH	36.3 CH
12	137.9 C	153.9 C	142.5 C	135.8 C	59.7 CH	137.6 C	147.7 C	145.4 C	135.0 C	134.1 C	58.6 CH	60.8 CH
13	206.7 C	122.6 CH	28.3 CH_2	204.8 C	218.1 C	206.3 C	71.7 CH	71.8 CH	204.4 C	204.2 C	220.2 C	220.1 C
14	54.7 CH_2	47.8 CH_2	38.7 CH_2	54.7 CH_2	55.3 CH_2	55.8 CH_2	49.8 CH_2	51.5 CH_2	51.3 CH_2	49.5 CH_2	51.0 CH_2	52.4 CH_2
15	23.1 CH_3	22.7 CH_3	23.6 CH_3	20.9 CH_3	20.9 CH_3	22.0 CH_3	23.4 CH_3	23.9 CH_3	22.5 CH_3	22.4 CH_3[e]	20.7 CH_3[e]	20.3 CH_3
16	16.1 CH_3	16.2 CH_3	16.3 CH_3	21.8 CH_3	22.4 CH_3	15.8 CH_3	16.1 CH_3	16.0 CH_3	19.8 CH_3	19.1 CH_3	22.3 CH_3[e]	22.2 CH_3
17	15.5 CH_3	15.5 CH_3	15.3 CH_3	16.8 CH_3	17.0 CH_3	114.0 CH_2	15.4 CH_3	15.4 CH_3	16.7 CH_3	19.1 CH_3	113.4 CH_2	22.9 CH_3
18	147.8 C	71.6 C	121.9 C	147.9 C	28.9 CH	147.8 C	129.9 C	129.2 C	150.0 C	149.6 C	29.1 CH[c]	28.8 CH[c]
19	24.4 CH_3	31.8 CH_3	21.7 CH_3[f]	24.3 CH_3	18.5 CH_3[f]	24.1 CH_3	22.1 CH_3[f]	21.5 CH_3[f]	24.6 CH_3	24.5 CH_3	19.2 CH_3[f]	19.6 CH_3
20	21.3 CH_3	31.8 CH_3	21.3 CH_3[f]	21.5 CH_3	18.1 CH_3[f]	21.5 CH_3	21.7 CH_3[f]	20.9 CH_3[f]	21.0 CH_3	21.9 CH_3[e]	18.3 CH_3[f]	17.8 CH_3
OAc						170.8 C						
						21.4 CH_3						

[a] ^{13}C NMR spectra were recorded at 50 MHz in $CHCl_3$ solution. Attached proton counts were determined from SFORD (1,3–7) and DEPT (9, 10, and 12–15) experiments. Assignments of 5 and 7 were made by XHCORR and COLOC experiments. Assignments of others were made by comparison with compounds 5 and 7. [b] Chemical shift was obtained in a C_6D_6 solution. [c–f] Signals within a column may be reversed.

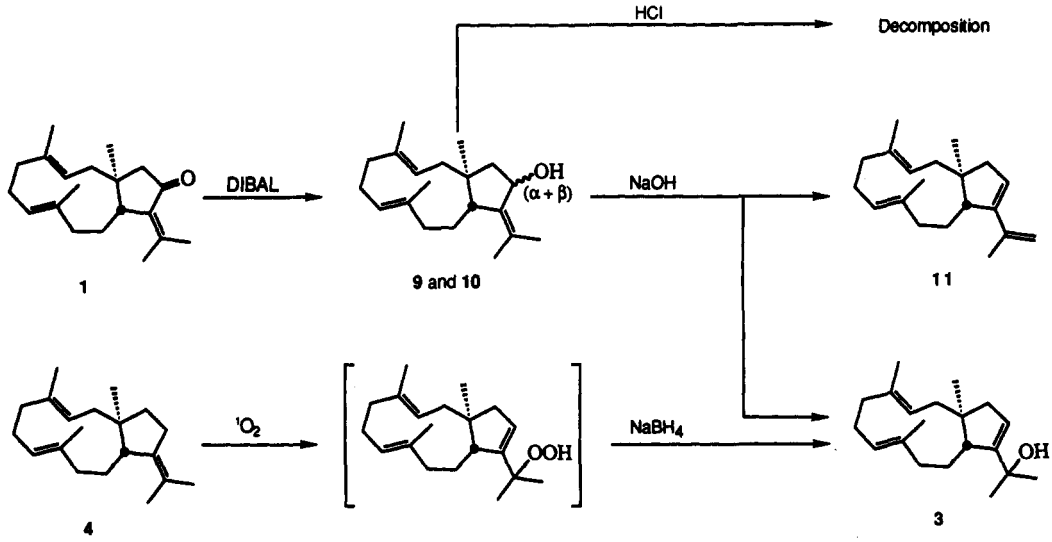


Figure 1. Chemical conversions of compounds 1 and 4 to the alcohol 3.

methods. Comparison of NMR data showed similarities between metabolites 1 and 3. However, there were several significant differences that indicated the presence of a new functional group in 3. Carbon signals at δ 206.7 (s), 147.8 (s), and 137.9 (s), which corresponded to an enone functionality in 1, were shifted to δ 153.9 (s), 122.6 (d), and 71.6 (s) in 3 (Table I). In the proton NMR spectrum (see Experimental Section), two methyl signals at δ 2.22 (br s) and 1.83 (br s), assigned in 1 as vinyl methyls at the terminal carbon of the conjugated exocyclic enone (C-12 to C-18), were shifted to δ 1.43 (s) and 1.38 (s) in 3. In addition, a new low-field signal appeared at δ 5.48 (br s). This proton showed couplings to upfield resonances at δ 2.25 and 1.93. Finally, the carbonyl absorption at 1700 cm^{-1} in the IR spectrum of 1 was replaced by a hydroxyl absorption at 3620 cm^{-1} in 3. All of these changes were accommodated by the migration of the C-12,18 double bond to the C-12,13 position and formation of a tertiary alcohol at C-18.

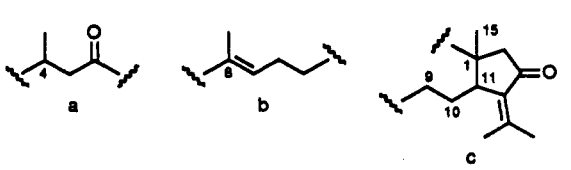
To confirm this interpretation, dolabellane 1 was chemically converted to dolabellane 3 (Figure 1). Reduction of 1 with diisobutylaluminum hydride (DIBAL-H) in THF gave the epimeric alcohols 9 and 10 in high yield. Attempts to convert these allylic alcohols to compound 3 in acidic media failed, resulting in very rapid conversion to complex products. Inspection of the ^1H NMR spectrum of the mixture indicated that the double bonds at Δ^3 and Δ^7 had disappeared. This reactivity is consistent with the propensity of the 11-membered ring to undergo transannular cyclization in a fashion analogous to that of the germacrene class of 10-membered ring sesquiterpenoids. Previous NOE studies indeed illustrated the favorable conformation of the dolabellanes to undergo this reaction.[6] Unexpectedly, treatment of 9 with concentrated NaOH in aqueous acetone resulted in the production of alcohol 3 and the corresponding tetraene 11 in high yield (Figure 1). The spectral data of synthetic 3 were identical with those of the natural product. Thus, diterpenoid 3 was fully defined

as 18-hydroxy-(1*S**,11*R**)-dolabell-3(*E*),7(*E*),12(*Z*)-triene. Comparison of the overall physical and spectral data of **3** with those reported for palominol (**8**)[14] indicated that these compounds were in fact identical. On the basis of our synthetic interconversions and reinterpretation of spectral and chemical data,[14] the structure reported for palominol should be corrected to that of dolabellane **3**.

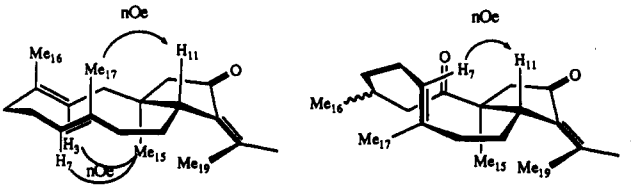
A volatile dolabellane hydrocarbon **4** was isolated as an oil (0.8% of extract) that was analyzed for $C_{20}H_{32}$ by high-resolution mass and ^{13}C NMR spectral methods. Analyses of NMR data revealed hydrocarbon **4** to possess an 11-membered ring identical with **1** and **3**. Differences were found however, in the five-membered ring. In the ^{13}C NMR spectrum, the carbonyl resonance at δ 206.7 in **1** was replaced by a methylene signal (δ 28.3 or 27.9). Corresponding changes were also found in the ^1H NMR spectrum in which the vinyl methyl signals at δ 2.22 and 1.83 in **1** were shifted to δ 1.61 and 1.59. From these data, hydrocarbon **4** was assigned as the C-13 reduction product of dolabellane **1**. A simple photooxidation followed by reduction confirmed this interpretation (Figure 1). Compound **4** reacted smoothly with singlet oxygen, generated photochemically by dye sensitization, to yield an intermediate hydroperoxide that was not characterized. Treatment of the reaction mixture with $NaBH_4$ gave dolabellane **3** as the only product, thus confirming the structure assignment of **4** and further confirming the structural assignment of dolabellane **3**.

Dolabellane **5** was isolated as an oil (0.3% yield ext) that was analyzed for $C_{20}H_{30}O_2$ by high-resolution mass and ^{13}C NMR spectral methods. NMR analysis revealed this metabolite to possess a five-membered ring with identical substitution as in dolabellane **1**. However, the ^{13}C NMR spectrum of this compound also showed a new carbonyl signal at δ 214.8 (Table I), indicating the presence of an additional ketone in the 11-membered ring. Signals corresponding to one of the double bonds in the 11-membered ring had also disappeared. The ^1H NMR spectrum of **5** (Table II) showed a signal at δ 0.98 (d, 7.0) recognized as a nonolefinic secondary methyl group. Proton COSY NMR experiments allowed these new spectral features to be interpreted. A proton signal at δ 2.57 (dd, 19.7, 10.9) was found to be coupled to two protons at δ 2.24–2.17 and 2.20–2.12. The upfield methyl doublet resonance at δ 0.98 was also coupled to a proton signal in the same region (δ 2.20–2.12). It seemed likely that both sets of protons were coupled to the same proton. However, this proton signal was obscured by others, and its assignment was not clear. This problem was solved by a proton–proton relay coherence transfer (^1H RCT) experiment in which a correlation was observed between protons at δ 2.57 and 0.98. The low-field chemical shift (δ 2.57) and the very large coupling constant (19.7 Hz) indicated that this proton was part of a methylene group adjacent to a carbonyl.

The combination of ^1H NMR COSY, RCT, and direct carbon-proton correlation (XHCORR) experiments revealed the presence of three partial structures (a–c).



The chemical shift of the carbon at C-1 in c was at significantly lower field (a change of 9.5 ppm) than in **1**, indicating the carbonyl of partial structure a was attached at this 9.5 ppm) than in **1**, indicating the carbonyl of partial structure a was attached at this position. This was supported by the two-dimensional long-range carbon proton correlation spectroscopy (COLOC) experiment (Table III), in which a coupling was observed between the carbonyl carbon (δ 214.8) and the C-15 methyl protons (δ 1.22). The remaining problem was the attachment of b to a and c. Since both the proton and carbon chemical shifts of C-9 were substantially lower than C-10, C-9 must be attached to C-8, the olefinic end of b. Thus, the planar structure of diketone **5** was defined.



crown configuration — **1**

Δ^7 double bond is rotated 180° — **5**

Results of a ^1H NMR NOEDS experiment with compound **5**.

proton (s) irradiated	proton (s) enhanced	measured enhancement (%)
3α(2.57)[a]	15	3.0
7	11	4.3
11	7, 19	3.3, 4.4
15	3α(2.57)[a], 14α(2.00)[a]	8.5, 2.6

[a]Chemical shifts of protons

Figure 2. NOE-derived conformations of the 11-membered rings of dolabellanes **1** and **5**.

Dolabellane **5** has three chiral centers (C-1, -4, and -11) and a trisubstituted double bond (Δ^7). The high-field chemical shift of the C-16 methyl carbon (δ 16.8) in the ^{13}C NMR spectrum confirmed an *E* configuration for the Δ^7 double bond. Proton NMR NOEDS experiments were crucial in assigning the stereochemistry of the chiral centers (Figure 2). The proton signals at C-3 (δ 2.57) and -15 (δ 1.22) were enhanced when each was irradiated. Irradiation of the methine proton at C-11 resulted in enhancement of the C-19 methyl. Since no enhancement was observed between the protons at C-11 and -15, the configurations are 1*S**,11*R**, identical in relative configuration with compound **1**.

An interesting feature of the conformation of the 11-membered ring in **5** was illustrated in these NOEDS experiments (Figure 2). Irradiation of the C-11 methine signal enhanced the olefinic proton at C-7 and vice versa. If the 11-membered ring of **5** is similar in conformation to **1**, enhancement would have been expected between protons at C-11 and -17. However, these enhancements were not observed. These results suggest a change in the conformation of the 11-membered ring in which the C-7 double bond of **5** had rotated by 180°. Inspection of a molecular model of this conformation revealed that the Δ^7 double bond is not only proximate but coplanar with the C-2 carbonyl group. Thus, as π bond interaction between two double bonds contributes to the crown conformation in **1**, the same interaction between a double bond and the ketone appears to contribute to a new conformation for the 11-membered ring in compound **5**.

The stereochemistry of the remaining chiral center at C-4 could not be determined by ^1H NMR NOE experiments since irradiation of the C-16 methyl protons failed to enhance any key proton signals. The configuration of this center was determined by NMR analysis of a rigid tricyclic diketone reaction product, **13** (Figure 3). Ep-

Table II. ^{1}H NMR Assignments for the Diterpenoids 5–7 and 12–15[a]

no.	5	6	12	13	14	15	7
2							2.21–2.14 (1H)[c] 1.84 (1 H, brdd, 13.1, 4.5)
3	2.57 (1 H, dd, 19.7, 10.9)	2.54 (1 H, dd, 19.4, 9.1)	2.65 (1 H, dd, 19.3, 3.0)	2.78 (1 H, dd, 7.9, 7.7)	1.58 (1 H, m)	1.42–1.33 (1 H)[c]	5.52 (1 H, ddd, 11.6, 4.4, 0.8)
	2.24–2.17 (1 H)[c]	2.35 (1 H, dd, 19.4, 3.5)	2.42 (1 H, dd, 19.3, 10.0)		1.12 (1 H, ddd, 12.7, 12.7, 2.1)	1.16 (1 H, dd, 13.3, 12.8)	
4	2.20–2.12 (1 H)[c]	2.17–2.10 (1 H)[c]	2.23 (1 H, m)	2.51 (1 H, m)	1.78–1.70 (1 H)[c]	1.63–1.56 (1 H)[c]	
5	2.18–2.03 (1 H)[c]	1.98–1.90 (1 H)[c]	1.88 (1 H, m)	1.98–1.85 (1 H)[c]	1.78–1.70 (1 H)[c]	1.85–1.80 (1 H)[c]	*b*
	1.43 (1 H, m)	1.55–1.44 (1 H)[c]	1.69 (1 H, m)	1.24 (1 H, m)	0.85 (1 H, m)	0.88 (1 H, m)	
6	2.18–2.03 (1 H, m)	2.12–2.02 (1 H)[c]	2.12 (1 H, dddd, 14.8, 10.3, 4.1, 1.5)	1.98–1.85 (2 H)[c]	1.78–1.70 (1 H)[c]	2.24 (1 H, dddd, 13.4, 3.2, 3.2, 3.1)	2.03–1.91 (2 H)[c]
	1.89 (1 H, m)	1.98–1.90 (1 H)[c]	1.37 (1 H, m)		1.50 (1 H, m)	1.47 (1 H, dddd, 13.3, 13.3, 13.1, 3.3)	
7	5.02 (1 H, m)	5.03 (1 H, brdd, 7.5, 7.5)	2.69 (1 H, dd, 9.8, 2.1)	2.27 (1 H, m)	2.28 (1 H, dd, 12.7, 3.6)	1.63 (1 H, m)	5.21 (1 H, brdd, 4.8, 4.2)
9	2.18–2.03 (2 H)[c]	2.22–2.15 (1 H)[c]	2.35 (1 H, brdd, 13.9, 8.1)	2.16 (1 H, m)	2.54 (1 H, ddd, 13.6, 10.9, 2.7)	2.08–1.95 (1 H)[c]	2.35–2.26 (2 H)[c]
		1.89 (1 H, ddd, 12.7, 12.7, 2.9)	1.23 (1 H, m)	1.68 (1 H, brdd, 13.2, 9.1)	2.19 (1 H, m)	1.88–1.80 (1 H)[c]	
10	1.82 (1 H, m)	1.76 (1 H, brddd, 11.7, 7.2, 2.6)	1.91 (1 H, m)	2.05–1.96 (1 H)[c]	1.88–1.79 (1 H)[c]	2.08–1.95 (1 H)[c]	1.75 (1 H, m)
	1.61 (1 H, m)	1.55–1.44 (1 H)[c]	1.72 (1 H, dddd, 16.0, 8.3, 4.5, 1.3)	1.98–1.85 (1 H)[c]	1.46 (1 H, m)	1.39 (1 H, m)	1.53 (1 H, m)
11	3.09 (1 H, brd, 6.0)	2.30 (1 H, ddd, 10.9, 7.5, 3.6)	2.72 (1 H, m)	2.74 (1 H, m)	2.14 (1 H, m)	2.87 (1 H, ddd, 10.9, 10.9, 6.8)	2.48 (1 H, brd, 10.6)
12		1.83 (1 H, ddd, 10.9, 3.4, 2.1)			1.83–1.78 (1 H)[c]	2.08–1.95 (1 H)[c]	
14	2.84 (1 H, brd, 15.9)	2.70 (1 H, brd, 17.0)	3.12 (1 H, brd, 16.2)	3.06 (1 H, brd, 16.1)	2.77 (1 H, dd, 17.1, 1.0)	2.72 (1 H, brd, 17.0)	*b*
	2.00 (1 H, d, 15.7)	2.05 (1 H, dd, 17.1, 2.0)	2.01 (1 H, d, 16.2)	2.00 (1 H, d, 16.1)	1.98 (1 H, dd, 17.1, 1.8)	2.01–1.95 (1 H)[c]	
15	1.22 (3 H, s)	1.15 (3 H, s)	1.25 (3 H, s)	1.27 (3 H, s)	1.03 (3 H, d, 0.9)	1.11 (3 H, brs)	1.24 (3 H, s)
16	0.98 (3 H, d, 7.0)	0.99 (3 H, d, 7.0)	1.00 (3 H, d, 7.1)	0.94 (3 H, d, 6.7)	0.88 (3 H, d, 6.0)	0.90 (3 H, d, 6.4)	1.54 (3 H, brs)
17	1.67 (3 H, brs)	1.64 (3 H, brs)	1.39 (3 H, s)	1.26 (3 H, s)	5.00 (1 H, brs)	1.32 (3 H, s)	5.31 (1 H, brs)
					4.94 (1 H, brs)		5.13 (1 H, brs)
18		2.05–1.97 (1 H)[c]			1.90 (1 H, m)	2.08–1.94 (1 H)[c]	
19	1.85 (3 H, d, 1.6)	0.99 (3 H, d, 7.1)[d]	1.81 (3 H, d, 2.0)	1.85 (3 H, d, 1.5)	1.00 (3 H, d, 6.9)[d]	1.01 (3 H, d, 6.9)[d]	1.80 (3 H, d, 0.8)
20	2.15 (3 H, d, 2.2)	1.11 (3 H, d, 6.9)[d]	2.22 (3 H, d, 2.3)	2.19 (3 H, d, 2.1)	0.90 (3 H, d, 6.7)[d]	0.94 (3 H, d, 7.0)[d]	2.18 (3 H, d, 1.5)
others					2.01 (1 H, d, 2.4, –OH)	1.61 (2 H, brs, –OH)	2.06 (3 H, s, –OAc)

[a] ^{1}H NMR spectra were recorded in $CDCl_3$ solution at 360 MHz. Assignments were aided by spin decoupling, COSY, and RCT (5 and 6) experiments. *J* values are reported in Hz and chemical shifts are given in δ units (ppm downfield from Me_4Si). [b] Nonassignable resonances. [c] Coupling constants were not determined. [d] Signals within a column may be reversed.

oxidation of **5** with *m*-chloroperbenzoic acid (*m*CPBA) gave the epoxide **12** in only modest yield. The structure of **12** was determined by HRMS, ^{1}H and ^{13}C NMR, and COSY experiments. Treatment of this compound with lithium diisopropylamide (LDA) resulted in transannular displacement of the epoxide to give diketone **13** as the major product. The structure of **13**, assigned by spectral methods, was found to possess the fusicoccane carbon skeleton. Diterpenes of this class are rare, but have been encountered from some fungi and liverworts.[15] In the marine environment, the diterpenoid epoxidictymene, isolated from the brown alga *Dictyota dichotoma*, is the only example of this carbon skeleton.[16]

All of the key protons of **13** were unambiguously assigned by ^{1}H NMR COSY experiments. The relative configurations of the chiral centers C-1, -3, -4, -7, -8, and -11 were readily assigned by ^{1}H NMR NOEDS (Figure 3). Irradiation of the proton at C-3 enhanced both methyls signals at C-15 and C-16. Also, irradiation of the C-16 methyl signals enhanced the C-3 proton. Therefore, these protons must be syn oriented to the plane of the molecule. Another factor supporting this interpretation was the lack of enhancement between the protons at C-3 and C-4. Mutual enhancements between the C-7 and C-11 protons

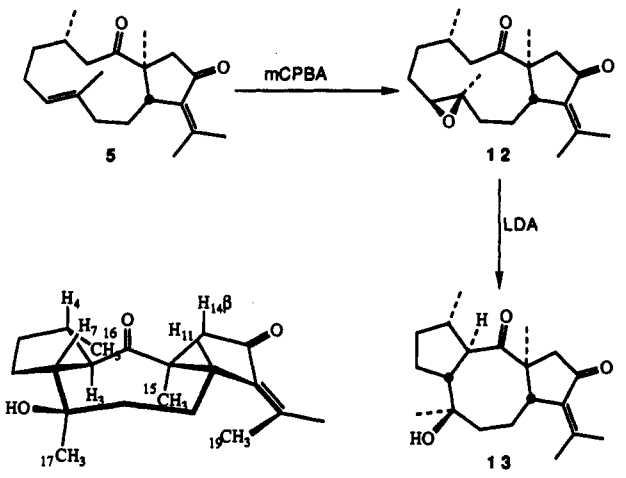
(15) (a) Turner, W. B.; Aldridge, D. C. *Fungal Metabolites*; Academic Press: London, 1983; Vol. II. (b) Hashimoto, T.; Tori, M.; Taira, Z.; Asakawa, Y. *Tetrahedron Lett.* **1985**, *26*, 6743. (c) Huneck, S.; Baxter, G.; Cameron, A. F.; Connolly, J. D.; Rycroft, D. S. *Tetrahedron Lett.* **1983**, *24*, 3787.

(16) Enoki, N.; Furusaki, A.; Suehiro, K.; Ishida, R.; Matsumoto, T. *Tetrahedron Lett.* **1983**, *24*, 4341.

Table III. Results of Two-Dimensional Carbon-Proton Long-Range Correlation (COLOC) Experiments[a] with Compounds 5 and 7

C no.	proton	
	5[b]	7[b]
1	14 (2.84), 15	2 (2.21–2.14),[c] 2 (1.84), 11, 15
2	15	15
3		2 (2.21–2.14),[c] 2 (1.84), 16
4		2 (2.21–2.14),[c] 16
5		16
6		
7	17	17 (5.31), 17 (5.13)
8	17	9 (2.35–2.26)
9		17 (5.31), 17 (5.13)
10		9 (2.35–2.26), 11
11		15
12	14 (2.00), 19, 20	11, 19, 20
13	14 (2.84), 14 (2.00)	11
14	15	15
15		2 (2.21–2.14)[c]
16		3
17		
18	19, 20	19, 20
19	20	20
20	19	19

[a] Experiments were performed at 50 MHz in $CDCl_3$ solutions. Parameters were optimized for couplings of 6 Hz. [b] The numbers in parentheses are the ^1H NMR chemical shifts of the protons that correlate. [c] Due to the overlapping with other protons, correlation was not clear.



Results of a ^1H NMR NOEDS experiment with diterpenoid 13.

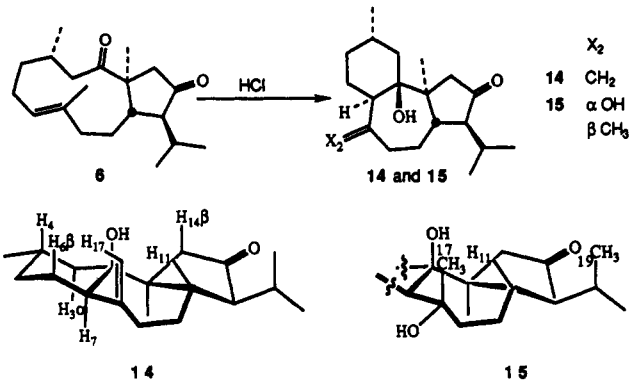
proton (s) irradiated	proton (s) enhanced	measured enhancement (%)
3	15, 16, 17	7.9, 5.5, 5.0
4	16	9.8
7	9β(2.05–1.96)[a], 11	1.8, 17.9
11	7, 14β(3.06)[a]	7.0, 1.1
16	3, 4	4.4, 7.6
17	3	5.0

[a] Chemical shifts of protons.

Figure 3. Formation and stereochemistry of diterpenoid 13.

allowed assignment of the relative configuration at C-7. The stereochemistry at C-8 was determined by the mutual enhancements of the C-3 and C-17 methyl protons. Irradiation of the C-7 proton failed to enhance the C-17 methyl, thus supporting this interpretation. Thus, the relative stereochemistry of **13** is 1*S**,3*R**,4*S**,7*R**,8*R**,11*R**, yielding the relative stereochemistry of **5** as 1*S**,4*S**,11*R**.

Dolabellane **6** was isolated as an oil (0.3% of the extract) that was analyzed for $C_{20}H_{32}O_2$ by high-resolution mass



Results of ^1H NMR NOEDS experiments with compounds 14 and 15.

	proton (s) irradiated	proton (s) enhanced	measured enhancement (%)
14	3α(1.12)[a]	7	5.3
	14β(2.77)[a]	OH	5.6
	17(4.94)[a]	6β(1.78–1.70)[a], OH	4.2, 3.4
15	11	17	3.9
	19	11	1.7

[a] Chemical shifts of protons.

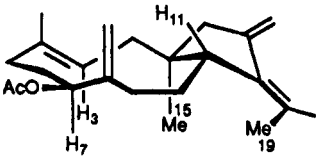
Figure 4. Formation and NOE-derived stereochemistry of compounds 14 and 15.

and ^{13}C NMR spectral methods. Spectral data for **6** were very similar to compound **5**. However, in the ^{13}C NMR spectrum (Table I), the two exocyclic olefinic carbon signals in **5** (C-12, -18) were replaced by two high-field carbon resonances at δ 59.7 (d) and 28.9 (d). Also, the carbonyl at δ 204.8 was shifted downfield to δ 218.1. Corresponding differences were also found in the ^1H NMR spectrum (Table II). Vinyl methyls found at δ 2.15 (d, 2.2) and 1.85 (d, 1.6) in **5** were shifted to δ 1.11 (d, 6.9) and 0.99 (d, 7.1) in dolabellane **6**. Finally, the carbonyl absorption at 1710 cm^{-1} in the IR spectrum was shifted to 1735 cm^{-1} in **6**, indicating the presence of a nonconjugated cyclopentanone system. Thus, the structure of **6** was defined as the 12,18-dihydro derivative of dolabellane **5**. The relative stereochemistry of the new chiral carbon at C-12 was also defined by NMR studies. The methine proton at this proton (δ 1.83) showed a long-range coupling with one of the methylene protons at C-14 (δ 2.05). Since the other proton (δ 2.70) of the same carbon displayed W-coupling to the C-15 methyl (δ 1.15) and was β-oriented to the 5-membered ring, it seemed very likely that the orientation of the C-12 proton was α. This conclusion was supported by the results of a ^1H NOEDS experiment (Figure 4). Irradiation of the methyl at δ 1.11 (C-19 or -20) enhanced the proton at δ 2.30 (C-11) by 10.0%. To confirm the structure assignment of **6**, the compound was converted to rigid tricarbocyclic derivatives that were confidently investigated by NOEDS methods (Figure 4). Treatment of **6** with dilute HCl in aqueous acetone afforded two major products, **14** and **15**, the structures of which were defined by a combination of high-resolution mass, ^1H and ^{13}C NMR, proton decoupling, and COSY experiments. Both **14** and **15** possess an unusual tricyclic carbon skeleton, discovered to occur naturally only recently in a metabolite from a Chinese soft coral of the genus *Clavularia*.[17] As before, the relative stereochemistries of the chiral centers in **14** and **15** were determined by ^1H NMR NOEDS mea-

(17) Xia, Z.; Zhang, Z. *Jiegou Huaxue* **1984**, *3*, 29 (*Chem. Abstr.* **1987**, *107*, 237056p).

surements (Figure 4). In tricyclic ketone 14, the hydroxyl proton signal at δ 2.01 (d, 2.3, C-2) was enhanced by irradiation of protons at δ 2.77 (dd, 17.1, 1.0, C-14β) and 4.94 (br s, C-17). Also, the proton at δ 2.28 (dd, 12.7, 3.6, C-7) was enhanced by the proton at δ 1.12 (ddd, 12.7, 12.7, 2.1, C-3). Since enhancement was not observed between the C-3 proton and the hydroxyl proton at C-2, their orientations to the ring must be α and β, respectively. An observed W-coupling between these protons supported this assignment. The large coupling (12.7 Hz) between C-3α and C-4 protons suggested that the methyl at C-16 is α-oriented to the cyclohexane ring. Thus, the relative stereochemistry of 14 was unambiguously defined. Because of the overlapping of many proton resonances, ^{1}H NMR NOEDS experiments of 15 were less successful. However, irradiation of the proton at δ 2.87 (ddd, 10.9, 10.9, 6.8, C-11) enhanced the methyl group at δ 1.32 (s, C-17), indicating that the orientation of the methyl group is β to the ring. Although, the orientation of the C-7 proton was not determined, the lack of enhancement of the methyl at C-17 suggested that they were *anti* to each other. Thus, the relative configurations of compounds 14 and 15 were defined as 1*S**,2*R**,4*S**,7*R**,8*S**(for 14),11*R**,12*S**.

Dolabellane 7 was isolated as a white solid (0.3% ext) that was analyzed for $C_{22}H_{32}O_3$ by high-resolution mass and ^{13}C NMR spectral methods. Compound 7 possessed two additional carbons recognized by ^{1}H and ^{13}C NMR data as an acetate ester. Comparison of relevant NMR spectra revealed that 7 has the same five-membered ring as compounds 1, 2, and 5. The structural variation of the 11-membered ring was determined by a combination of ^{1}H NMR COSY, XHCORR, and ^{13}C COLOC experiments (Table III). An olefinic proton signal at δ 5.52 (ddd, 11.6, 4.4, 0.8) was coupled with protons at δ 1.54 (3 H, br s), 2.21–2.14 (1 H, multiplicities unknown), and 1.84 (1 H, brdd, 13.1, 4.5). An XHCORR experiment showed that the latter two protons were attached to the same carbon at δ 40.8 (C-2). Several carbon–proton long-range correlations defined the region of C-1–C-5 as identical with dolabellanes 1, 3, and 4. Homoallylic proton couplings between the methyl protons at δ 1.80 (C-19) and 2.18 (C-20) and a proton at δ 2.48 (br d, 10.6) allowed this latter proton to be assigned at C-11. In addition, this proton was coupled to protons at δ 1.75 and 1.53 (C-10), which were further coupled to two proton resonances at δ 2.35–2.26 assigned to the allylic carbon at C-9. These data established the region C-8 to C-11. The acetoxyl-bearing carbon at δ 76.1 (d) was coupled to the exocyclic methylene protons (C-17), indicating the position of the acetyl group at C-7.



Compound 7 has an additional chiral center at C-7, the relative stereochemistry of which was also defined by NMR studies. Irradiation of the olefinic proton at C-3 enhanced the C-7 proton by 4.1%. Signals of both protons were subsequently enhanced by the irradiation of the C-15 methyl protons (4.5% for the C-3 proton, and 4.7% for the C-7 proton), indicating the acetoxyl group at C-7 is β. Irradiation of the C-11 proton enhanced the methyl protons at C-19 by 5.6% and confirmed the stereochemistry of the ring junction as trans. Thus, metabolite 7 was confidently assigned as 7(*S**)-acetoxy-13-keto-(1*S**,11*R**)-dolabella-3(*E*),8(17),12(18)-triene.

Experimental Section

General Procedures. Infrared spectra were recorded as thin films on salt plates. ^{1}H NMR, COSY, and RCT spectra were recorded in $CDCl_3$ solutions. *J* values are given in hertz. NOE difference spectroscopy (NOEDS) experiments were performed in general as outlined by Hall and Sanders.[18] ^{13}C NMR spectra of other compounds, direct (XHCORR), and long-range (COLOC) carbon–proton correlation spectra were recorded in $CDCl_3$. Both high- and low-resolution mass measurements were supplied by the Mass Spectrometry Service Laboratory, The University of Iowa. Optical rotations were measured with a 10-cm microcell. All solvents used were either spectral grade or distilled from glass prior to use.

Collection and Extraction. Specimens of *E. laciniata* Duchassaing and Michelotti (voucher number CI86-228)[19] were collected by hand using SCUBA at −20- to 25-m depth in July 1986, adjacent to the Tobago Cays, eastern Caribbean Sea. The collection was surface air-dried in the shade and immediately frozen. The gorgonian was next repeatedly extracted with CH_2Cl_2 and the combined extracts were evaporated to yield 13 g of crude organic materials (from 0.6 kg, dry weight of the gorgonian). Compounds 1 and 3–7 were eluted from a vacuum flash silica gel column with 0–20% EtOAc in isooctane and further purified with the same solvents by HPLC using preparative Si gel columns.

13-Keto-(1*S*,11*R*)-dolabella-3(*E*),7(*E*),12(18)-triene (1). The ketone 1 was isolated as an oil after final purification by HPLC (10% EtOAc in isooctane). The extract yielded 1.5 g (12% of the extract) of 1, $[\alpha]_D$ +32° (*c* 1.9, $CHCl_3$) (lit. $[\alpha]_D$ +31° (*c* 0.9, $CHCl_3$)).[6]

18-Hydroxy-(1*S,11*R**)-dolabella-3(*E*),7(*E*),12(*E*)-triene (3).** The alcohol 3 was isolated as a white solid by HPLC (5% of EtOAc in isooctane). The extract yielded 160 mg (1.2% of the crude extract) of 3, mp 52–53 °C, which exhibited $[\alpha]_D$ −28° (*c* 0.7, $CHCl_3$) and displayed the following spectral features: HRMS M^+ *m/z* obsd 288.2465, $C_{20}H_{32}O$ required 288.2455; low-resolution MS *m/z* (relative intensity) 288 (10), 273 (14), 270 (80), 229 (56), 189 (38), 187 (59), 177 (53), 173 (49), 164 (37), 161 (40), 159 (100), 152 (84); IR ($CHCl_3$) 3620, 2980, 2920, 1690, 1450, 1390, 1160, 1120 cm^{-1}; UV (MeOH) no λ_{max}; ^{1}H NMR ($CDCl_3$) δ 5.22 (1 H, ddd, *J* = 11.7, 5.1, 1.2, H-3), 4.85 (1 H, br dd, *J* = 10.4, 1.0, H-7), 2.37 (1 H, br d, *J* = 10.4, H-11), 2.25 (1 H, multiplicities unknown, H-14), 1.93 (1 H, dd *J* = 16.5, 3.2, H-14), 1.63 (3 H, br s, H-17), 1.51 (3 H, br s, H-16), 1.43 (3 H, br s, H-19/20), 1.38 (3 H, br s, H-19/20), 1.17 (3 H, br s, H-15); ^{13}C NMR ($CDCl_3$) Table I.

(1*S,11*R**)-Dolabella-3(*E*),7(*E*),12(18)-triene (4).** The triene 4 was isolated as an oil by HPLC (100% isooctane). The extract yielded 100 mg (0.8% of the crude extract) of 4. Compound 4 showed $[\alpha]_D$ −149° (*c* 0.8, $CHCl_3$) and displayed the following spectral features: HRMS M^+ *m/z* obsd 272.2500, $C_{20}H_{32}$ required 272.2504; low-resolution MS *m/z* (relative intensity) 272 (11), 229 (20), 216 (22), 189 (26), 161 (36), 136 (84), 121 (100), 107 (37), 93 (31); IR (film) 2940, 2860, 1670, 1450, 1390, 1370, 920 cm^{-1}; UV (MeOH) no λ_{max}; ^{1}H NMR ($CDCl_3$) δ 5.24 (1 H, br dd, *J* = 11.0, 4.6, H-3), 4.89 (1 H, br d, *J* = 10.0, H-7), 1.64 (3 H, br s, H-17), 1.61 (3 H, br s, H-19/20), 1.59 (3 H, br s, H-19/20), 1.44 (3 H, br s, H-16), 1.19 (3 H, br s, H-15); ^{13}C NMR ($CDCl_3$) Table I.

2,13-Diketo-(1*S,4*S**,11*R**)-dolabella-7(*E*),12(18)-diene (5).** The ketone 5 was isolated as an oil by HPLC (10% EtOAc in isooctane, 35 mg, 0.3% of the crude extract). Compound 5 exhibited $[\alpha]_D$ −27° (*c* 0.7, $CHCl_3$) and displayed the following spectral features: HRMS; M^+ *m/z* obsd 302.2246, $C_{20}H_{30}O_2$ required 302.2246; low-resolution MS *m/z* (relative intensity) 302 (42), 163 (11), 153 (15), 150 (100), 135 (40), 109 (29), 93 (27), 81 (33), 69 (55), 55 (37); IR (film) 2960, 1710, 1700, 1640, 1450, 1375, 1265, 1020 cm^{-1}; UV (MeOH) 254 nm (ε 3300).

2,13-Diketo-(1*S,4*S**,11*R**,12*S**)-dolabell-7(*E*)-ene (6).** The ketone 6 was isolated as an oil by HPLC (5% EtOAc in isooctane, 35 mg, 0.3% of the crude extract). Compound 6 exhibited [α] −44° (*c* 0.6, $CHCl_3$) and displayed the following spectral

(18) Hall, L. D.; Sanders, J. K. M. *J. Am. Chem. Soc.* **1980**, *102*, 5703.
(19) Specimens of *E. laciniata* Duchassaing and Michelotti (code No. Fenical CI86-228) are on deposit in the octocoral collection, Smithsonian Institution, Washington, DC, under the curatorship of Dr. Frederick M. Bayer.

features: FABMS $(M + H)^+$ m/z obsd 305.2483, $C_{20}H_{32}O_2$ required 305.2481; low-resolution MS m/z (relative intensity) 305 (100), 303 (47), 287 (86), 259 (16), 154 (85), 136 (80), 123 (39), 109 (40); IR (film) 2960, 1735, 1700, 1460, 1390, 1170 cm^{-1}; UV (MeOH) no λ_{max}.

7(*R)-Acetoxy-13-keto-(1*S**,11*R**)-dolabella-3(*E*),8-(17),12(18)-triene (7).** The acetate 7 was isolated as white solid by HPLC (15% EtOAc in isooctane). Recrystallization from acetone gave 33 mg (0.3% of the crude extract) of 7, mp 103–104 °C. Compound 7 showed $[\alpha]_D$ +170° (*c* 0.7, $CHCl_3$) and displayed the following spectral features: FABMS $(M + H)^+$ m/z obsd 345.2446, $C_{22}H_{32}O_3$ required 345.2430; low-resolution MS m/z (relative intensity) 345 (15), 307 (64), 289 (37), 154 (100), 136 (100), 120 (26), 107 (36); IR (film) 2940, 1730, 1705, 1640, 1440, 1370, 1240, 1040 cm^{-1}; UV (MeOH) 254 nm (ϵ 5200).

Reduction of Dolabellane 1. To a stirred solution of 1 (60 mg, 0.21 mmol) in 3 mL of dry THF under N_2, 350 μL of a 1 M DIBAL solution in CH_2Cl_2 was added. After the solution was stirred for 1 h, 5 mL of 1:1 (v/v) mixture of THF and water and 150 μL of 1 N NaOH were added. After the solution was stirred for 5 min, 20 mL of Et_2O and 20 mL of water were added. The Et_2O layer was washed with saturated $NaHCO_3$ (15 mL) and water (2 × 15 mL) and dried under vacuum. Purification by HPLC (10% EtOAc in isooctane) gave 9 (33 mg, 0.11 mmol, 55% yield) and 10 (20 mg, 0.06 mmol, 31%). Compound 9 was isolated as an oil that exhibited $[\alpha]_D$ −80° (*c* 0.7, $CHCl_3$) and displayed the following spectral features: HRMS $M^+ - H_2O$ m/z obsd 270.2350, $C_{20}H_{32}O$ required 270.2349; low-resolution MS m/z (relative intensity) 270 (18), 255 (10), 187 (23), 173 (17), 162 (20), 159 (43), 147 (36), 134 (100), 119 (90), 105 (59); IR (film) 3400, 2920, 1670, 1620, 1450, 1385, 1370, 1040 cm^{-1} UV (MeOH) no λ_{max}; ^1H NMR ($CDCl_3$) δ 5.24 (1 H, dd, J = 11.0, 5.0, H-3), 4.89 (1 H, br d, J = 10.0, H-7), 4.65 (1 H, br d, J = 5.7, H-13), 1.82 (3 H, br s, H-20), 1.69 (3 H, br s, H-19), 1.63 (3 H, br s, H-17), 1.47 (3 H, br s, H-16), 1.10 (3 H, br s, H-15). Compound 10 was isolated as a white solid, mp 124–125 °C, which showed $[\alpha]_D$ −181° (*c* 0.7, $CHCl_3$) and displayed the following spectral features: HRMS M^+ m/z obsd 288.2480, $C_{20}H_{32}O$ required 288.2455; low-resolution MS m/z (relative intensity) 288 (6), 270 (100), 255 (36), 227 (21), 187 (68), 173 (42), 159 (83); IR ($CHCl_3$) 3600, 2980, 2920, 1670, 1445, 1390, 1375, 1050 cm^{-1}; UV (MeOH) no λ_{max}; ^1H NMR ($CDCl_3$) δ 5.19 (1 H, dd J = 11.4, 4.6, H-3), 4.87 (1 H, br d, J = 10.3, H-7), 4.65 (1 H, dd, J = 5.7, 5.1, H-13), 1.80 (3 H, br s, H-20), 1.67 (3 H, br s, H-19), 1.63 (3 H, br s, H-17), 1.43 (3 H, br s, H-16), 1.18 (3 H, br s, H-15); ^{13}C NMR data of 9 and 10 are shown in Table I.

Reaction of 9 with NaOH. To a stirred solution of 9 (13 mg, 0.05 mmol) in 1 mL of Me_2CO was added 0.5 mL of 1 N NaOH solution. Instantly, the color of the solution turned to yellow. After 30 min, the solution was extracted with 20 mL of Et_2O and dried under vacuum. Purification by HPLC (5% EtOAc in isooctane) gave the tetraene 11 (2.9 mg, 0.01 mmol, 24% yield), alcohol 3 (3.6 mg, 0.01 mmol, 28%), and the reactant 9 (4.9 mg, 0.02 mmol, 38%). ^1H NMR ($CDCl_3$) data for 11: δ 5.60 (1 H, br s), 5.27 (1 H, dd, J ≈ 11.6, 5.1), 4.88 (1 H, br d, J = 10.0), 4.86 (1 H, br s), 4.83 (1 H, br s), 1.88 (3 H, br s), 1.60 (3 H, br s), 1.47 (3 H, br s), 1.20 (3 H, br s). Further characterization was not pursued. Spectral data of 3 were identical with those of the natural compound.

Photooxidation of Dolabellane 4. Photooxidation of 4 was performed in general by following the methods outlined by Foote and co-workers.[20] To an ice-cooled and stirred solution of 4 (19 mg, 0.07 mmol) in 10 mL of dry CH_2Cl_2 was added 2.5 mg of methylene blue. A 100-W tungsten lamp was used as the light source. After irradiation and aeration (80 mL per min) for 15 min, all of the reactant had disappeared by TLC analysis. The reaction mixture was then filtered through a small silica column under vacuum, and the CH_2Cl_2 solvent was removed under vacuum. The residue was dissolved in 5 mL of EtOH, and 10 mg of $NaBH_4$ was added. After being stirred for 30 min, the reaction mixture was extracted with Et_2O. After removal of the Et_2O under vacuum, the residue was purified by Si HPLC (5% EtOAc in isooctane) to give dolabellane 3 (4.5 mg) as the sole product. NMR data of the product were identical with naturally occurring compound (23% yield).

Epoxidation of Dolabellane 5. To a stirred solution of 5 (27 mg, 0.09 mmol) in 5 mL of CH_2Cl_2 buffered with anhydrous Na_2HPO_4 was added 1.3 equiv of *m*CPBA. After the solution was stirred for 2 h at room temperature, the CH_2Cl_2 layer was washed with 10% Na_2SO_3 (2 × 15 mL), 5% $NaHCO_3$ (2 × 15 mL), and finally with brine. After the CH_2Cl_2 was evaporated and the solution was dried under vacuum, the major product 12 was purified by Si HPLC (25% EtOAc in isooctane, 13 mg, 0.04 mmol, 46% yield). The epoxide 12 was isolated as a white solid, mp 137–138 °C, which exhibited the following spectral features: HRMS M^+ m/z obsd 318.2199, $C_{20}H_{30}O_3$ required 318.2196; low-resolution MS m/z (relative intensity) 318 (4), 300 (5), 285 (3), 203 (6), 175 (9), 161 (20), 150 (100), 136 (46), 121 (29); IR (NaCl) 2960, 1710, 1695, 1625, 1470, 1390, 1260, 1195, 1030 cm^{-1}; UV (MeOH) 255 nm (ϵ 4000).

Transannular Cyclization of 12. To a stirred solution of 12 (6 mg, 0.02 mmol) in 1.5 mL of dried THF at −76 °C under N_2 was added 150 μL of LDA (10% wt suspension in hexane). After the solution was stirred for 1 h, excess LDA and THF were removed under vacuum. Si HPLC purification (50% EtOAc in isooctane) gave 13 (3.5 mg, 0.01 mmol, 58% yield) as an oil that showed the following spectral features: HRMS M^+ m/z obsd 318.2209, $C_{20}H_{30}O_3$ required 318.2196; low-resolution MS m/z (relative intensity) 318 (3), 300 (100), 285 (23), 257 (12), 207 (22), 193 (21), 177 (39), 165 (62), 161 (12); IR (film) 3480, 2960, 2930, 1705, 1700, 1620, 1460, 1380, 1370, 1205, 755 cm^{-1}; UV (MeOH) 250 nm (ϵ 6000).

Transannular Cyclization of 6. To a stirred solution of 6 (17 mg, 0.06 mmol) in a mixture of 3 mL of acetone and water (2:1, v/v) was added 100 μL of concd HCl. After being stirred for 2 h at room temperature, the mixture was extracted with Et_2O (30 mL). The Et_2O layer was washed with saturated $NaHCO_3$ (20 mL) and water (20 mL) and dried under vacuum. Purification by Si HPLC (30% EtOAc in isooctane) gave 14 (9 mg, 0.03 mmol, 53% yield) and 15 (7 mg, 0.02 mmol, 39%). Compound 14 was isolated as an oil that showed $[\alpha]_D$ −29° (*c* 0.7, $CHCl_3$) and displayed the following spectral features: HRMS M^+ m/z obsd 304.2402, $C_{20}H_{32}O_2$ required 304.2403; low-resolution MS m/z (relative intensity) 304 (38), 289 (18), 243 (12), 205 (15), 192 (31), 177 (22), 165 (100), 159 (11); IR (film) 3550, 2950, 2930, 1735, 1635, 1460, 1385, 1270, 1195, 950, 900 cm^{-1}; UV (MeOH) no λ_{max}. Compound 15 was isolated as an oil that showed $[\alpha]_D$ = −26° (*c* 0.6, $CHCl_3$) and exhibited the following spectral features: HRMS $(M - H_2O)^+$ m/z obsd 304.2393, $C_{20}H_{34}O_3$ required 304.2403; low-resolution MS m/z (relative intensity) 304 (23), 289 (7), 209 (11), 205 (14), 192 (20), 166 (100), 165 (54), 163 (12); IR (film) 3480, 2960, 2930, 1725, 1460, 1390, 1370, 1275, 1205, 1090, 895, 760 cm^{-1}; UV (MeOH) no λ_{max}.

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Supplementary Material Available: Copies of the ^{13}C NMR spectra of dolabellanes 3–7 and derivatives 9–15 (12 pages). Ordering information is given on any current masthead page.

(20) Foote, C. S., Wexler, S., Ando, W. and Higgins, R. *J. Am. Chem. Soc.* **1968**, *90*, 975.