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THAI–DANISH COLLABORATION IN MARINE RESEARCH[1]

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ABSTRACT

The first Danish natural science activity in Thailand was the Koh Chang and Gulf of Siam Expedition 1899–1900, with Johannes Schmidt covering botany and Th. Mortensen collecting and studying the shallow-water fauna. The Dana and the Galathea Deep-Sea Expeditions also worked in the Gulf and received an overwhelming reception during their visit to Bangkok in 1929 and 1951, respectively. Research in the Gulf was occasionally carried out during the American sponsored Naga Expedition 1959–61, with three Danish participants. The marine biological part of the Fifth Thai-Danish Expedition in 1966 primarily involved quantitative grab sampling off the entire west coast of Thailand. Other objectives were selection of a suitable site for the planned marine center, creation of a reference collection for local use, and training of young Thai biologist.The cooperation eventually led to the founding of the Phuket Marine Biological Center (PMBC). Recent activities have included the large Scientific Cooperation Programme (SCP) 1996–2000, involving PMBC and the Danish environmental and fisheries institutes and several university institutes. One biodiversity project was BIOSHELF which during six cruises operated a large variety of equipment at 133 benthic stations; another was concerned with the pelagic community structure, function, and productivity with particular emphasis on an assessment of potential fisheries resources, and a third one dealt with mangrove forest research: hydrodynamics, litter fall and degradation, tidal import and export, crab influence, transformation of C, N and P compounds, etc. Minor programmes have been concerned with marine mammals and sea snakes.

INTRODUCTION

The very first connection between Thailand and Danish science was the publication in 1788 of the detailed description (in Danish), with excellent figures, of a boring bivalve, *Pholas siamensis*, from the Thai Gulf (KNUDSEN & JENSEN, 2001, figs. 1–4). It was provided by Dr. J. G. König (1728–85), physician in the Danish settlement Trankebar and later living in Madras; he collected extensively (mainly plants) in India and elsewhere. The description was due to the Danish malacologist Lorenz Spengler (1720–1807), Keeper of Kunstkammeret, the royal collection of art, natural objects, etc. The 12-cm long type specimen is unique in probably being the first described mollusc from Thailand and the oldest alcohol-preserved mollusc in the Copenhagen Zoological Museum.

A hundred years later the first beginning of Danish marine science exploration in Thai waters was an expedition conducted by two young biologists, introducing several later expeditionary activities, one of which eventually led to the establishment and development of the Phuket Marine Biological Center.

[1]Based on a lecture at the Symposium "Centenary Celebration of Thai-Danish Co-operation in Biodiversity", Queen Sirikit Botanic Garden, Chiang Mai, Thailand, 10–11 February 2001.

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THE KOH CHANG AND GULF OF SIAM EXPEDITION, 1899–1900

The driving force behind this first Danish scientific expedition to Thailand was Andreas de Richelieu (1852–1932). As a young naval lieutenant, he came to Siam in 1875 and made a brilliant career in the Royal Navy, thus initiating an invasion during the next decades of Danish naval officers, advisers, businessmen, etc. He eventually rose to the rank of admiral and became minister of naval affairs and a close friend of King Chulalongkorn (KAARSTED, 1990).

During a visit to Denmark in 1898, Richelieu had met Johannes Schmidt (1877–1933), who the same year had become M. Sc. in botany. During their discussion about a possible scientific expedition to Siam, Richelieu had recommended Koh Chang Island on the east coast of the Gulf of Siam as a potential site. He knew the governor, there was a naval station on the island, and soldiers could assist with collecting, cooking, etc. For the accompanying zoologist, he approached Theodor Mortensen (1868–1952), who had obtained his M. Sc. degree in 1895.

Their expenses were covered by the Carlsberg Foundation (1200 DKK provided for each), and they were granted a free passage on the East Asiatic Company's S/S *Siam* to Singapore, leaving Copenhagen 1 October 1899. From Singapore they proceeded to Bangkok and arrived at Koh Chang on 22 December.

Figure 1. The house on Koh Chang used during the Siam Gulf Expedition, with Johannes Schmidt's laboratory to the right of the steps. The person in front is Th. Mortensen. (After WINGE & TÅNING, 1947)

At the time the British were anxiously protecting what they regarded as their well-earned privileges. In Bangkok the commerce attaché refused to believe that the two Danes were peaceful naturalists—they were obviously spies investigating the possibilities for mining and exploitation of the luxuriant forests and rich freshwater supplies of the island. The Russians and the Danish East Asiatic Company might be behind this visit—the former to establish a coal station, the latter to exploit the timber (KAARSTED, 1990: 142). However, through the probable intervention of the powerful admiral, all was settled smoothly.

During the following months, until 21 March 1900, the two scientists worked with Koh Chang as their base (Fig. 1). Schmidt carried out his botanical studies of plankton (already initiated on the way out on the *Siam* by letting seawater used to wash the decks pass through a plankton net). He was particularly interested in an investigation of the mangrove vegetation and studied and took photographs of the rich and almost untouched rain forest on Koh Chang. Mortensen collected and studied the beach and shallow-water fauna down to ca. 50 m depth by hand-collecting intertidally and dredging, trawling and seining. He also kept a detailed field diary with a wealth of biological observations (JENSEN & KNUDSEN, 2001). It is still in the Copenhagen Zoological Museum, where Kathe Jensen has just finished a translation into English for publication.

The surroundings of Koh Chang, however, turned out to be very poor for dredging, the bottom being deep, soft mud with very little animal life. Fortunately, Admiral Richelieu offered to place a rather large boat and several times also a naval vessel, the Siamese M.S. *Chamroen*, at Mortensen's disposal. On Koh Lom and Koh Kahdat near Koh Chang, dredging was carried out on sand bottoms with corals and an abundant animal life. Additional collections were made in mangroves and on the rich coral reefs, and large numbers of worms, crustaceans, brittle stars and boring bivalves were revealed when the coral blocks were broken (MORTENSEN, 1902). Even better conditions were found further north on and near Koh Chuen, Koh Kram and particularly Koh Mesan. Here there was no drinking water, but Richelieu ordered supplies of food and water for a week's stay.

In his popular account of the expedition in the later book on Johannes Schmidt's life and achievements by friends and collaborators, MORTENSEN (1947) tells the following anecdote: Herluf Winge, the mammal specialist at the Copenhagen Zoological Museum, had urged Mortensen to collect skulls of the local dogs. Mortensen knew that the words in Siamese were "hua ma", but he was ignorant of the fact that in addition to "dog", "ma" may also mean "to come", "horse", and "mother-in-law"; slight differences in pronunciation make all the difference. When applying for help from the governor, he actually asked for a horse's head, so the governor looked uneasy, but then smiled and said "bow-wow". Mortensen was happy that the head of the man's mother-in-law had not been asked for!

Results

This expedition was the earliest one to investigate life in the Gulf of Siam. The first results appeared in five monographs published in 1902–10 by the Royal Danish Academy of Sciences and Letters. Rudolph Bergh treated the tectibranch and nudibranch snails (60 pp., 3 pls.; 23 species, 8 of which were new) and Herman Lynge the clams and mussels (203 pp., 5 pls.; 375 species, 27 of which new). The American carcinologist Mary Rathbun wrote a much-cited treatise on the crabs (68 pp., 2 pls; 103 species, 28 of which new), and Mortensen covered the sea urchins (124 pp., 7 pls.; 16 species, 12 of which new). Finally,

Figure 2. Th. Mortensen (centre) at work during one of his many later, worldwide expeditions. Shown here at work in Japan on board the vessel *Hyatori Maru* in the summer of 1914. (After WOLFF, 1967)

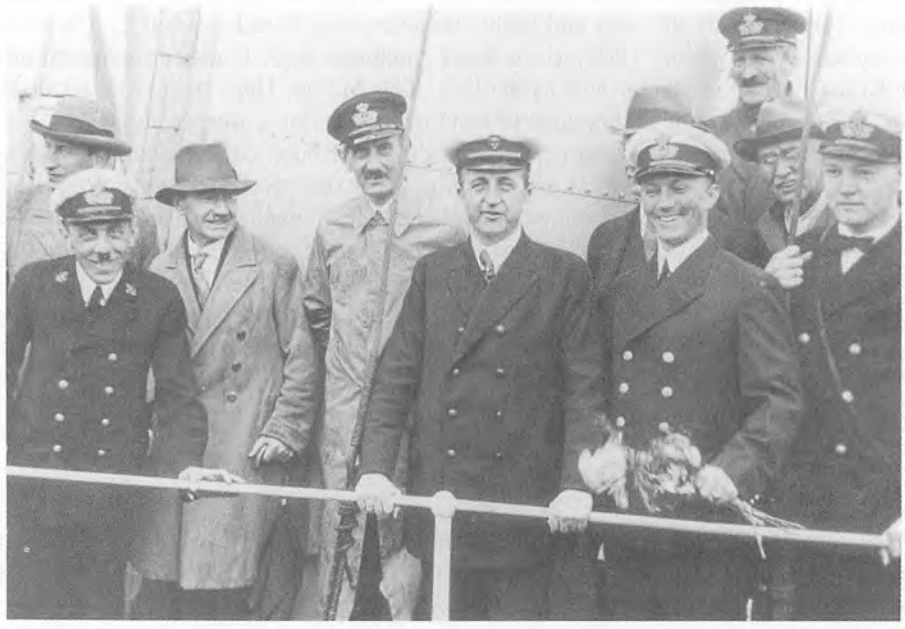

Figure 3. Circumnavigation of the *Dana*, departure in June 1928. Front row: N. C. Andersen (ship's doctor), Johannes Schmidt, Poul Jespersen and Anton Bruun (zoologists). Second row: R. Spärck (zoologist), Th. Mortensen (participating at St. Helena in 1930), J. N. Nielsen (hydrographer). Rear: Ove Paulsen (botanist). (Zoological Museum)

Carl With published, with a revision of the whole group, a study of the minute land pseudoscorpions from Koh Chang, including former Danish collections from the Nicobar Islands (214 pp., 4 pls.; 37 species, 19 of which new).

Together with other results from Mortensen's extensive travels during the next 30 years (Figs. 2 and 3), further findings from the Siam Expedition were mainly included in "Collected Papers from Dr. Th. Mortensen's Pacific Expeditions" with over 6000 pages in more than 80 papers. JENSEN & KNUDSEN (2001) provide a list of such publications, with special reference to the bivalves.

Schmidt published his mangrove studies as a D.Sc. thesis (SCHMIDT, 1903). Being a thesis, in those days it was compulsary that it had to appear in Danish. He also published on some planktonic ciliates (SCHMIDT, 1902) and edited "The Flora of Koh Chang", concluded in 1916, with several contributions by him (BRUUN, 1961).

Land Animal Collecting on Koh Chang and Elsewhere, 1958–59

Although the present account is devoted to marine activities, it should be briefly mentioned that additional Danish land collecting was carried out on Koh Chang by Birgit Degerbøl (1929–) at the end of the otherwise botanical First Thai-Danish Expedition 1958–59, in which she participated with her husband, the botanist Bertel Hansen (Fig. 11). She did collect, however, the vast majority of animals (about 3000 samples) in the Doi Sutep Mountains in the Chiang Mai Province. Her special interest was millipedes, on which H. Enghoff and S. Golovatch in 1987, 1993 and 1994 published revisions of three genera, with descriptions of 30 new species. A synopsis (1985) on the Opiliones (harvestmen) by S. Suzuki included keys to all taxa and dealt with 106 species, of which 72 were new to Thailand and 37 were new to science. Another very important contribution was Alan Solem's monograph from 1966 on the land snails, covering 52 species, 7 of which were new. Finally, in 1964 Erna Mohr described a new species of the brush-tailed porcupine genus *Atherurus*, based on the head with skull, neck skin and tail—the hunter insisted on keeping the rest for his dinner!

THE CARLSBERG FOUNDATION'S DANA EXPEDITION, 1928–30

After his return from Siam, Johannes Schmidt was in 1901 appointed as a fishery biologist (plankton) and eventually changed from botany to zoology. In the early 1920s he gained world-wide recognition by demonstrating—after almost 20 years of pursuit—that the European freshwater eel propagates in the Sargasso Sea, from where the larvae start their 2-year migration to Europe.

In 1928 he set out on the famous Dana Expedition Round the World (Fig. 3), which provided by far the largest existing collections of the pelagic fauna of the world's oceans (SCHMIDT, 1932; WOLFF, 1967: 173–197; 2002, 2004).

The Gulf of Thailand is part of the very large, Indo-Malayan shelf area which separates the deep basins of the western Pacific Ocean and the eastern Indian Ocean. After investigations in the deep South China Sea, *Dana's* work on the shelf was devoted to investigating to what extent the oceanic fauna penetrates into the shelf area.

Between 20 April and 4 May 1929, 5 days were spent in the Gulf, operating nets of

two sizes (5 and 7 hauls), 7 hauls with closing net, a few quantitative bottom samples and 8 hydrographical stations. While at anchor, night collecting by dip-net at lantern light provided especially many sea snakes (6 species, being half of the 12 species caught during the entire expedition); a seventh, new species was taken close off Saigon (SMITH, 1935). Many snakes had surprisingly large fishes as prey in their stomach.

The reception in Bangkok by the Thai authorities was overwhelming. There were visits to temples and palaces and to Ayuthaya, the former capital. Schmidt lectured at the Siam Society in Chulalongkorn University, and various ministers, numerous fishery biologists and scores of students from schools and colleges were invited on board and shown an exhibit of particularly spectacular animals collected (Fig. 4).

After a week which everyone on board later regarded as the greatest cultural experience during the entire expedition (BRUUN, 1932), the *Dana* headed south. In the Gulf, Schmidt found time for a short, sentimental visit to Koh Chang after almost 30 years' absence. Of his former assistants, Schmidt could find only one person who was still alive and joined the party (BRUUN, 1961, with photo). Acting as interpreter, the Thai fishery biologist Luang Choola was invited to join *Dana* for a few weeks as a guest. Shortly after departure, the extraordinary event of a total eclipse was experienced.

THE GALATHEA DEEP-SEA EXPEDITION, 1950–52

Twenty-two years after *Dana*, another great circumnavigating expedition from Denmark called at Bangkok, in June 1951. As a continuation of the pelagic work of the *Dana* in the free water masses, the *Galathea* was concentrating on the deep-sea floor and was the first to prove (in the Philippine Trench) that life can survive even at the greatest depths on Earth

Figure 4. The *Dana* at anchor in April 1929 off the office building of the Danish East Asiatic Co. Ltd. (with flag) and its Hotel Oriental (behind the ship's stern). (After SCHMIDT, 1932.)

Figure 5. The *Galathea* at anchor near Koh Sichang. (Photograph by P. Rasmussen.)

under tremendous pressure (WOLFF, 1967: 251–305, 2000a, 2000b). The leader was Anton Bruun (1901–61), who as a young zoologist had participated in the entire Dana Expedition (Fig. 3), and I was serving as Deputy Leader. The captain was Commodore Svend Greve (the *Galathea* was a Royal Navy ship)—he had also been on the *Dana*, as navigation officer.

Prior to going up the Chao Phrya River, the following activities were conducted in the Thai Gulf: collecting in the tidal zone of Koh Sichang Island (Fig. 5), quantitative grab samples at 14 stations (18–75 m) plus 11 samples at one station (55 m), hauls with silk net, and 3 stations with measurements of phytoplankton productivity using radioisotopes, another pioneering research achievement on the *Galathea*. As on the *Dana*, much time was spent lantern-light fishing with dip net. At one anchorage no less than 574 specimens of sea snakes (Fig. 6) were caught; drowning experiments showed that specimens were able to survive more than 2 hours under water. Besides sea snakes and young flying fish, medusae were particularly abundant, with 10–15 species caught at each station (Fig. 7).

The friendliness with which the expedition was received in Bangkok even surpassed that shown to the *Dana*, emphasizing the close connections between the royal navies of the two countries. There were gala dinners, excursions, visits to fishery laboratories, and lectures; on board were open-ship arrangements (Fig. 8) and three receptions, one of which was attended by the Prince Regent Rangsit. One young fishery biologist, Swarng Charernphol (Fig. 9), joined us as a guest when leaving Bangkok after this grand reception.

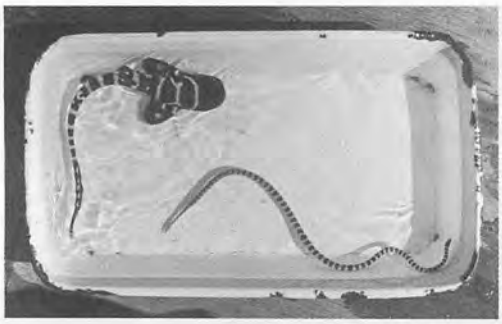

Figure 6. Sea snake (*Hydrophis atriceps*) and a small shark (*Stegostoma*) with similar colour pattern, caught at the same locality in the Gulf of Thailand. (Photograph by P. Rasmussen.)

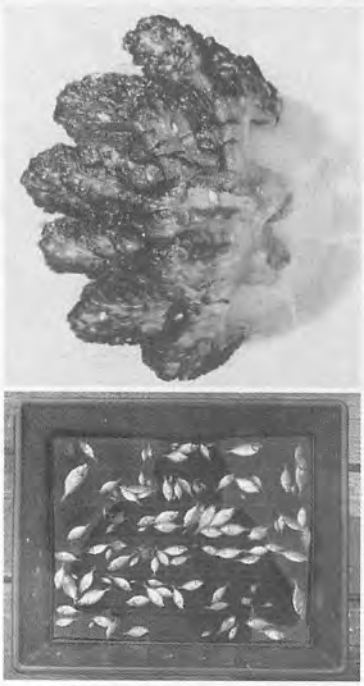

Figure 7. A giant rhizostome medusa from the Gulf of Thailand (diameter ca. 30 cm) with more than 100 small horse mackerels and about 10 swimming crabs seeking shade and shelter under it. (Photograph by P. Rasmussen.)

Figure 8. Newspaper front page. At left Thai fishery biologists on the quarterdeck listen to my explanations; at right the leader Anton Bruun and Hakon Mielche, author and head of the Press Section.

Figure 9. Fishery biologist Swarng Charernphol photographed as guest on board the *Galathea*; later Commander and Chief Scientist on the *Dhanarajata* during the Fifth Thai-Danish Expedition. (Photograph by P. Rasmussen.)

Figure 10. The well-equipped *Dhanarajata* was acquired in 1964 as part of the Japanese war reparations. She was a 400-ton stern trawler with a crew of 34 men. (Photograph by B. Muus.)

Figure 11. Planning on board the *Dhanarajata*. From left: Gunnar Seidenfaden, botanist; unidentified; Helge Ernst, film instructor; Bertel Hansen, botanist; Gunnar Thorson, zoologist; and Tem Smitinand, Curator at the Forest Herbarium in Bangkok. (Photograph by B. Muus.)

THE NAGA EXPEDITION, 1959–61

Dr. Anton Bruun's reputation as an oceanographer, with special reference to SE Asia, was so well established that he was elected leader of the American Naga Expedition (US-AID and Scripps Institution of Oceanography, California). It operated during 1959–61 in the South China Sea and adjacent waters and had as a major objective the training of Thai and Vietnamese fishery biologists. In addition to Bruun, two younger Danish zoologists participated in several cruises: Jørgen Knudsen (1918–), Zoological Museum, Copenhagen, and Bent Muus (1924–2006), Danish Institute for Fishery Research, later Zoological Museum.

THE FIFTH THAI-DANISH EXPEDITION, 1966

When Gunnar Seidenfaden (1908–2001, Fig. 11) in 1995 was nominated Danish Ambassador in Bangkok he resumed his former keen interests in botany, particularly orchids, and initiated the First Thai-Danish Expedition of 1958–59.

Having collected orchids during this and later Thai-Danish and private expeditions to other parts of the country, he wished to extend his studies to the west coast and nearby islands. But in order to have access to a suitable vessel, marine biology had to be part of the program, and his approach to his friend, Professor Gunnar Thorson (1906–71), head of the Marine Biological Laboratory at Helsingør, Denmark, was met with enthusiasm (SEIDENFADEN *ET AL.*, 1968; MUUS, 1996). The Thai Government supplied the brand new M/S *Dhanarajata* of the Royal Navy (Fig. 10) and granted considerable funds. Assistance was also received from the Fisheries and Forest Departments. On the Danish side, a large grant was donated by the Carlsberg Foundation; the East Asiatic Co. Ltd. provided free transport of equipment, and the Botanical and Zoological Museums in Copenhagen also supported the venture.

Participants and Objectives

In addition to Thorson (Fig. 11), the zoological staff consisted of Kurt Ockelmann (1924–), also from Helsingør, Bent Muus[2], former participant in the Naga Expedition, and the Chilean Victor A. Gallardo (1934–), who was working at the Helsingør Laboratory as a postgraduate. Raoul Serène, UNESCO Expert in Taxonomy, joined for one week, identifying the crabs collected. Helge Ernst, instructor, and Peter Roos, photographer, shot a film which was later shown on Danish TV and is kept in the Zoological Museum. A total of 11 Thai graduate students participated in rotating teams; besides receiving training, they took part in the hard work of processing the samples.

The zoological objectives were: 1, research on fish-food animals on sediment bottoms from a quantitative point of view; 2, comparison with bottom communities of animals at higher latitudes; 3, creation of a broad reference collection of the marine fauna for local use; 4, selection of a suitable site for the planned marine biological centre; and 5, training of young Thai marine zoologists.

[2]Gunnar Thorson and Bent Muus appear on a photo from the quarterdeck on the *Dhanarajata* (PMBC Res. Bull. No. 28, 1981, fig. 1).

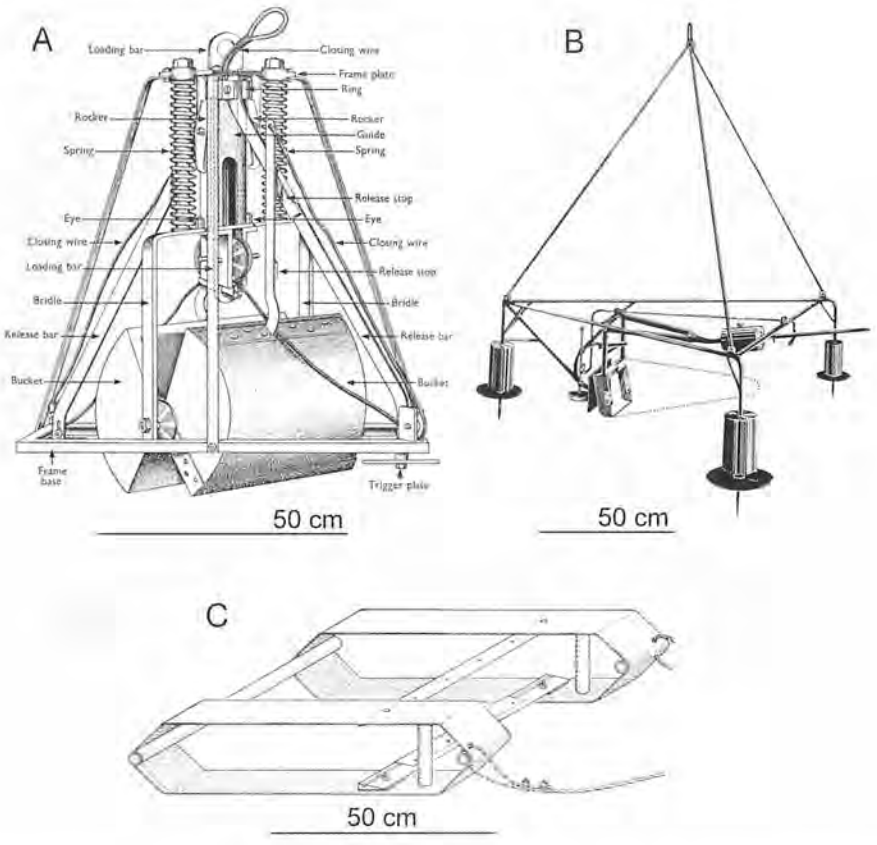

Figure 12. Quantitative bottom samplers and sledge operated during the Fifth Thai-Danish Expedition. Smith-McIntyre grab (unloaded position). B, mousetrap sampler (dotted line indicates the net of nylon gauze attached to a movable frame). C, Ockelmann detritus sledge for epibenthic sampling. (After SMITH & MCINTYRE, 1954; MUUS, 1964; OCKELMANN, 1964)

The Gear Employed

The principal tool for quantitative sampling was the Smith-McIntyre bottom grab (Fig. 12A), covering 32 x 32 cm (0.1 m^2) and digging on an average 8 cm deep. The so-called mousetrap (Fig. 12B), constructed by Bent Muus a few years earlier, was used for collecting meiofaunal animals (< ca. 1 mm); it covers 1/50 m^2 (ca. 15 x 15 cm), and digs about 2 cm deep. The epibenthic sledge (Fig. 13C), designed by Ockelmann also shortly before, proved less suitable, due to too much coral- and shell debris. A triangular dredge (each side 45 cm) and a commercial trawl for larger animals were also used (Table 1).

Work was begun 6 January 1966, and lasted until 9 March. Towards the end, five days were spent with the botanists in a camp on Koh Terutao, the southernmost island (Fig. 13).

Figure 13. The camp on Koh Terutao where the botanists and zoologists spent five days together. (Photograph by B. Muus.)

Table 1. Number of marine biological operations during the Fifth Thai-Danish Expedition, 1966.

No. of samples	Quantitative samples	Depth (m)
367	0.1 m^2 grab samples at 37 stations	10–97
13	0.1 m^2 grab samples at 1 station	tidal zone
50	0.1 m^2 grab samples at 50 stations	1–8
72	mousetrap samples	10–79
	Qualitative samples	
35	triangular-dredge samples	2–17
4	detritus-sledge samples	10–28
21	trawlings	13–85
40	stations with shore collecting: sandy beaches, mangroves, reefs and rocks	–

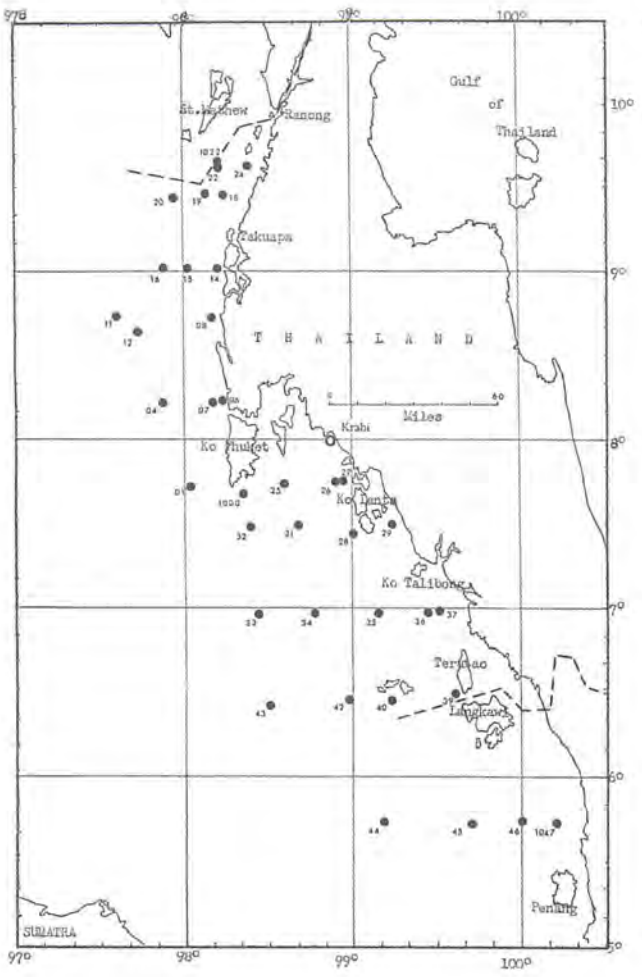

Figure 14. The Fifth Thai-Danish Expedition. Ten transects with 37 quantitative stations beyond 10 m depth.

Activities

The following details are mainly based on a report by Gallardo (dated May 1966) and a detailed station list, both in the Copenhagen Zoological Museum (unpublished); additional particulars are from maps and station lists in PHASUK (1992) and information in SEIDENFADEN *ET AL.* (1968) or kindly provided by B. Muus.

As the very first comprehensive quantitative investigation in tropical waters, 37 stations at depths beyond 10 m were located in 10 transects (Fig. 14). At nearly all stations 10 Smith-McIntyre grab samples were taken, amounting to 367 successful samples (Table 1). Each sample was weighed and its volume was estimated (3–16 litres, average about 8 litres) and then washed through sieves down to 2 mm mesh size; live animals were removed individually, weighed and preserved. Usually 20–30 samples were processed daily, but large amounts of shell debris made the task very difficult and required the efforts of about 10 persons. Finally, the animals were sorted into groups under a microscope by Ockelmann, Muus and Gallardo.

Another 12 grab samples were taken at a single station and 50 samples very close to the shore (1–8 m) at Krabi (Fig. 14). The mousetrap was at most of the grab-sample stations operated twice, this being the first time an instrument of this type was used in shallow water in the tropics. In suitable localities shore collecting, partially by skin-diving, took place (Table 1).

Results

According to Gallardo's unpublished report, the grab samples yielded more than 6000 specimens of macrobenthos. Gallardo recorded the number of specimens for each of 29 taxa and their percentage of the total number; the most numerous are listed in Table 2. Thorson (*in* SEIDENFADEN *ET AL.*, 1968: 287) gave somewhat different percentages for a few groups (Table 2).

The data very convincingly show that the soft-bottom epifauna and infauna are characterized by low densities of individuals and low biomass, but a very high diversity, with a great number of rather small species, each represented by few individuals. This is in marked contrast to what occurs in arctic and temperate waters where only a few really plentiful animals (in shallow water mainly bivalves) dominate over vast areas. The results were a great surprize to Thorson. He felt very disappointed to learn that his previous ideas of "parallel soft-bottom communities" at all latitudes (*e.g.*, THORSON, 1957) now proved to be a failure in the tropics, at least in the Andaman Sea.

The enormous species diversity in the Andaman Sea is one of the richest known and found in most groups of benthic invertebrates (mainly epifauna) and fishes. There are, e.g., at least 40 species of mytilids or mussels (in Danish waters only 8 species). On the other hand, many species are present in small numbers of individuals. On an average, 11 species

Table 2. Contents of 346* quantitative grab samples, 0.1 m^2.

Animal groups	Gallardo		Thorson
	No. of specimens	% of total no.	% of total no.
Polychaeta (bristle worms)	2923	48.3	73
Other worm groups	206	3.3	
Amphipoda	617	10.2	?
Ophiuroidea (brittle stars)	389	6.4	?
Natantia (shrimps)	356	5.8	8.3
Brachyura (crabs)	300	4.9	8
Bivalvia (clams, mussels, etc.)	294	4.8	?
Thalassinidea (burrowing "lobsters")	214	3.5	6
19 other groups	746	12.8	
Total	**6045**	**100.0**	**89.3**

*The number is reduced because c. 20 data sheets were lost en route.

and only 17 individuals were thus found per grab sample, with a tendency to increase in numbers with decreasing depths, particularly at less than 10 m (K. W. Ockelmann, pers. comm.). At Station 1018, at 15 m depth, a special analysis showed that the 10 grab samples comprised 94 species, 60 of which numbered only 1–2 individuals (Thorson *in* SEIDENFADEN *ET AL.*, 1968). The Pyramidellidae (minute parasitic snails) from one single station numbered ca. 60 individuals, representing half as many species, and the peculiarly twisted arc shell *Trisidos* was found alive only once, while dead shells of it were not rare at all. Experience was similar with many other species (K. Ockelmann, pers. comm.).

Muddy bottoms turned out to be very poor both in species and individuals compared to sandy bottoms.

Equally surprising were the small weights of animals per m^2 in spite of the richness in species. Thus, 80% of all grab samples had weights of 0–10 g per m^2, 9% had 10–20 g per m^2, 8% had 20–50 g per m^2, and only 3% had weights of more than 50 g per m^2. The corresponding *average* weight in cold temperate seas is 250–300 g per m^2, or 5 to more than 50 times as much as the weight of 97% of the Thai samples (THORSON *op. cit.*). Although the biomass and number of animals are no doubt underestimated due to coarse sieves, the large amounts of shell fragments and the pressure of work, it is obvious that the standing stocks are much lower than in boreal and arctic seas; this, at least in part, is explained by the faster energy flux and lower productivity in tropical waters.

Regarding productivity, Thorson also compared the low number of individuals in Thai waters to the very high figures in grab samples from off Roscoff (English Channel), Scotland and New England, and considered the general productivity to be poor (also supported by preliminary data from mousetrap samples). This does not, however, apply to the shrimp fauna: while in temperate seas we find an average of 1 shrimp per 2 m^2, the Thai numbers were ca. 10 per m^2 and rising even to 30–37 shrimps per m^2. Usually 6–7 species were involved, including young stages of species growing to a full size of 12–14 cm. Based on these data, Thorson rightfully predicted a future exploitation of the shrimp fauna.

Publications

The number of papers directly derived from the expedition is rather limited. SERÈNE & SOH (1976) treated the collected crabs: 67 species, 30 of which were previously unrecorded and 7 were new. BOONYANATE & HYLLEBERG (1993) published a list of the 84 species of well preserved fishes with measurements, and PIYAKARNCHANA & RATANAVICHIEN (1972) reported on the distribution of three species of lancelets. Based on 3284 specimens of polychaetes, PHASUK (1992) referred 209 to species or genus but left description of new species and genera to future publications; his paper also includes references to an unpublished paper on the stomatopods (P. Naiyanetr) and two theses in Thai, with English abstract, one on echinoderms (S. Sriyakorn) and one on lancelets (A. Ratanavichien). OCKELMANN (1983) defined a new subfamily of mytilid bivalves and described 10 new species, two of which were from the expedition. Finally, EGEROD (1974) reported on two families of collected algae.

Regarding Thorson's "parallel communities", GALLARDO (1968) made an interesting comparison between the cold temperate and tropical infaunas, and KENDALL & ASCHAN (1993) included an Arctic site in their latitudinal comparison. Species diversity in boreal,

tropical and deep-sea environments was recorded by SANDERS (1998), using rarefaction methodology.

Other Expedition Objectives

As mentioned above, an important aim was training of young Thai marine biologists. Several of the 11 persons have later contributed substantially to Thai marine research.

During the expedition a number of possible sites for a forthcoming marine biological center were surveyed before the location on the SE corner of Phuket Island was agreed on. However, the history of the Phuket Marine Biological Center (PMBC) since its erection in 1971 and its many research activities with participation of Danish scientists is not part of the present study (see *e.g.*, CHAROENPANICH & HYLLEBERG, 1988).

Material from the Fifth Thai-Danish Expedition became the basis for the later, much extended Reference Collection of marine organisms at PMBC (BOONPRAKOB & HYLLEBERG, 1983).

RECENT MAJOR ACTIVITIES

The Scientific Cooperation Programme (SCP), 1996–2000

A 5 years', mainly DANIDA-sponsored, scientific programme (SCP) was concerned with the biodiversity of the Andaman Sea and its shelf and slope. SCP was conducted in connection with the donation of R/V *Chakratong Tongyai* (Fig. 15) from DANIDA to PMBC. The three main projects dealt with benthic animals (BIOSHELF), plankton ecology and productivity, and dissolved and particulate matter in a mangrove. SCF included, in addition to PMBC, one institute from Odense University and three from University of Copenhagen plus two other research institutes (fisheries and environment).

An SCP Concluding Conference was held in February 2001 in Phuket. There were lectures on programme formulation, implementation, etc., information about PMBC and the Danish institutes involved, and 17 lectures on scientific items.

The Thai-Danish BIOSHELF Surveys 1996–2000

The objective of this project was to expand the general knowledge of the diversity of benthic animals down to 1000 m depth within the Thai Economic Exclusive Zone (EEZ) (AUNGTONYA *ET AL.*, 2000; BUSSARAWIT & AUNGTONYA, 2002; TENDAL *ET AL.*, 2002). The cooperating institutions were PMBC (leader Dr. Somchai Bussarawit) and the Copenhagen Zoological Museum (leader Dr. Claus Nielsen).

During 6 cruises, 98 stations on 12 transects were sampled at 40–970 m with 16 extra stations within the Thai EEZ (Fig. 16) and 19 near-shore stations. The large variety of equipment included Olsen box corer, Smith-McIntyre grab and Ockelmann detritus sledge (Fig. 12), epibenthic sledge, two types of dredges, Agassiz and beam trawls, other types of trawls and baited traps.

The size and character of the samples were very variable. A narrow zone rich in large invertebrates was found between 500 and 700 m along the slope (AUNGTONYA *ET AL.*, 2000). Work on the polychaetes (about 50 families) is in progress, following an international

Figure 15. The DANIDA-sponsored *Chakratong Tongyai* was named after Minister of Agriculture and Cooperatives, M. C. R. Chakratong Tongyai, the first Chairman of the Commission Board of PMBC. The tonnage (GT) is 464, length 38.4 m and width 9 m. The ship is owned by the Thai Department of Fisheries and allocated to operate in waters attached to the PMBS.

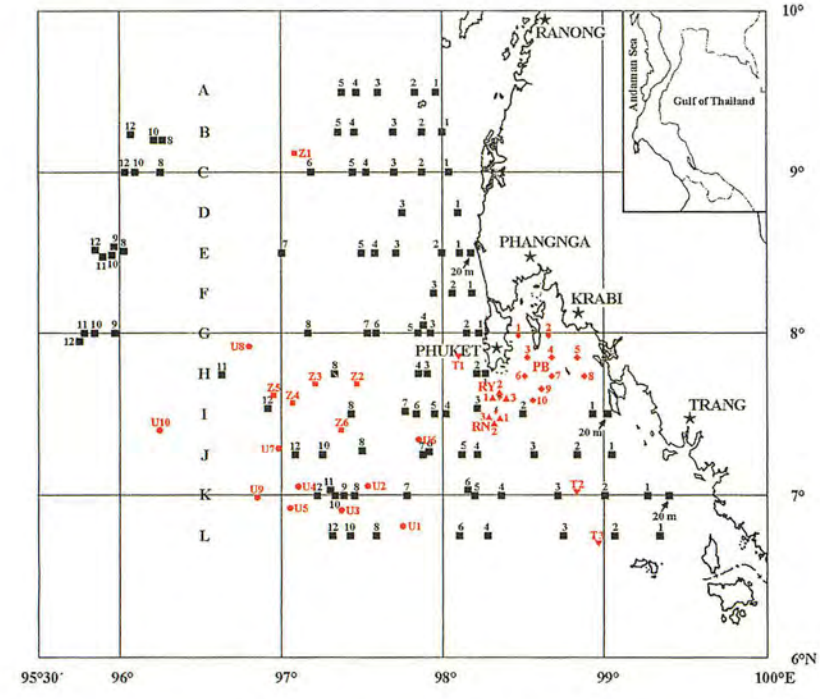

Figure 16. Location of BIOSHELF Transect stations (black) (■) and additional stations (red) (● ▲ ▼ ◆) 1998–2000). A–L = Transect lines. Numbers indicate sampling points along transect lines. (After AUNGTONYA *ET AL.*, 2000, modified)

workshop at PMBC in 1997 with 12 participants from 6 countries (EIBYE-JACOBSEN, 2002). Similarly, a workshop on crustaceans in 1998 had 26 participants from 8 countries (BRUCE *ET AL.*, 2002). Other groups currently being studied are molluscs (with 49 gastropod and 39 bivalve families), Foraminifera and the meiofauna. Publication of results is planned in a special volume of PMBC Research Bulletin with the working title "The Deep-water Fauna of the Andaman Sea Continental Margin" (eds. S. Bussarawit & O. Tendal).

Starch Gel Electrophoresis (SGE)

Genetic information in biological macromolecules (proteines and DNA) is now being routinely utilized in the study of life history and evolutionary relationships of organisms.

Allozyme analysis by means of starch gel electrophores (SGE) is particularly attractive because of its simplicity and rather low costs. As part of the BIOSHELF Project, a training course and workshop on SGE was held at PMBC in 1996 with 24 participants in order to provide the basis for applying this metod.

Thai-Danish Plankton Investigations

Prior to the SCP project on marine productivity and plankton dynamics, a few Thai-Danish investigations within these fields should be briefly mentioned. During an expedition in 1976 to the Surin Islands in the Andaman Sea, Søren Wium Andersen conducted the first measurements in the area on primary production (PMBC Res. Bull. No. 16: 1–4, 1977), supplemented by his measurements, also in 1976, at Phuket Island (Ophelia 18: 53–60, 1979). In 1982/83 Vudhichai Janekarn and Thomas Kiørboe investigated the distribution of fish larvae at 57 stations in coastal waters of the Andaman Sea (PMBS Res. Bull. No. 56: 41–61, 1991). During 1984 off Phuket Island they carried out a one year study of the seasonal and spatial distribution of fish larvae, with measurements of physico-chemical variables and phytoplankton biomass and production (PMBC Res. Bull. No. 56: 23–40, 1991). The first PMBC/DANIDA training course and workshop on marine fish larvae and plankton ecology was held in 1991, with published Proceedings (Kiørboe *et al.*, PMBC Spec. Publ. No. 8: 1–29, 1991).

The SCP project—"Pelagic Andaman Sea community structure, function and productivity with particular emphasis on an assessment of potential fisheries resources"—comprised several sub-projects dealing with environmental biology and ecology of pelagic organisms, from bacteria to fish larvae. The sampling strategies were designed to cover the entire Andaman Sea of Thailand within the 5-year duration of SCP. The field samplings were very successful.

The co-operating institutions were PMBC (Dr. Janekarn), Copenhagen University, Botanical Institute (Dr. Helge A.Thomsen) and Marine Biological Laboratory (Drs. Peter Kofoed Bjørnsen and Per Juel Hansen), Danish Institute for Fisheries research (Dr. Peter Munk) and National Environmental Research Institute (Dr. Torkel Gissel Nielsen).

The main part of the investigation was conducted during 4 cruises in March and August 1996 and February and September 1997. Sampling was performed during the daytime along 3 transects extending across the shelf and the upper slope (Fig. 17). An additional transect with 12 stations was carried out SW of Phuket Island in November 2000. Previous shelf investigations have suggested that a shelf-break front of mixing water

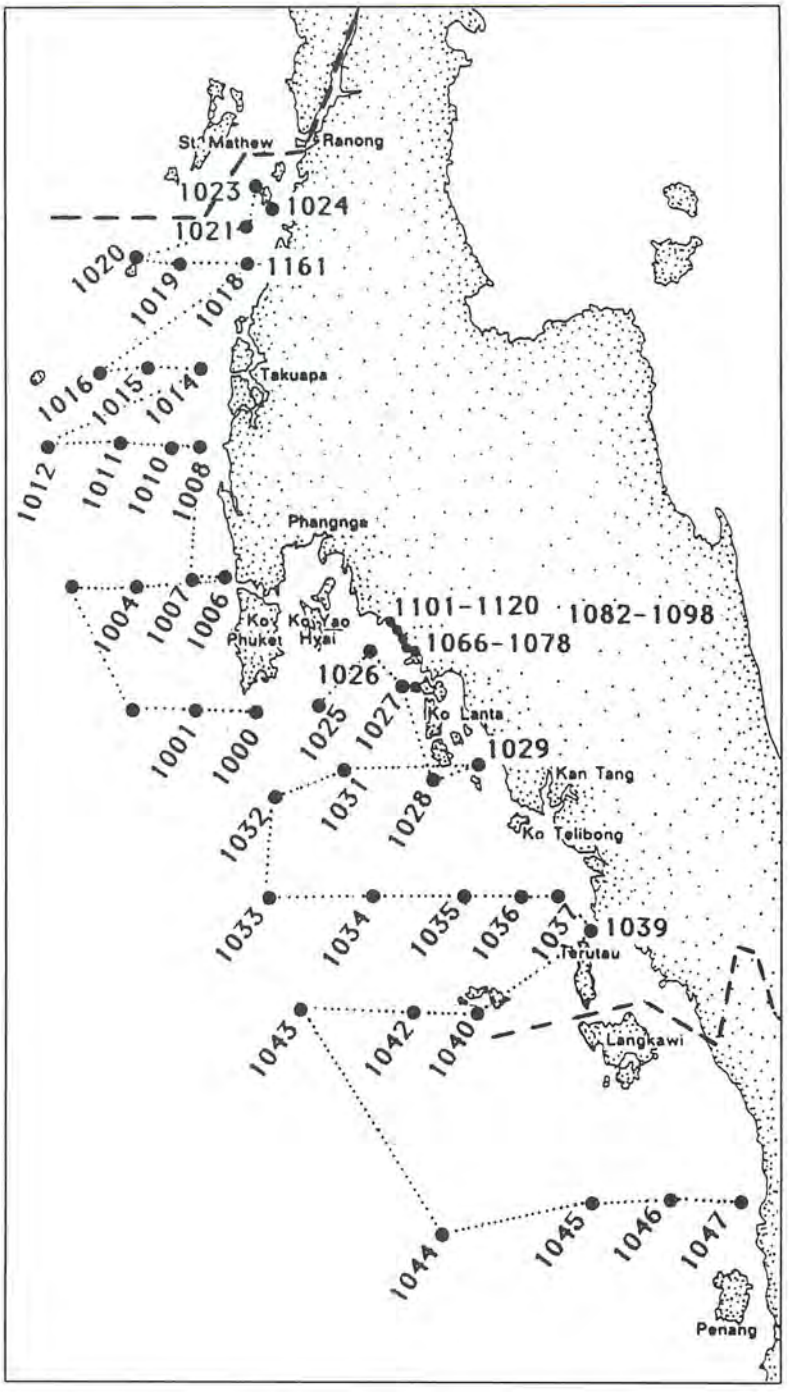

Figure 17. Three plankton station transects beyond the shelf, operated on two weeks' cruises on the *Chakratong Tongyai* during the Northeast and Southwest Monsoon seasons in 1996 and 1997. (After NIELSEN, 2005.

Figure 18. Excavation of burrows of leaf-eating sesarmid crabs in the Bangrong mangrove. (Photograph by N. Thongtham.)

was highly productive and potentially important for the productivity of the area. However, no peak in primary production or standing stock of key components of the microbial food web was observed (NIELSEN *ET AL.*, 2004). A similar conclusion was reached for copepod biomass and egg production rate (SATAPOOMIN *ET AL.*, 2004). The site of particularly high production was at the mid shelf front where breaking of the shoaling waves persistently introduced cold, salt nutrient-rich water to the euphotic zone, resulting in a enhanced phytoplankton biomass and production.

Feeding patterns of fish larvae and abundances and biomass of fish larvae and mesozooplankton were also estimated and related to environmental data (ØSTERGAARD *ET AL.*, 2005 and MUNK *ET AL.*, 2004). Just after the termination of the SCP, a workshop on these themes was held (MUNK *ET AL.*, PMBC Spec. Publ. No. 27: 1–41, 2000).

Based on the SCP results, areas of major biological importance can now be identified, and substantial linkages between hydrography and the organisms at different trophic levels can be described.

Mangrove Forest Research

The tradition for mangrove studies from the days of Schmidt was revived by Vagn Hansen (1924–2002) at PMBC where the first national mangrove symposium was held in 1976. During 1987–92, Thai scientists and Danish colleagues from Odense University conducted pioneer studies of mangrove sediment biochemistry, measuring community metabolism, nutrient dynamics, sulfate reduction and acetate turnover at Ao Nam Bor (PMBC Res. Bull. No. 60: 37–64, 1995 and Aquat. Microb. Ecol. 15: 165–175, 1998).

The SCP-sponsored Bangrong Mangrove Forest Programme—"Mangrove and seagrass connections – transformations and transport of dissolved and particulate matter within and between these ecosystems and the surroundings"—was carried out by scientists from PMBC and Odense University, lead by Erik Kristensen. It has already resulted in an impressive number of major publications (at least 10). One study was concerned with the hydrodynamics and nutrient dynamics of the mangrove (SURASWADI *ET AL.*, 2002 and SURASWADI, 2003). Studies showed that most of the litter fall is retained (eaten by crabs or decomposed) while most of the compounds are exported (SURASWADI, 2003). Burrows of sesarmid crabs (Fig. 18) increase the interface between sediment and water/air significantly, and the crabs are important in leaf degradation (i.e. THONGTHAM & KRISTENSEN, 2003). Studies of transformation of carbon, nitrogen and phosphorus compounds in sediments and waterways included i.a. determination of sediment metabolism (HOLMER *ET AL.*, 1999), of oxidation level and mineralization (KRISTENSEN *ET AL.*, 2000), and of variability in benthic processes (HOLMER *ET AL.*, 2001).

Cooperation in Marine Mammology

Studies of cetaceans (whales and dolphins) and sirenians (sea cows) in Thai waters were begun in 1991 and involve research capacity development and public education. Four universities and the Departments of Fisheries and Forestry (Marine National Parks) participate from the Thai side and the Zoological Institute and Zoological Museum, University of Copenhagen, from the Danish side. Based on the literature and available collections, ANDERSEN & KINZE (1999) published a list of 17 cetaceans recorded in Thailand, with maps, figures in colour and identification key.

Sea Snake Research Cooperation

Based on the very diverse sea snake fauna in Thai waters, Thai-Danish studies for over 20 years of systematics, biogeography and ecology have made this particular fauna one of the best investigated anywhere. At a DANIDA-funded workshop at PMBC in 1998, the Sea Snake Working Group was founded, with participation from seven South Asian countries. The Second Sea Snake Workshop was held in Nhatrang, Vietnam, in 2004. The ongoing project involves the latest DNA technologies and has as its future goal to produce sea snake serum. Thai participants are Queen Saovabha Memorial Institute (Thai Red Cross) and the Fisheries Department; Danes participating are from the Zoological Institute, University of Copenhagen, and the School of Conservation, Royal Academy of Fine Arts.

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