Distribution of Dinoflagellate Cysts in the Surface Sediment of the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia

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ABSTRACT

To obtain more information on the distribution of dinoflagellate cysts in Thai and Malaysian waters, the surface sediment samples of 48 stations in the Gulf of Thailand and the east coast of Peninsular Malaysia were collected by M.V. SEAFDEC during the research cruise in September 1995 and repeated again in April 1996. Cysts of 20 species belonging to Goniolacoid, Tuberculodinioid and Peridinioid were found in the surface sediments collected from both cruises. ***Spiniferites*** spp. (= *Gonyaulax* spp.) were the dominant cyst in Thai and Malaysian waters. No cysts of harmful species were observed during this study.

Introduction

Marine dinoflagellates have been known to alternate between vegetative (motile cell) and resting stage (non-motile cell) in their life history. The resting cysts are produced during a sexual phase in its life cycle. A recent review by Anderson (1984) showed cysts have a variety of potential functions in the overall ecology of the dinoflagellates such as:

1) seed population to initiate red tides
2) a survival mechanism through environmental extremes
3) agents for species dispersal
4) means for genetic recombination
5) direct sources of toxicity
6) a factor in bloom termination

The potential importance of benthic dinoflagellate cysts, *Gonyaulax tamarensis* (=*Alexandrium tamarense*) and *G. excavata* (= *A. catenella*), in initiating toxic shellfish was pointed out by Anderson and Wall (1978). The importance of life cycle events in the population dynamics of *G. tamarensis* demonstrated that the blooms of this species were initiated by excystment and terminated mainly by encystment (Anderson *et al*. 1983). Cysts of *Chattonella* spp. also seem to play an important role in the Seto Inland Sea, Japan (Imai and Itoh, 1987). However, this important role of dinoflagellate cysts in Thai and East Coast of Peninsular Malaysia have not been studied.

Concerning shellfish intoxication, it has been proposed that shellfish toxicity in the deep water might be due to the ingestion of cysts of toxic species (Bourne, 1965). Dale *et al*. (1978) found natural samples of *Gonyaulax excavata* cysts were ten times more toxic than the vegetative cells. The study of Lirdwitayaprasit *et al*. (1990) showed the cyst production of *Alexandrium catenella* under laboratory conditions was more toxic than the vegetative cells. However, very few studies have been carried out on the distribution of benthic dinoflagellate cysts in the surface sediments of ASEAN waters. For example, the distribution of cyst of toxic dinoflagellate *Pyrodinium bahamense* is little known in the waters of Thailand and the east coast of Peninsular Malaysia. The blooms of this species were found for the first time in the northwestern coast of Borneo (Brunei and Sabah waters), the Philippines and Eastern Indonesia in 1976, 1983 and 1994, respectively (Maclean, 1989 and Wiadnyana *et al*., 1996). The blooms reoccurred again some years later in some other places, but it has been almost an annual feature in Manila Bay since 1991 (Bajarias and Relox, 1996). There is a possibility that the vegetative cells and cysts of this toxic species could be dispersed into the Gulf of Thailand and the east coast of Peninsular Malaysia by the discharge of water and sediments from ships' ballast tank, translocation of shellfish and water current.

To provide baseline information on dinoflagellate ecology and also for the preparation of a red tide management programme, investigation of benthic cysts in these areas was carried out.

Materials and Methods

The surface sediment samples of 48 stations were collected using the gravity core sampler during the collaborative research cruises from September 3 - October 3, 1995 and repeated again during April 23 - May 23, 1996 by M.V. SEAFDEC. The study area is shown in Fig. 1.

Surface sediment samples of about 1 cm in thickness each were cut and kept in plastic bottles with a small amount of seawater above the sediment. The sample preparation for identification and quantitative analysis of the benthic cysts was performed using the method described by Matsuoka *et al.* (1989) while the main references used in this study for identification purposes were Matsuoka and Fukuyo (1995), Matsuoka (1985 a, b, c) and Matsuoka (1987). Both empty cysts and living were identified and counted.

Results and Discussion

Environmental Conditions

Some physical parameters during the surveys were recorded and shown in Table1. These parameters from the two cruises are almost identical and show no clear relationship with the average total cyst densities.

Abundance and Distribution

A total of 20 species of the modern dinoflagellate cysts belonging to Goniolacoid, Tuberculodinioid and Peridinioid were found in this study and shown in Table 2. The abundance and distribution of cysts in both cruises was almost the same with the average cyst densities shown in Fig. 2-21. All cysts were found in small densities in the surface sediment samples of both Thai and Malaysian waters and most of them were found at depths of more than 30 metres. There are two possible reasons to explain this observation, one probably due to fishing activities, especially trawl fishing which stirs the surface sediment and resuspended the cysts into the water column, while the other could possibly be at depths of 0-30 metres, cysts were exposed to the optimal conditions for germination including high temperature and high light intensity.

Cysts of *Spiniferites* spp. were the dominant species in both the upper and lower parts of the Gulf whereas cysts of *Protoperidinium* spp. were found almost entirely in the upper part of the Gulf (Stations 4 to 16). In Malaysian waters only cysts of *Spiniferites* spp. were the dominant group throughout the east coast of Peninsular Malaysia. Bujak (1984) pointed out that protoperidiniacean dinoflagellate abundance is associated with high diatom productivity and closely related to the rich dissolved nutrients such as those present in the upwelling areas. Matsuoka (1987) suggested that the areas dominated by protoperidiniacean cysts could be divided into two categories. One is related to the upwelling areas such as the regions be off Pisca, Peru, off West Africa and off Western South Africa. Another could probably be related to the enrichment of nutrients by rivers such as the Gulf of Main, Dover Strait, Gulf of Mexico, etc. The appearance of protoperidiniacean cysts in the upper part

Table 1. Physical parameters and average total dinoflagellate cysts in the surface sediment samples from the Gulf of Thailand and East Coast of Peninsular Malaysia; 1 = first cruise; 2 = second cruise

Station	Depth(m)		Temperature (oC)		Surface Sediment Characteristic	Total
	1	2	1	2		cysts/cm3
1	27	27	29.4	29.9	Brownish coarse sandy mud	NO
2	30	30	29.0	30.1	Brownish coarse sandy mud	NO
3	31	31	28.9	30.4	Brownish coarse sandy mud	NO
4	23	23	28.9	30.4	Brownish coarse sandy with shell fragments	36
5	34	34	29.1	30.0	Brownish coarse sandy with shell fragments	12
6	51	53	28.9	28.3	Brownish coarse sandy with shell fragments	84
7	54	53	28.9	29.7	Brownish fine sandy mud with shell fragments	NO
8	40	40	28.8	29.7	Brownish fine sandy mud with shell fragments	12
9	36	37	28.7	28.5	Brownish fine sandy mud with shell fragments	36
10	48	48	28.6	28.5	Brownish fine sandy mud with shell fragments	24
11	54	53	28.6	28.5	Brownish fine sandy mud with shell fragments	36
15	56	58	28.8	28.2	Brownish fine sandy mud with shell fragments	24
16	50	50	28.8	27.5	Brownish fine sandy mud with shell fragments	72
17	46	46	28.9	27.5	Brownish fine sandy mud with shell fragments	60
18	61	61	28.1	28.0	Brownish fine sandy mud with shell fragments	60
22	59	58	27.5	28.4	Brownish fine sandy mud with shell fragments	72
23	34	34	28.7	28.5	Black silt clay with shell fragments	12
24	29	29	29.2	29.2	Brown fine sandy mud with shell fragments	NO
25	40	40	27.9	29.1	Brown fine sandy mud with shell fragments	24
29	32	33	28.8	29.2	Brown fine sandy mud with shell fragments	12
30	24	24	29.2	29.8	Brown-yellowish silt clay with shell fragments	24
31	29	29	29.3	29.3	Brown-yellowish silt clay with shell fragments	NO
32	55	55	27.7	28.3	Brown-yellowish silt clay with shell fragments	NO
38	49	50	27.9	28.1	Brown fine sandy mud with shell fragments	NO
39	28	28	29.4	29.5	Brown coarse sandy mud with shell fragments	12
40	22	22	29.4	30.1	Brown coarse sandy mud with shell fragments	12
41	41	42	28.1	28.9	Brown fine sandy mud with shell fragments	12
42	49	49	27.1	27.4	Brown fine sandy mud with shell fragments	NO
50	51	51	28.6	26.5	Brown fine sandy mud with shell fragments	NO
51	48	50	27.7	27.2	Brown fine sandy mud with shell fragments	NO
52	39	39	27.7	27.4	Brown coarse sandy mud with shell fragments	36
53	53	53	28.8	27.1	Brown coarse sandy mud with shell fragments	24
60	57	57	27.5	26.4	Brown coarse sandy mud with shell fragments	36
61	52	52	27.2	26.9	Brown coarse sandy mud with shell fragments	60
62	61	61	26.5	26.4	Brown coarse sandy mud with shell fragments	48
63	64	64	25.5	26.1	Brown coarse sandy mud with shell fragments	96
64	59	59	25.2	26.2	Brown coarse sandy mud with shell fragments	96
65	66	66	24.2	26.0	Brown coarse sandy mud with shell fragments	48
69	67	67	24.0	26.0	Brown coarse sandy mud with shell fragments	24
70	39	39	27.2	26.9	Brown coarse sandy mud with shell fragments	NO
71	35	35	28.3	27.2	Brown coarse sandy mud with shell fragments	NO
72	55	54	25.7	26.2	Brown coarse sandy mud with shell fragments	24
75	50	50	26.5	26.3	Brown coarse sandy mud with shell fragments	12
76	25	26	28.4	28.0	Brown coarse sandy mud with shell fragments	24
77	48	48	27.2	26.4	Brown coarse sandy mud with shell fragments	12
78	65	66	24.2	26.0	Brown coarse sandy mud with shell fragments	36
79	59	59	25.8	26.4	Brown coarse sandy mud with shell fragments	84
80	34	34	28.5	27.0	Brown coarse sandy mud with shell fragments	12
81	51	52	27.3	26.9	Brown coarse sandy mud with shell fragments	72

NO = no cyst was observed

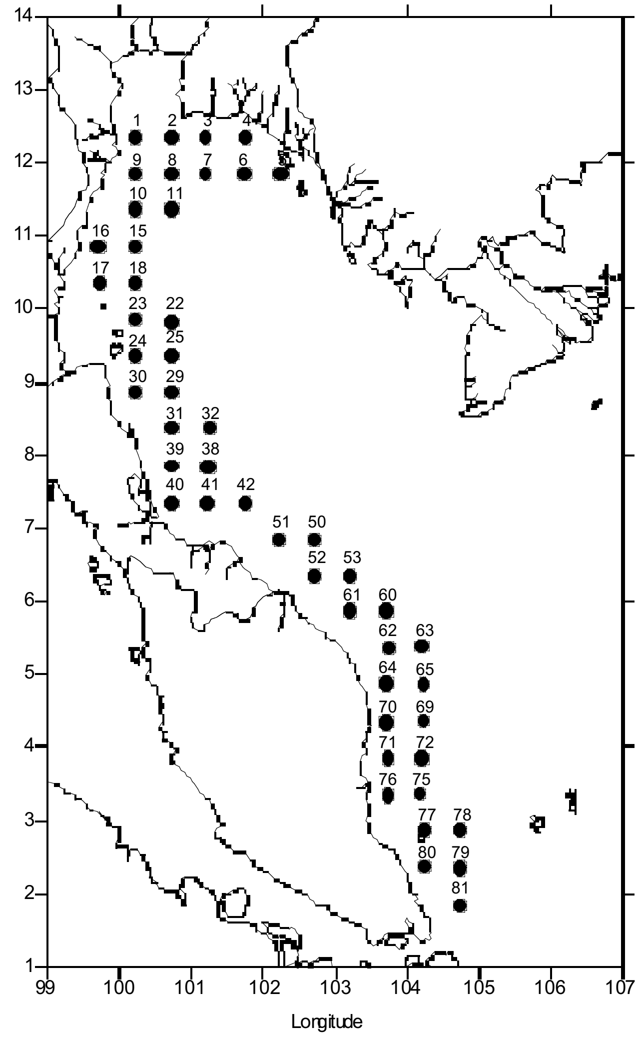

Fig. 1. Area and Stations of Dinoflagellate Cyst Sampling in the Gulf of Thailand and the East Coast of Peninsular Malaysia

of the Gulf of Thailand, where nutrient concentrations and productivity of diatoms are high, as shown in this study, is consistent with the discussion above.

Although cysts of harmful species have not been observed in this study, dinoflagellate cysts type E found at station 76 (Fig. 17), type F found at stations 5 and 39 (Fig. 18) and type H found at station 65 (Fig. 20) were similar to cysts of the *Alexandrium* group. This area has a possibility of being contaminated by motile cells and cysts of toxic species from the discharge of water and sediment from ships ballast tank during transportation into Thai and Malaysian waters.

Conclusions and Recommendations

1) This study provided more information on the distribution of dinoflagellate cysts in Thai and East Coast of Peninsular Malaysia waters useful for a cyst and/or red tide monitoring programme.
2) It is important to note that although cysts of toxic species have not been found in this study some observed cysts were similar to the cyst from the genus *Alexandrium*, some species of which were reported as the PSP (Paralytic Shellfish Poisoning) toxin producing organisms.
3) Further investigation should be conducted on germination experiments to clarify the roles of benthic cysts in this area.

Table 2. Checklist of dinoflagellate cysts found in the surface sediment samples from the Gulf of Thailand (T) and the East Coast of Peninsular Malaysia (M)

Peleontological name for cyst	Biological name for motile cell	T	M
	Goniolacoid		
1. *Spiniferites cf. bulloideus*	*Gonyaulax scrippsae*	/	/
2. *Spiniferites cf. ramosus*	*Gonyaulax spinifera complex*	/	/
3. *Spiniferites sp. 1*	*Gonyaulax sp. 1*	/	
4. *Operculodinium centrocarpum*	*Protoceratium reticulatum*	/	/
5. *Lingulodinium machaerophorum*	*Gonyaulax polyedra*	/	/
	Tuberculodinioid		
6. *Tuberculodinium vancampoae*	*Pyrophacus steinii*	/	/
	Peridinioid		
7. *Trinoventedinium cf. capitatum*	*Protoperidinium pentagonum*		/
8.	*Protoperidinium sp. 1*	/	/
9.	*Protoperidinium sp. 2*	/	
10. *Stelladinium sp.*	*Protoperidinium sp. 3*	/	
11.	*Scrippsiella sp.*	/	
	Unknown		
12. *Dinoflagellate Cyst Type A*		/	/
13. *Dinoflagellate Cyst Type B*		/	
14. *Dinoflagellate Cyst Type C*		/	
15. *Dinoflagellate Cyst Type D*		/	
16. *Dinoflagellate Cyst Type E*			/
17. *Dinoflagellate Cyst Type F*		/	
18. *Dinoflagellate Cyst Type G*		/	
19. *Dinoflagellate Cyst Type H*			/
20. *Dinoflagellate Cyst Type I*			/

Acknowledgements

The author would like to thank the staff of M.V. SEAFDEC, Miss Montira Piamphipmanus, Mrs. Jutamas Jivaluk and Dr. Charumas Chareonpanich for their assistance in collecting the 35 surface-sediment samples. This study was supported by South East Asian Fisheries Development Center (SEAFDEC) through the Collaborative Research Programme between the SEAFDEC Training Department, Thailand and the Marine Fisheries Resources Development and Management Department, Malaysia.

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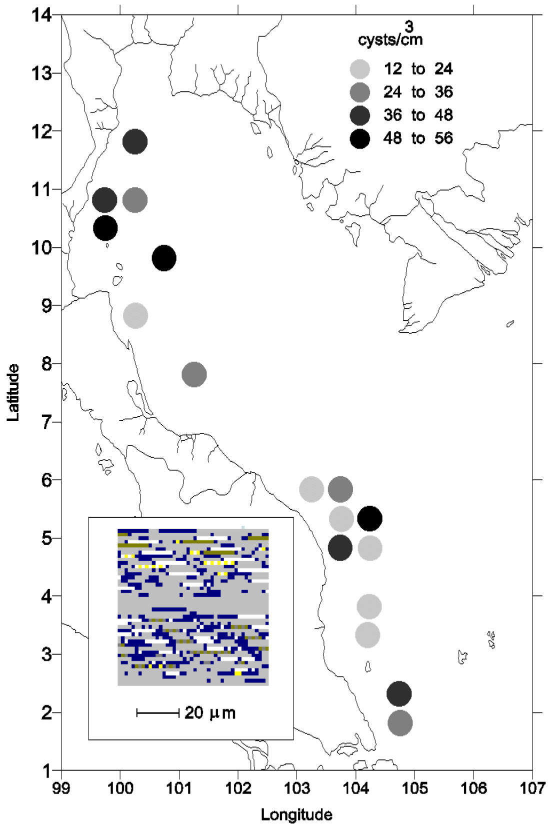

Fig. 2. Distribution and abundance of Spinferites cf. bulloideus

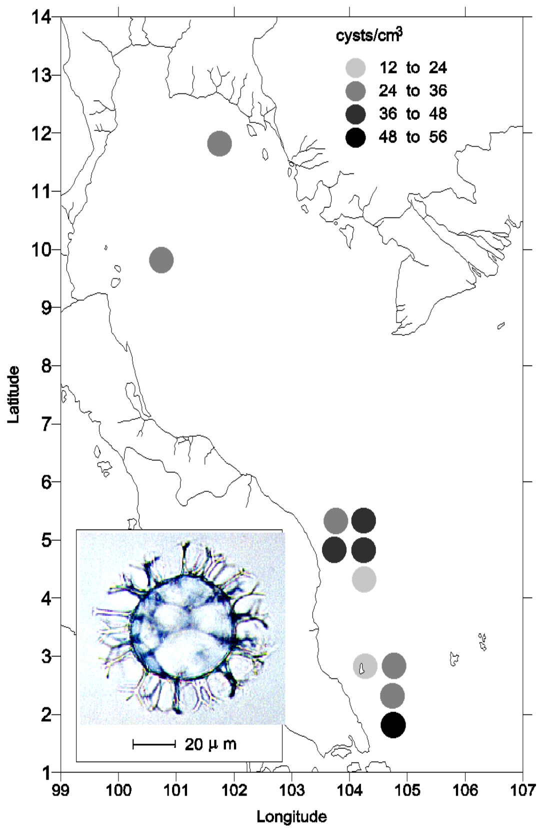

Fig. 3. Distribution and abundance of Spinferites cf. ramosus

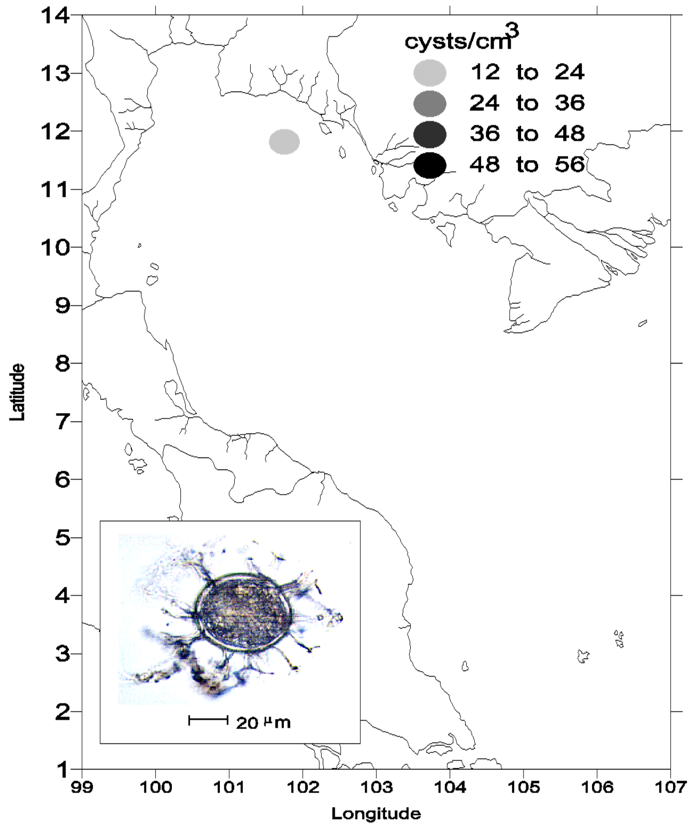

Fig. 4. Distribution and abundance of *Spinferites* sp. 1

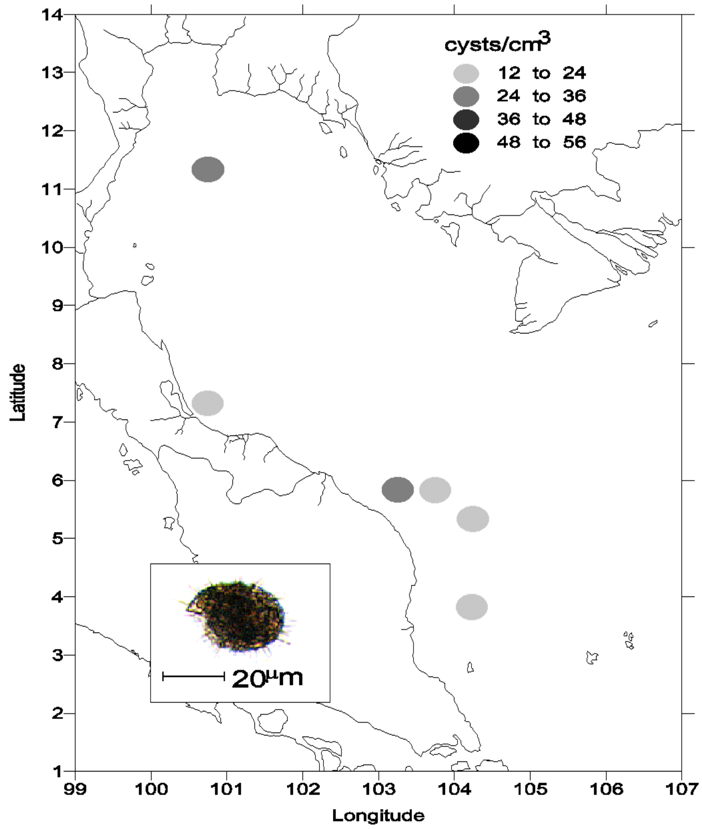

Fig. 5. Distribution and abundance of *Operculodinium centrocarpum*

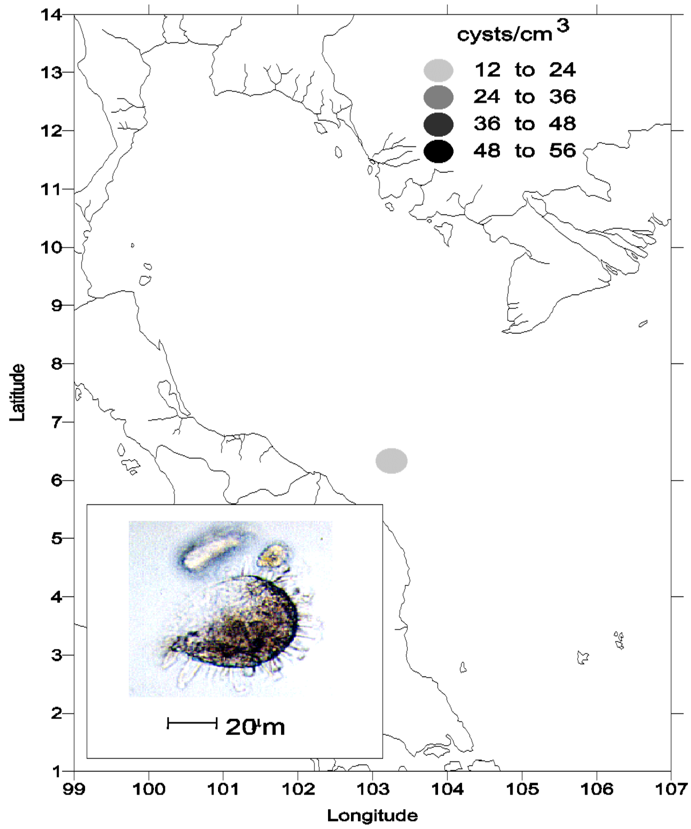

Fig. 6. Distribution and abundance of Lingulodinium machaerophorum

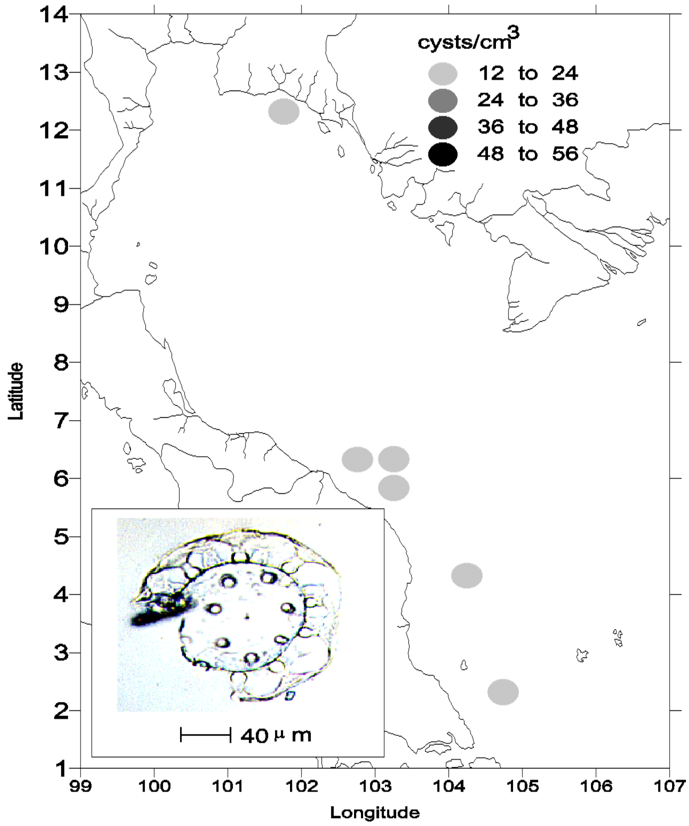

Fig. 7. Distribution and abundance of Tuberculodinium vancampoae

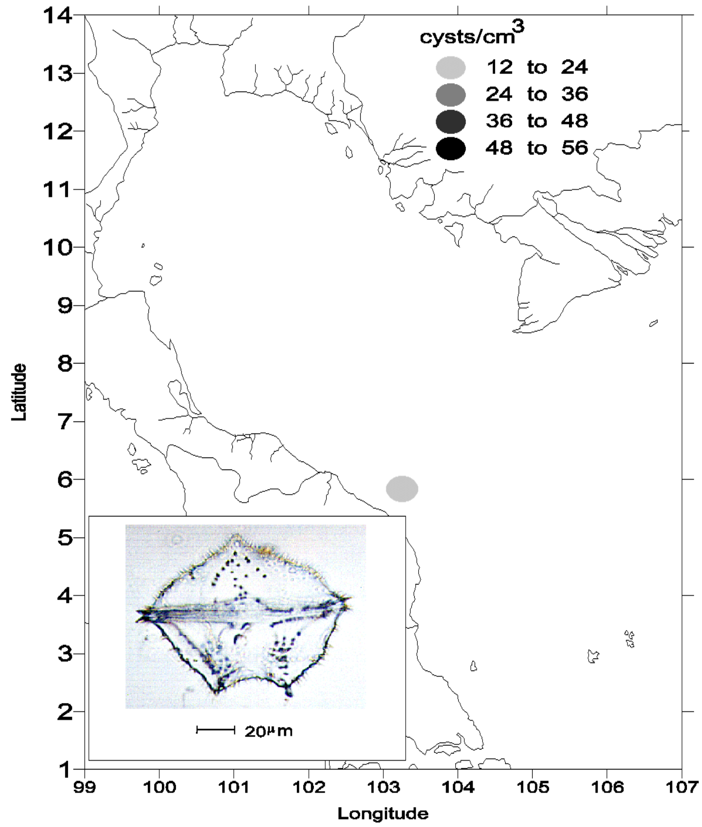

Fig. 8. Distribution and abundance of *Trinovantedinium cf. capitatum*

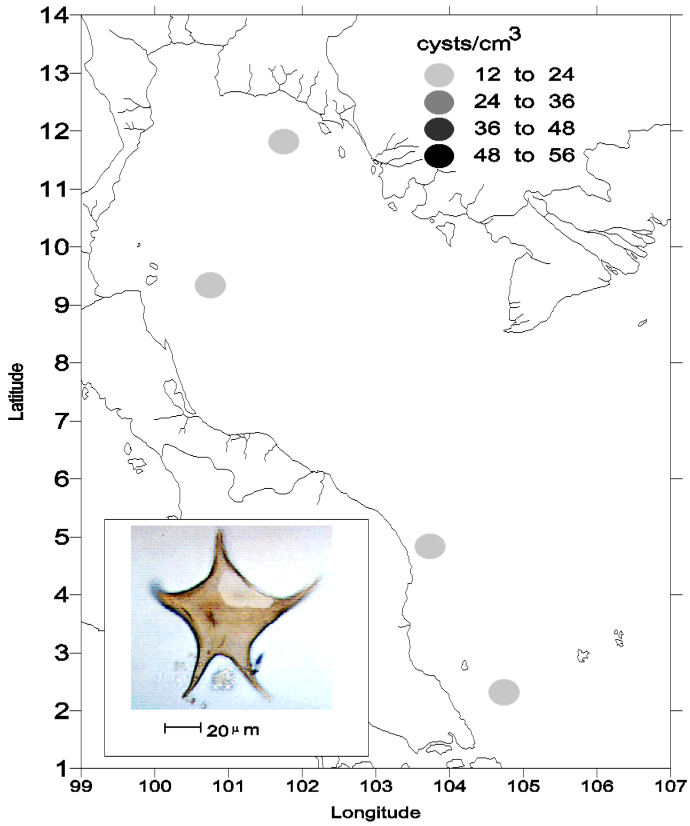

Fig. 9. Distribution and abundance of *Protoperidinium* sp. 1

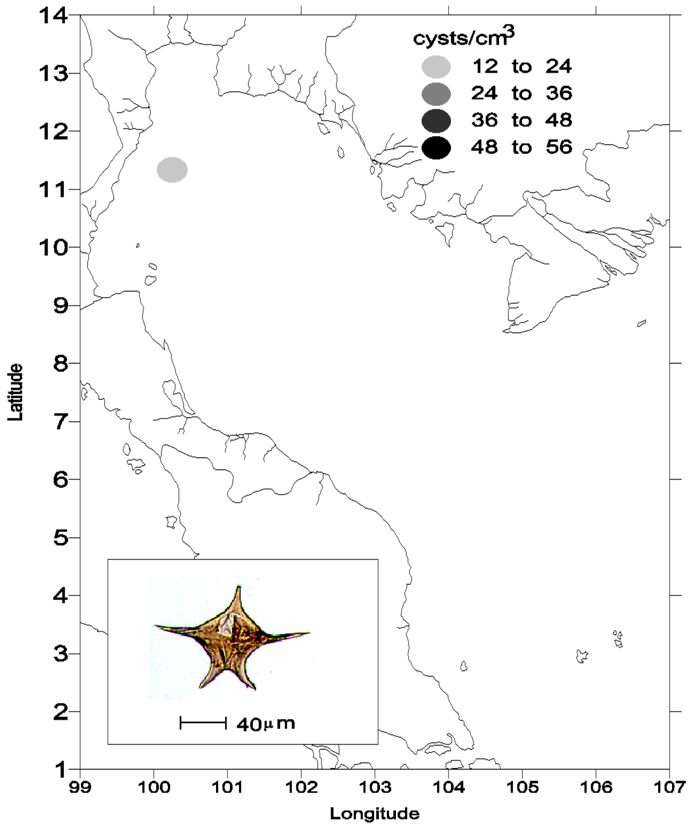

Fig. 10. Distribution and abundance of *Protoperidinium* sp. 2

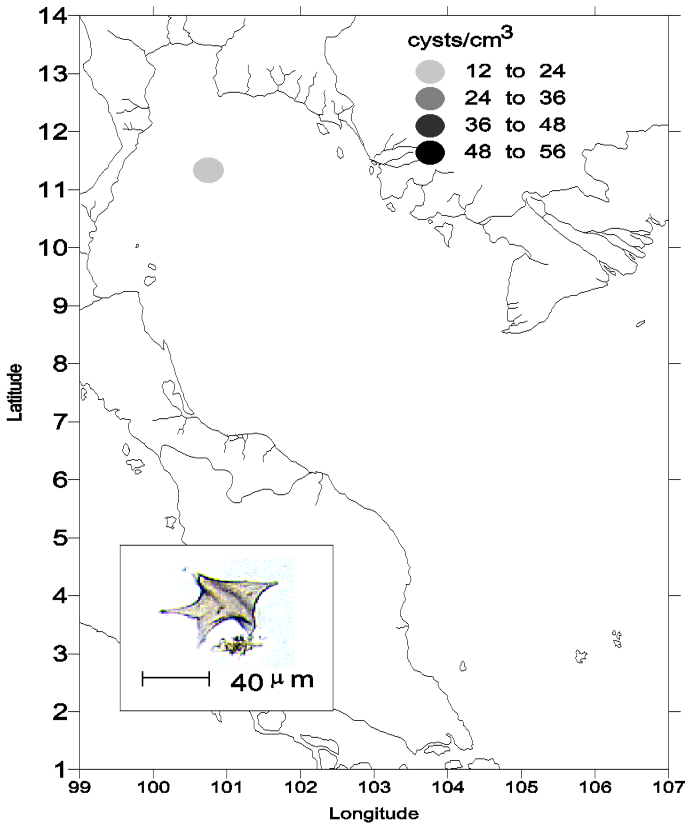

Fig. 11. Distribution and abundance of *Protoperidinium* sp. 3

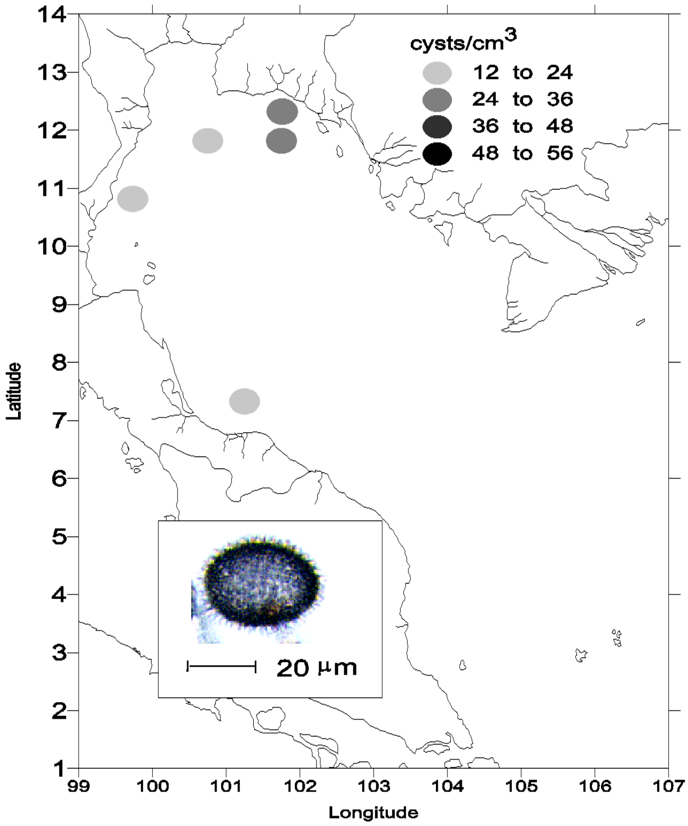

Fig. 12. Distribution and abundance of *Scrippsiella* sp.

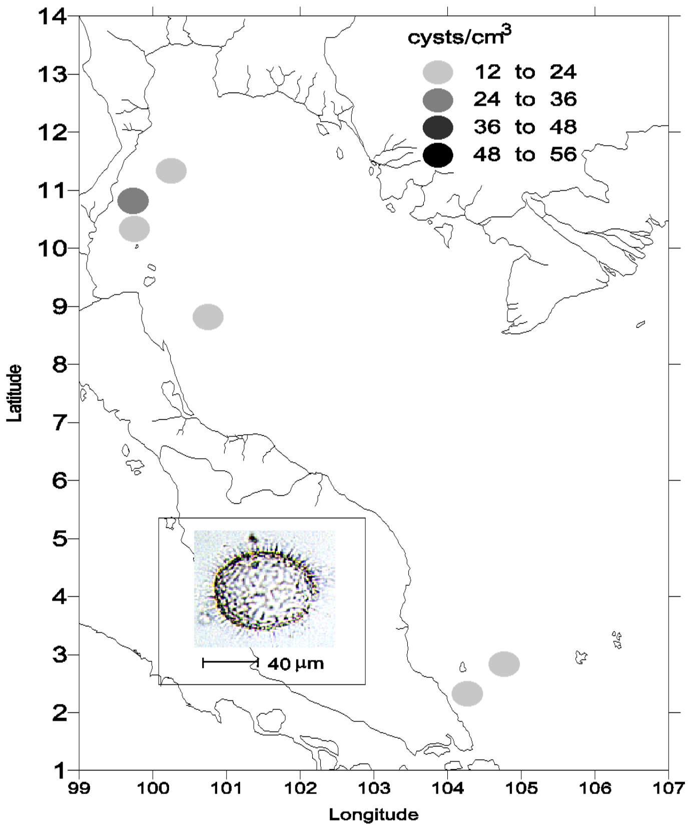

Fig. 13. Distribution and abundance of Dinoflagellate Cyst Type A

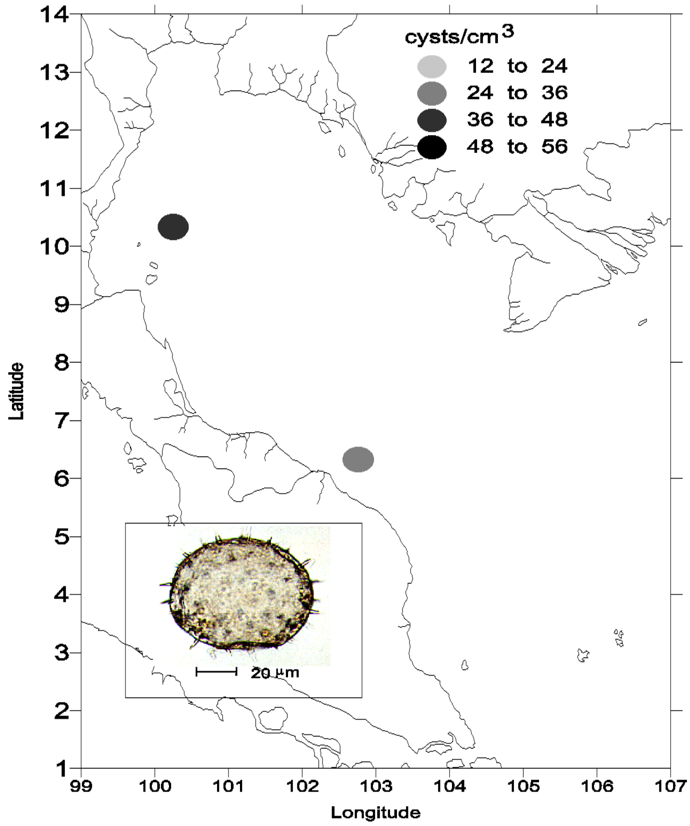

Fig. 14. Distribution and abundance of Dinoflagellate Cyst Type B

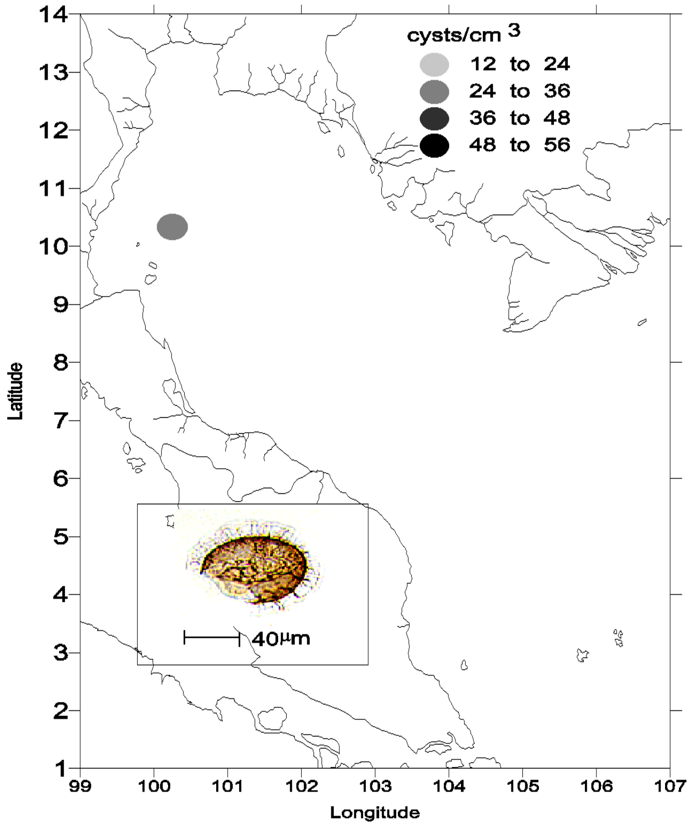

Fig. 15. Distribution and abundance of Dinoflagellate Cyst Type C

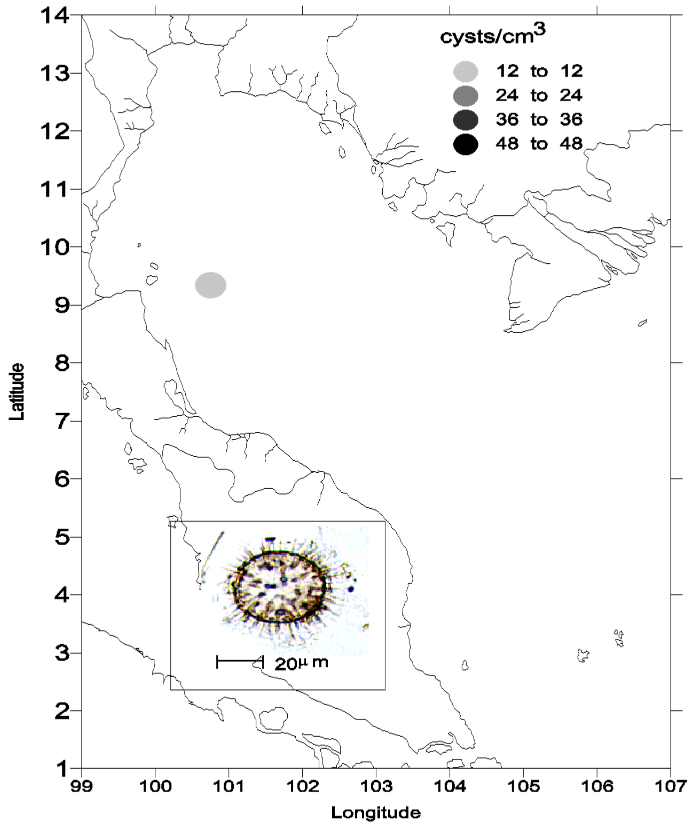

Fig. 16. Distribution and abundance of Dinoflagellate Cyst Type D

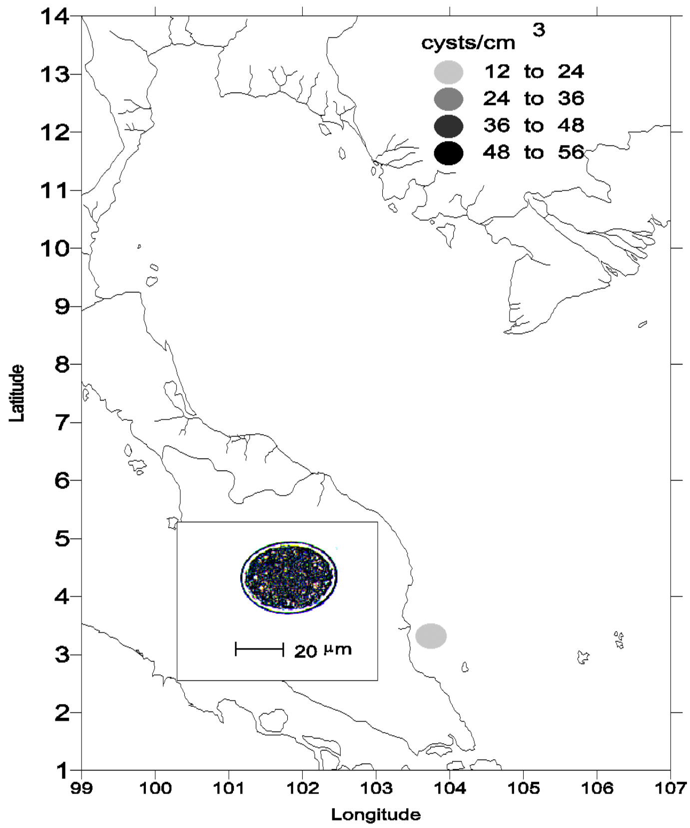

Fig. 17. Distribution and abundance of Dinoflagellate Cyst Type E

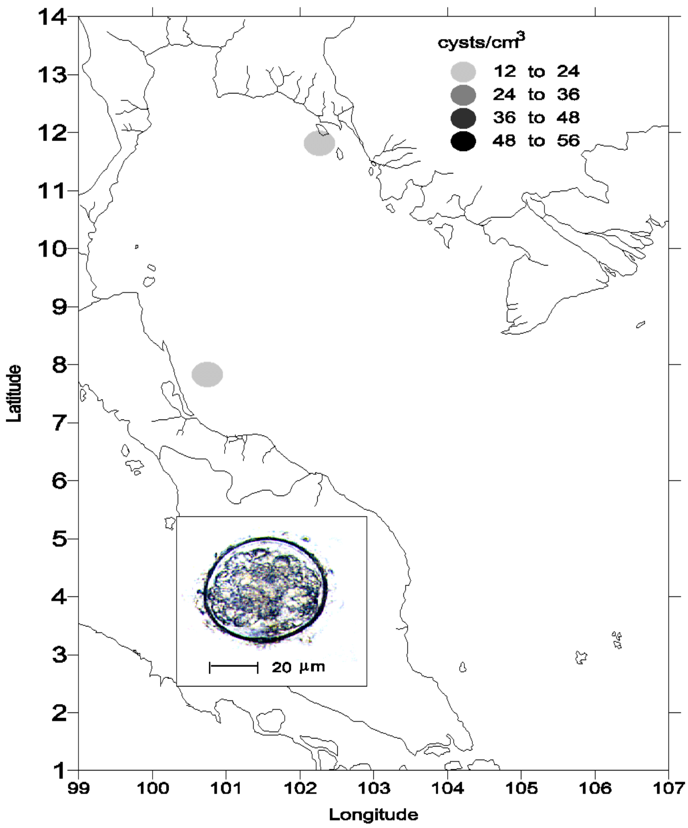

Fig. 18. Distribution and abundance of Dinoflagellate Cyst Type F

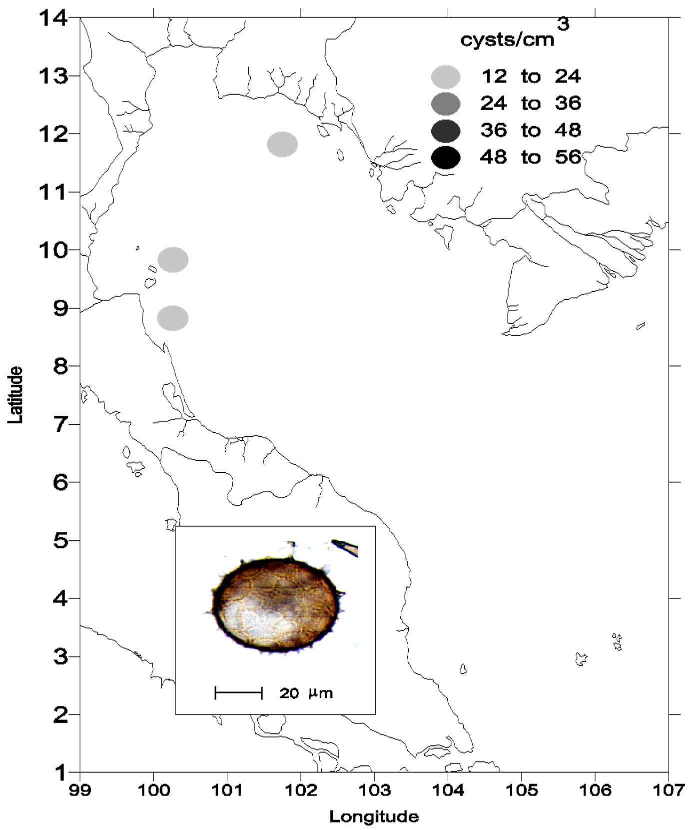

Fig. 19. Distribution and abundance of Dinoflagellate Cyst Type G

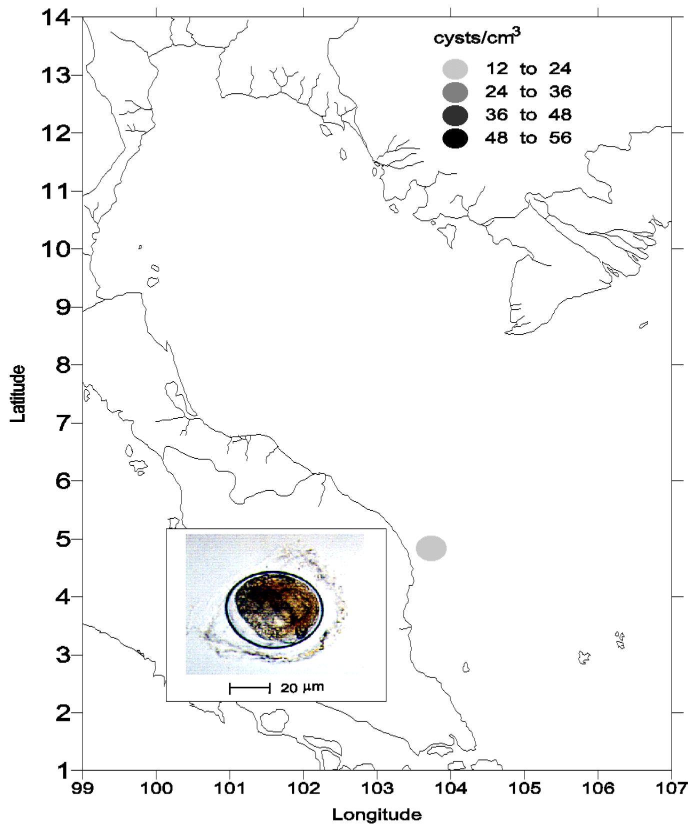

Fig. 20. Distribution and abundance of Dinoflagellate Cyst Type H

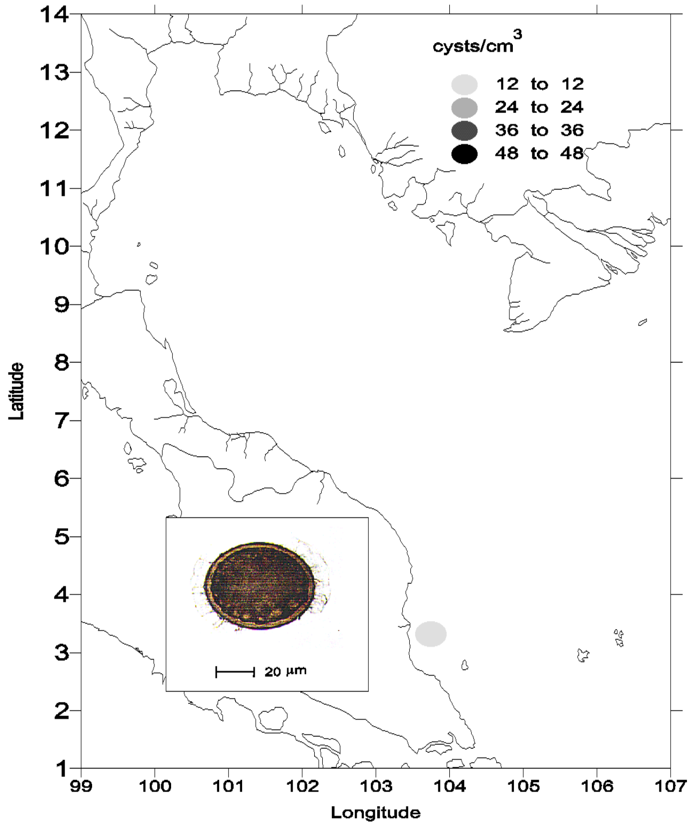

Fig. 21. Distribution and abundance of Dinoflagellate Cyst Type I

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