

# Deep-Sea Resource Explorations: Challenges of the Southeast Asian Countries

Natinee Sukramongkol

This article attempts to summarize the available information on “Deep Sea Explorations” in the Southeast Asian region and adjacent waters, and synthesize the reports from the SEAFDEC Member Countries during meetings, training sessions and workshops supported by the Japanese Trust Fund under the Project on “Development of Demersal Fishery Resources Living in Un-trawlable Fishing Grounds in the Southeast Asian Region: Deep-Sea Fisheries Exploration in Southeast Asia” which was implemented from 2007 until 2010.

The SEAFDEC Project on “Development of Demersal Fishery Resources Living in Un-trawlable Fishing Grounds in the Southeast Asian Region: Deep-Sea Fisheries Exploration in the Southeast Asia” covers the seawaters that surround the Southeast Asian countries, mainly the South China Sea, Andaman Sea, and Gulf of Thailand. The South China Sea is a marginal sea which is part of the Pacific Ocean, encompassing an area of around 3,500,000 km<sup>2</sup> from Singapore and Malacca Strait to the Strait of Taiwan. It is located south of mainland China and Taiwan, west of the Philippines, northwest of Sabah and Sarawak in East Malaysia and Brunei Darussalam, north of Indonesia, northeast of Peninsular Malaysia and Singapore, and east of Vietnam. The process of extension culminated in seafloor spreading around 30 million years ago resulted in the V-shaped basin at present. More than 200 islands and reefs had been identified in the South China Sea area, most of which are within the Spratly Islands. The largest singular feature in the Spratly Islands is a 100 km wide seamount called Reed Table mount also known as Reed Bank, in the northeastern part of the Islands which is separated from Palawan Island of the Philippines by the Palawan Trench (Tonnesson, 2005). The Reed Bank was an island until it sunk about 7000 years ago and completely submerged at a depth of 20 m. With an area of 8,866 km<sup>2</sup>, it is one of the largest submerged atoll structures of the world (Tonnesson, 2005).

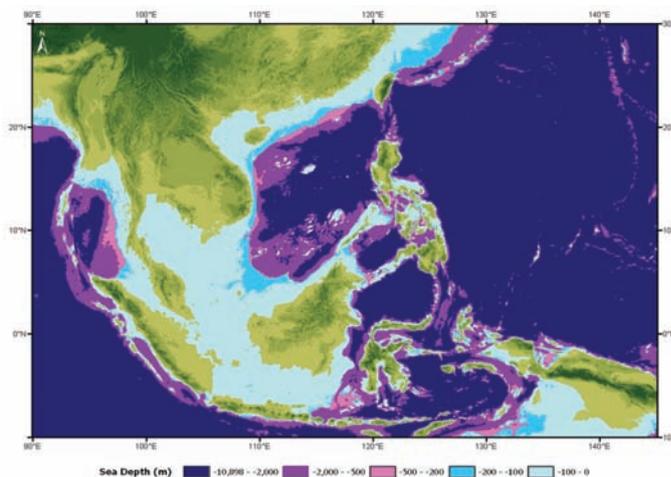
The Gulf of Thailand is bordered by Cambodia, Thailand, and Vietnam (south of the mouth of the Mekong River) up to Malaysian coast (city of Kota Baru), covering an area of roughly 320,000 km<sup>2</sup>. The southwestern part of the sea from the Gulf of Thailand to the Java Sea is the great continental shelf called “Sunda Platform” occupying 50.2% of the whole area where the water is generally shallow at less than 61 m depth (Tang, 2001; Tonnesson, 2005). In the northern part of the sea, a deep basin or sea valley lying

off Palawan Islands which reaches 5,016 m and this zone also has an abyssal plain with a depth of about 4,300 m (Wyrcki, 1961).

With an area of 798,000 km<sup>2</sup>, the Andaman Sea is a marginal sea of the northeastern Indian Ocean bounded to the north by the Irrawaddy River delta of Myanmar; to the east by peninsular Myanmar, Thailand, and Malaysia; to the south by Sumatra Island of Indonesia and by the Strait of Malacca; and to the west by the Andaman and Nicobar Islands which are part of the union territory of India. At the southwestern reaches, the Andaman Sea narrows to form the Strait of Malacca, which separates the Malay Peninsula from Sumatra Island. Andaman Sea is a part to the southeast of the Bay of Bengal, south of Myanmar, west of Thailand and east of the Indian Ocean. The coastline is roughly 1,200 kilometers long (north-south) and 650 kilometers wide (east-west). Its average depth is 870 meters and the maximum depth is 3,777 meters.

## What is a “Deep Sea”?

“Deep sea” can be classified into four zones, namely: the **mesopelagic** as the uppermost zone which ranges from 200 to 1,000 m below sea level; the **bathypelagic** occupying the 1,000-4,000 m depth zone; the **abyssopelagic** from 4,000 to 6,000 m; and the **hadopelagic** as the zone with deep-ocean trenches (FAO, 2005). Various considerations had been made to define a deep sea, where some works used the depth-based zonation of the mesopelagic as the start of the deepwater habitat.



Deep sea areas in Southeast Asia (Laongmanee, 2009)  
ETOPO1 Data, 1 minute resolution from: <http://www.ngdc.noaa.gov/mgg/bathymetry/relief.html>

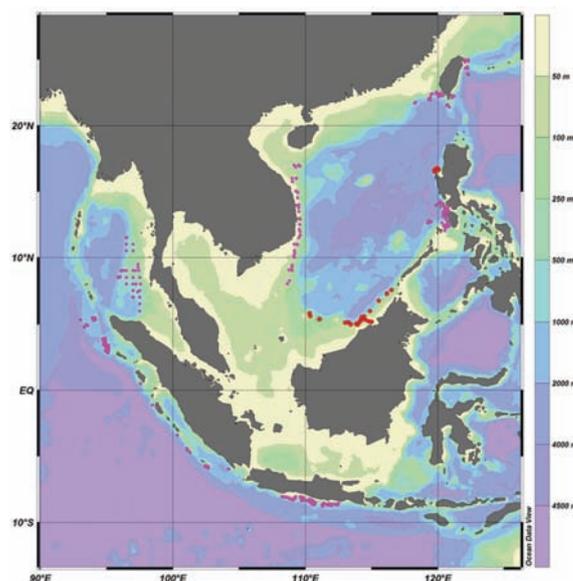
During the recent FAO Workshop on the Vulnerable Ecosystems and Destructive Fishing in Deep-Sea Fisheries (FAO, 2008), it was clarified that a “deep sea” is “the marine environment that extends downwards from the continental shelf break, i.e. waters deeper than 200 m to its maximum depth”. It was also emphasized during the 2008 Workshop that deep sea fisheries currently operate only at depths of less than about 2,000 m although the deep sea environment extends to the maximum depths of the ocean and future prospective exploitations could include the deeper waters.

## Fishing Practices and Explorations in Deep Sea Areas of Southeast Asia

Although a great continental shelf occupies almost 50% of the South China Sea, the continental slope and the deep basin down to nearly 1,000 to 5,000 m are the largest habitat around the Philippines, Taiwan, Indonesia, and part of the Andaman Sea areas. Within the 100 m depth, the fishery resources have been intensively exploited by trawling and while the shallow-water fishes in the region have been well documented, the deep sea fauna have not yet been fully investigated (Yeh *et al.*, 2003). The known deep sea pelagic resources are those of tunas, billfishes, and sharks, which are already being utilized. However, little or no information are available on the resources in the Exclusive Economic Zone (EEZs) of the countries in Southeast Asia especially the demersal resources beyond 100 m on the continental shelf and slopes, which could be due to the fact that no surveys have been specifically directed at the deep sea demersal and mesopelagic resources in the region.

In the late 70s, an investigation of the deep sea fishery resources in the Asian region was conducted during the FAO assisted survey of the marine fishery resources of countries bordering the Indian Ocean using the Norwegian research vessel, the R.V. Fridtjof Nansen. The survey covered the waters of Indonesia, Malaysia, Myanmar, and Thailand (Nishida and Sivasubramaniam, 1986). In 1979-1980, the R.V. Fridtjof Nansen which was well equipped for acoustic and fishery resource surveys carried out 49 bottom trawl operations in Myanmar waters, 7 operations in the waters of Thailand, and 4 operations in Indonesian waters (Nishida and Sivasubramaniam, 1986). Results from the acoustic survey and experimental trawling operations of the R.V. Fridtjof Nansen indicated substantial resources of deep sea shrimps and lobsters in the unexploited zone that ranges from 200 to 350 m of the EEZs of Myanmar and Thailand (Nishida and Sivasubramaniam, 1986).

Early expeditions in the deep sea of the South China Sea were started in Philippine waters in 1843 (Ramiscal, 2009). At the beginning of the 20<sup>th</sup> century, the US



Demersal resources survey conducted on the continental shelf and slope (100-1,000 m) in the South China Sea and Andaman Sea from 1983 to 2010

Pink= survey by national research vessels;  
Dark red=survey under the collaboration with SEAFDEC Member Countries

Bureau of Fisheries organized long series of deep sea sampling expeditions in the Pacific and Hawaiian Islands, Philippines and Indonesia using the vessel “Albatross”. The “Albatross” stayed in the Philippines from February 1908 to January 1910 and conducted dredging and trawling survey of about 292 stations at sea depths of more than 185 m (Ramiscal, 2009). From those Albatross expeditions, numerous taxonomic works were produced and many new crustacean species in Philippine waters had been described including a living fossil of the glypheoid, *Neoglyphea inopinata* (Ramiscal, 2009).

Another major series of deep sea explorations in Philippine waters was carried out by the French National Museum of Natural History (“MUSORSTOM”), using the R.V. Vauban and the R.V. Coriolis in 1976, 1981, and 1985 at the southwest waters off Luzon, Mindoro, and Marinduque, respectively. The survey was focused on the recapture of *Neoglyphea* (glypheoid lobsters) specimens.

Significant deep sea resource surveys in Philippine waters were conducted under the project “Census of Marine Life” (2005 to 2008) which focused on the taxonomy and morphology of deep sea benthic fauna (Ramiscal, 2009), considering that 88% of the Philippine territorial waters are deep water zones. The surveys covered the areas at Panglao Island (in 2004), Western Pacific off Luzon Island (in 2007), and off Lubang and Mindoro (in 2008) with sea depths that range from 100 to 2,250 m.

The explorations in many areas off Philippine waters since 2004 reported significant catches of the pandalid shrimps



Above: Deep-sea exploration at Lingayen Gulf of Philippines onboard the M.V. DA-BFAR in 2008; and Left: data recording during the survey

(*Heterocarpus woodmasoni*, *H. hayashii*, *H. dorsalis*) which were abundant at sea depths between 200 and 600 m. SEAFDEC/TD in collaboration with the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) conducted deep sea fishery resources survey in 2008 on the continental shelf-slopes with depths ranging from 200 to 1000 m at Lingayen Gulf located on the northwest of Luzon in the Philippines (SEAFDEC, 2008). The catch composition of the deep sea demersal fishes caught using the beam-trawl in Lingayen Gulf comprised more than 50% belonging to the family Macrouridae, Colocongridae, and Sternoptychidae (SEAFDEC, 2008). The catch per unit area (CPUA) according to depth range indicated an interesting distribution of the potential deep sea fishery resources in Lingayen Gulf. An average CPUA for all crustaceans and fish caught from beam trawl was reported at 207 kg/km<sup>2</sup> with the highest at depth between 200 and 400 m at 348 kg/km<sup>2</sup> (SEAFDEC, 2008).

In the waters of Thailand, attempts were made to assess the state of the demersal resources in the Andaman Sea at sea depths between 16 and 85 m during the 5<sup>th</sup> Thai-Danish Expedition (FTDE) in 1966 using the national research vessel, the R.V. Thanarat (Seidenfaden *et al.*, 1968). The fishes collected during the FTDE included 80 species from 41 families and the specimens comprising 64 species were

deposited at Phuket Marine Biological Center (Hylleberg and Boonyanate, 1993). Three major surveys of the deep sea demersal resources in the Andaman Sea at the sea depths of more than 200 m were conducted in 1975, 1981, and 1987 (DOF Thailand, 1983; SEAFDEC, 1982; Nishida and Sivasubramaniam, 1986; Ananpongsuk, 1989). The survey covered the continental slope at depth from 200 m to 550 m off Marid coast (Myanmar), and off southwest of Phuket to Adang Island (Thailand).

In 1981, during the joint survey of Thai-Japanese-SEAFDEC using the R.V. NAGASAKI MARU, the predominant groups of deep sea shrimps and lobsters, cephalopods, Nemipteridae, Synodontidae, and Elasmobranchii were recorded at depths that range from 200 to 400 m around the continental slope off Myanmar and Thai waters (SEAFDEC, 1982; Nishida and Sivasubramaniam, 1986). At least 35 families of fish were identified after the deep sea trawl survey in the Andaman Sea of Thailand in 1981-1987 (DOF Thailand, 1983; Ananpongsuk, 1989; Nishida and Sivasubramaniam, 1986).

SEAFDEC (1982) and Ananpongsuk (1989) reported that the species found in waters with depths more than 200 m were the Nomeidae (*Cubiceps squamicep*), Polymixiidae (*Polymixia japonicus*; *Polymixia berndti*), and Macrouridae (*Coelorhynchus* sp.; *Hymetnocephalus* sp.; *Nezumia* sp.; *Malacocephalus laevis*). Moreover, decapod and cephalopod groups such as deep sea shrimps, spiny lobster, and crabs were also caught where the CPUE of deep sea shrimps was from 3.7 kg/hr and 14.1 kg/hr (Ananpongsuk, 1989). In 1987, a survey was conducted at sea depths between 400 and 421 m in the southwestern waters off Phuket Island using the M.V. Paknam. The maximum CPUE was 181.8 kg/hr of which the CPUE of useful species was 20.3 kg/hr, 11.5 kg/hr for crustaceans, and 150.0 kg/hr for trash fish (Ananpongsuk, 1989).

Recently, a comprehensive survey under the project “Biodiversity of the Andaman Sea Shelf (BIOSHSELF)” by the scientific collaborative program between Denmark and the Phuket Marine Biological Center (PMBC) of Thailand was conducted in 1996-2000 (Aungtonya *et al.*, 2000). The survey covered the areas from the border of Myanmar in the north to the Malaysian border in the south of the waters of Thailand using the R.V. Chakratong Tongyai (Aungtonya



Species of pandalid shrimps caught during the deep sea surveys in the Philippines (Ramiscal, 2009)



Spiny lobster caught during the survey in Thai waters (Siripitrakool, 2009)

*et al.*, 2000). Deep sea fauna that included the polychaetes, crustaceans, mollusks, and fishes collected from the survey were used as inputs during the series of PMBC-DANIDA International Workshops at PMBC, Thailand in 1997-1998 (Bussarawit *et al.*, 2008).

Records showed that deep sea surveys had been conducted in Myanmar since 1968 (SEAFDEC, 2009). However, the most significant survey was conducted in 1979-1980 by FAO/UNDP using the R.V. Fridtjof Nansen. The survey reports indicated that the estimated biomass of demersal fishes in Myanmar waters was between 750,000 and 800,000 tons (Sætersda *et al.*, 1999). Off the waters of Myanmar, the average trawl catch rate was reported at 259 kg/hr at depths that range from 90 to 100 m (Sivasubramaniam, 1985). The fish species *Priacanthus macrocanthus* and *Peristedion weberi* were reported to be the most significant catch at the depths between 100 and 150 m, although *Nemipterus japonicus* was the most frequent species caught at greater depths (151-350 m).

Moreover, sea robins (*Peristedion weberi*) and deep sea lobsters (*Puerulus* sp.) were also noticeably significant (Rijavec and Htun, 1984). In 1985, the Department of Fisheries (DOF) of Myanmar collected data from 533 shrimp trawls and reported catch rates of about 31.2 kg/hr which confirmed the results from the Thai-Myanmar joint survey at 31.6 kg/hr (Htay Oo, 2009). Although there was no information on the deep sea fishery resources at depths more than 200 m based on trawl survey on the continental shelves and slopes off Myanmar waters, but the collaborative survey of the un-trawlable areas between Thailand and Myanmar in 1990 using the R.V. Chulabhorn reported that the commercial fish species at the continental slope areas comprised the yellow snapper at average catch rate of 1.7 kg/100 hooks and the banded grouper at average catch rate of 0.9 kg/100 hooks. In 2007, the M.V. SEAFDEC 2 conducted the bottom trawl survey on the continental shelf at the eastern central part off Myanmar waters up to 100 m depth and reported that the highest catch

was the lizard fish (*Saurida undosquamis*) which comprised about 20% of the total catch at 91 kg/hr (Han Win, 2010).

Deep sea trawl surveys in the waters of Indonesia were first initiated at the Indian Ocean south off Java in 1972 and 1975 with assistance from the Fisheries Research Agency of South Korea under a bilateral agreement (Sumiono, 2009). From 1979 to 1981, joint explorations of the fisheries and stock assessment of demersal fish resources were carried out under the collaborative Jetindofish Project among the Government of Indonesia, the Federal Republic of Germany, the Commonwealth of Australia, and the FAO/UNDP as coordinating agency, in the Indian Ocean subareas (Sumiono, 2009). The surveys were conducted at the south off Lombok Island to Eastern off Timor from sea depth of 50 m to 200 m (Lohmeyer, 1982).

Moreover, in 1980 the R.V. Fridtjof Nansen conducted bottom trawl surveys at the west coast of Sumatra under the agreement between the Government of Indonesia and the FAO/SCSDEVPRO, where the estimated standing stock of demersal fishes was reported at 65,000 tons although the survey was conducted with insufficient time and thus, more research would be needed (Aglen *et al.*, 1981). An extensive deep sea fishery resources survey in Indonesian waters was conducted in Banda Sea, Arafura Sea, and Timor Sea in 1992 and 1993 using the R.V. Baruna Jaya-I (Badrudin *et al.*, 2004; Badrudin *et al.*, 2005), at the continental shelf and slope with depths ranging from 200 m to 1,000 m (Sumiono and Iskandar, 1993; Soselisa *et al.*, 1993; Wudianto and Barus, 1993). Recently, a joint survey of the country's fishery resources was implemented between the Government of Indonesia and Overseas Fishery Cooperation Foundation (OFCF) of Japan, using the R.V. Baruna Jaya IV on the west coast of Sumatra and Java of Indonesia between 2004 and 2005. The results from the survey in 2004 provided general knowledge about the diversity and abundance of fauna indicating high diversity in the area (OFCF and AMFR, 2006). A total of 456 fish species, 52 crustacean species, and 42 cephalopod species were recorded from the results of 138 trawling operations in 2004-2005. The survey also revealed that the area serves as a habitat for the commercially useful species such as the red roughy *Haplostethus crassispinus*, black roughy *Haplostethus rubelloterus*, Alfonsino *Beryx splendens*, and blackthroat seaperch *Deoderlrieinia berycoides* (OFCF and AMFR, 2006).

The results of the surveys conducted in the various parts of west off Sumatra, south off Java, and south off Lombok Island to eastern off Timor, indicated that the fishery resources in the deep water areas of the Indian Ocean are still less exploited (Aglen *et al.*, 1981; Lohmeyer, 1982; OFCF and AMFR, 2006). However, the density of the

demersal stocks in the Indian Ocean was lower than those of Java Sea and the fish density had the tendency to increase towards the coast (Sumiono, 2009). High density of the deep sea shrimps was found at depth between 200 and 300 m (Lohmeyer, 1982). In the Arafura Sea and Timor Sea, the stock density of deep sea prawn seemed to fluctuate between 280 kg/km<sup>2</sup> and 1970 kg/km<sup>2</sup> at sea depths ranging from 400 m to 800 m (Sumiono and Iskandar, 1993). The catch rates of the caridean prawn (*Aristeus virilis*, *Heterocarpus woodmasoni*) and marine lobsters (*Metanephrops sibogae*) decreased from Arafura Sea to Timor Sea but giant red shrimp (*Aristeomorpha foliacea*) tends to increase (Sumiono and Iskandar, 1993).

The estimated stock density of the demersal fishes at sea depths ranging from 200 m to 1,000 m in Arafura Sea (sub area of Tanimbar) and Timor Sea were 475 kg/km<sup>2</sup> and 294 kg/km<sup>2</sup>, respectively. The demersal fish stock in the sub-areas of Western Sumatra however, fluctuated between 829 kg/km<sup>2</sup> and 1,773 kg/km<sup>2</sup> at sea depths from 500 m to 1,000 m (Badrudin, 2006). The highest demersal fish stock density was observed at sea depths between 500 m and 750 m in the western part of Banda Aceh (Badrudin *et al.*, 2006).

The dominant demersal fish families found in the deep water areas of Indian Ocean and other parts of Indonesia were



Important shrimp species caught during the surveys in Indonesian waters: left - *Aristeus virilis* at 703 m deep and right - *Heterocarpus* spp. at 882 m deep (Sumiono, 2009)



Sorting of marine species caught during the deep sea survey of Indonesian waters (Sumiono, 2009)

Ophidiidae, Macrouridae, Myctophidae, Alepocephalidae, Plesiobatidae, Acropomatidae, and Trichiuridae. The major species in terms of number and highest relative abundance (CPUE) were *Lamprogrammus niger*, *Trichiurus lepturus*, the lantern fish *Diaphus* sp., the rat-tails macrouridae *Caelorinchus divergens*, the neoscopelids *Neoscopelus macrolepidotus*, the spinyfins *Dirtemoides pauciradiatus*, the alepocephalid *Bajacalifornia erimorensis*, and the trachichthyds *Haplostetus crassispinus* (Badrudin *et al.*, 2006; Sumiono, 2009).

Deep sea resource surveys in Vietnam were conducted under the two major projects, namely: Viet-Xo Joint Survey in 1978-1988, and the ALMRV I and II in 1996-1997 and 2000-2005, respectively (Nghia, 2009). The Viet-Xo joint surveys were conducted using the otter trawl in about 1,312 stations (at sea depths of more than 200 m) where the catch rates fluctuated from 30 kg/hr to 460 kg/hr (Nghia, 2009). The Assessment of the Living Marine Resources in Vietnam (ALMRV) surveys off Vietnam waters which were supported by DANIDA comprised the ALMRV Phase I using the otter trawl in the deep sea areas of 63 stations and the ALMRV Phase II using the otter trawl, trap, and bottom longline on the continental slope of 28 stations.

The first attempted marine resources survey in Malaysia using its national research vessels was in the EEZ of Malaysia in 1985-1987 using the R.V. Rastrelliger, and in 1996-1997 using the K.K. Manchong (Sallehudin, 2009). However, access to the deep sea resources at the area more than 30 nm offshore was made in 2004 to 2005 onboard the K.K. Manchong (Sallehudin, 2009). Considering the limited EEZ area of the coast of Peninsular Malaysia, trawl fishing in the deeper end of its EEZ had been limited at sea depth of about 185 m in the east and 100 m in the west coast of Peninsular Malaysia (FAO, 1999). The R.V. Fridtjof Nansen also visited the west coast of Peninsular Malaysia in 1980 and reported that the catch rate from trawling was about 395 kg/hr at 90 m depth (Sivasubramaniam, 1985). The survey in the Malaysian EEZ off Sarawak waters in 2004-2005 indicated that the average catch rates of demersal fish at depths between 92 m and 185 m were 44.8 kg/hr in 1987, 109.7 kg/hr in 1998, and 82.4 kg/hr (Sallehudin, 2009).

The dominant species were *Priacanthus macrocanthus*, *Saurida tumbil*, *S. longimanus*, *Decapterus kurroides* while the deep sea species found during the survey in 2004-2005 were *Lophiomus* spp. (ghost shark) and *Malakichthys elegans* (Sallehudin, 2009). At the un-trawlable areas in Sarawak waters, the catch by bottom vertical longline (BVL) comprised the Ariidae, Lutjanidae, Squalidae, Lethrinidae, Nemipteridae, Potunidae, and Muraenidae (Sallehudin, 2009).



Catch from the deep sea survey in Sabah and Sarawak waters onboard the M.V. SEAFDEC 2 in 2010. Photo by: Abdul Aziz Yusof

The relatively short history of the fishery research survey at offshore areas of Brunei Darussalam started in 2004. Information on the fishery resources at the continental shelves and slopes (sea depths between 100 and 400 m) off Brunei Darussalam waters were derived from the results of the collaborative survey between Brunei Darussalam and SEAFDEC using the M.V. SEAFDEC 2 starting in 2008. The survey indicated that the fish density along the continental slope ranged from 0.63 to 1.53 mt/km<sup>2</sup>, ave: 1.2 mt/km<sup>2</sup> (Matzaini, 2009). The species composition from the demersal trawl on the continental shelf and upper slope (100-200 m) was dominated by the lizard fish (*Saurida tumbil*) and nemipterids (*Nemipterus* sp.). At the lower continental slope (200-400 m) the catch comprised the silver belly sea perch followed by lantern fishes and beard fish. Moreover, a significant amount of deep sea shrimps (*Heterocarpus* sp., *Plesionika* sp.) were caught by beam trawl at the sea depth between 215 and 374 m (Matzaini, 2009).



Deep sea resources survey onboard the M.V. SEAFDEC 2 in the waters of Brunei Darussalam in 2009.



Isopod caught during the deep sea survey in Malaysia (2010). Photo by: Abdul Aziz Yusof



Above: *Heterocarpus* sp. and Below: *Plesionika* sp. (Matzaini, 2009)

## Deep Sea Fisheries Resource Explorations by SEAFDEC

SEAFDEC in close collaboration with the Member Countries has been supporting the investigations of the deep sea fishery resources in the Southeast Asian waters. Such assistance includes human resource development (HRD) activities in the form of training sessions, workshops, on-the-job training, to encourage the Member Countries to take initiatives in conducting deep sea resource explorations in their EEZs to investigate the status and potentials of the deep sea fishery resources.

From the point of view of the international concern on ecosystem approach for deep sea fisheries, collaboration and coordination with other relevant initiatives were also enhanced. The results of the surveys (**Table 1**) had been compiled in a form of the set of guidelines and standard operation procedures in the level of scientific surveys and operations while the initial set of collection fishes collected from the survey had been catalogued.

## References

- Aglen, A., L. Foyn, O.R. Godo, S. Myklevoll and O.J. Ostvedt. 1981. A survey of the marine fish resources of the North and West Coast of Sumatera, August 1980. Institute of Marine Research. Bergen; 55 p
- Ananpongsuk, S. 1989. Report of some offshore demersal resources of the Andaman Sea. Southeast Asian Fisheries Development Center, Training Department, Samut Prakan, TD/RES/20; 30 p
- Aung Htay Oo. 2009. Status of Deep Sea Fisheries Survey in Myanmar. Paper presented during the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource

Table 1. Explorations made by Member Countries with assistance from SEAFDEC

Activity	2007	2008	2009	2010
Supporting Deep Sea Fishery Resources Survey		<ul style="list-style-type: none"> <li>Lingayen Gulf, Philippines (May)</li> <li>Brunei Darussalam waters (June)</li> </ul>	<ul style="list-style-type: none"> <li>Brunei Darussalam waters (March)</li> </ul>	<ul style="list-style-type: none"> <li>Brunei Darussalam waters (Sep-Oct)</li> <li>Malaysia, off Sabah and Sarawak (July-Aug)</li> </ul>
Development/improvement of deep sea sampling gears and technology	<ul style="list-style-type: none"> <li>Fishing trial of deep-sea beam trawl and Isac-Kid Mid-Water Trawl (IKMT)</li> </ul>	<ul style="list-style-type: none"> <li>Beam trawl sampling gear development</li> </ul>	<ul style="list-style-type: none"> <li>Workshop: SOP and development/improvement of sampling gears for the deep sea resource exploration (May)</li> </ul>	<ul style="list-style-type: none"> <li>Agassiz trawl development</li> </ul>
Human resources development (HRD)		<ul style="list-style-type: none"> <li>Shipboard training: Survey methodology using deep sea beam trawl, bottom trawl, and deep-sea trap onboard M.V. DA-BFAR (May)</li> </ul>	<ul style="list-style-type: none"> <li>Training workshop: Deep-sea fish identification (Jan.)</li> </ul>	<ul style="list-style-type: none"> <li>Training Workshop: Research Methodologies for the Study on Impact of Fishing to Deep Sea Ecosystem (Oct)</li> </ul>
Deep sea ecosystem and impact from fishery				<ul style="list-style-type: none"> <li>Expert Meeting: Deep sea fishing and its impact to ecosystem deep sea resource exploration (Sep)</li> </ul>
Information dissemination	<p>SOP Publications:</p> <ul style="list-style-type: none"> <li>IKMT (TD/RES112)</li> <li>Deep-Sea Beam trawl (TD/RES113)</li> <li>Collapsible Fish Trap (TD/RES114)</li> <li>Check List of Deep Sea Fishes in the Southeast Asian Waters (TD/RES115)</li> </ul>	<ul style="list-style-type: none"> <li>Preliminary report on the fishery resources exploration on the continental slopes in Lingayen Gulf, the Philippines (TD/RES127)</li> <li>Report of the training workshop on the deep sea fishery resources exploration on the continental slopes in Southeast Asian waters (TD/RP124)</li> </ul>	<ul style="list-style-type: none"> <li>Set of posters of fishes and the initial set of collection and catalogue of fishes collected from the survey</li> <li>Report of the training workshop deep-sea fish identification (TD/RP/137)</li> <li>Report of the workshop on SOP and development/improvement of sampling gears for the deep sea resource exploration (TD/RP143)</li> </ul>	<ul style="list-style-type: none"> <li>Report of the expert meeting deep sea fishing and its impact to ecosystem deep sea resource exploration (TD/RP/140)</li> <li>Report of the training workshop on research methodologies for the study on impact of fishing to deep sea ecosystem (TD/RP/141)</li> <li>Establishment of regional and national network to share information</li> </ul>

Exploration, 26-28 May 2009, SEAFDEC Training Department, Samut Prakan, Thailand

Aungtonya, C., S. Thaipal and O. Tendal. 2000. A preliminary report on the Thai-Danish bioshelf surveys (1996-2000) of the west coast of Thailand, Andaman Sea. Phuket Mar. Biol. Cent. Res. Bull. 63:53-76

Badrudin, M., B. Suniono and S. Nurhakim. 2004. Hook rates and composition of bottom longline catches in the Waters of the Arafura Sea. Indonesian Fisheries Research Journal. AMFR. MMAF, 10(1):9-14

Badrudin, M., Wudianto, N.N. Wiadnyana and S. Nurhakim. 2006. Deepsea fish resources potential and diversity in the waters of Western Sumatera of the Eastern Indian Ocean. Indonesian Fish. Res. J.; 25 p

Bussarawit, Somchai, Ole Secher Tendal, Claus Nielsen and Arne Redsted Rasmussen. 2008. Summary of the Thai-Danish biodiversity project on the Andaman Sea continental shelf and slope (1996-2000). Phuket Mar. Biol. Cent. Spec. Publ. 31:75-81

DOF Thailand, 1983. Some deep-sea fishes in the Andaman

Sea. Exploratory fishing division, Department of Fisheries, Bangkok, Thailand. No.14; 70 p

FAO, 2005. Report on DEEP-SEA 2003: An international conference on governance of deep-sea fisheries. Queenstown, New Zealand, 1-5 December 2003. Fisheries Report. No.3/1; 718 p

FAO, 2008. Report of the FAO workshop on vulnerable ecosystems and destructive fishing in deep-sea fisheries. Rome, 26-29 June 2007. FAO Fisheries Report. No.829; 18 p

Han Win. 2010. Impact of deep sea fishing in Myanmar. In: Report of the Training Workshop on Research Methodologies for the Study on Impact of Fishing to Deep Sea Ecosystem. SEAFDEC Training Department, Samut Prakan, Thailand

Hylleberg, J. and Boonyanate, P., 1993. Fishes from the 5<sup>th</sup> Thai-Danish expedition to the Andaman Sea in 1966. Phuket Mar. Biol. Cent. Spec. Publ., 12:41-51

Laongmanee, Penchan. 2009. Interpretation of terms in SOP for Deep Sea Resources Exploration. Paper presented

- during the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource Exploration, 26-28 May 2009, SEAFDEC Training Department, Samut Prakan, Thailand
- Lohmeyer, U.P., 1982. Joint Eastern tropical Indian Ocean fishery survey. Summary report module II. Directorate General of Fisheries, Indonesia; 143 p
- Matzaini Haji Juna. 2009. Offshore Resources Survey of Brunei Darussalam. Paper presented during the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource Exploration, 26-28 May 2009, SEAFDEC Training Department, Samut Prakan, Thailand
- Nghia, Nguyen Viet. 2009. Status of Resources Surveys related to Deep Sea Exploration in Vietnam. Paper presented during the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource Exploration, 26-28 May 2009, SEAFDEC Training Department, Samut Prakan, Thailand
- Nishida, T. and Sivasubramaniam, K., 1986. Atlas of deep water demersal fishery resources in the Bay of Bengal. BOBP/WP/53; 49 p
- OFCF and AMFR, 2006. Report of the Japan-Indonesia deep sea fishery resources joint exploration project. Overseas fishery cooperation foundation of Japan and the agency for marine and fisheries research of Indonesia; 154 p
- Ramiscal, Rafael. 2009. Deep sea fisheries surveys – Philippines. Paper presented during the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource Exploration, 26-28 May 2009, SEAFDEC Training Department, Samut Prakan, Thailand
- Sallehuin bin Jamon. 2009. Deep Sea Resources Research and Survey in Malaysian Waters. Paper presented during the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource Exploration, 26-28 May 2009, SEAFDEC Training Department, Samut Prakan, Thailand
- Sætersdal, G., G. Bianchi, T. Stroemne, S.C. Venema. 1999. The DR. FRIDTJOF NANSEN Programme 1975–1993: Investigations of fishery resources in developing countries. History of the programme and review of results. FAO Fisheries Technical Paper. No. 391; 434 p
- SEAFDEC, 1982. Report of the Thai-Japanese-SEAFDEC joint oceanographic survey in the Andaman Sea onboard the Nagasaki-Maru 1-5 November 1981. TD/RP/07; 251 p
- SEAFDEC, 2008. Preliminary report on the fishery resources exploration on the continental slopes in the Lingayen Gulf, Philippines, Southeast Asian Fisheries Development Center, Training Department, Samut Prakan, Thailand. TD/RES/127; 25 p
- SEAFDEC, 2009. Report of the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource Exploration, 26-28 May 2009. Southeast Asian Fisheries Development Center, Training Department, Samut Prakan, Thailand. TD/RP/143; 300 p
- SEAFDEC, 2010. Report of the Training Workshop on Research Methodologies for the Study on Impact of Fishing to Deep Sea Ecosystem. Southeast Asian Fisheries Development Center, Training Department, Samutprakan, Thailand. TD/RP/141; 120 p
- Seidenfaden, G., T. Smitinand and G. Thorson. 1968. Report on the fifth Thai-Danish expedition 1996. Nat. Hist. Bull. Siam Soc. 22:245–261
- Siripittrakool, Pisanu. 2009. Deep Sea Fisheries Survey in Thailand. Paper presented during the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource Exploration, 26-28 May 2009, SEAFDEC Training Department, Samut Prakan, Thailand
- Sivasubramaniam, K. and Maldeniya, R. 1985. The demersal fisheries of Sri Lanka. BOBP/WP/41; 41 p
- Sumiono, Bambang. 2009. Deep Sea Demersal and Prawn Resources Exploration Surveys in Indonesia. Paper presented during the Regional Workshop on the Standard Operating Procedures and Development/Improvement of Sampling Gears for Deep Sea Resource Exploration, 26-28 May 2009, SEAFDEC Training Department, Samut Prakan, Thailand
- Sumiono, B., and Iskandar, B., 1993. Distribution and stock density of deepwater prawn in the Wetters of Tanimbar and Timor Sea. J. Mar. Fish. Res., (77), 1-15. (In Indonesian, Abstract in English)
- Tang, V. T., 2001. The Eastern Sea (Resources and environment). The Gioi Publisher. Hanoi; 199 p
- Tønnesson, S., 2005. Locating the South China Sea *In: Locating Southeast Asia: Geographies of Knowledge and Politics of Space*. Singapore University Press. Singapore; pp 203–233.
- Wyrski, K., 1961. Physical oceanography of the Southeast Asian Waters. Scientific results of marine investigations of the South China Sea and the Gulf of Thailand 1959-1961. Naga Report; vol.2, Scripps Institution of Oceanography. La Jolla, California; 195 p
- Yeh, H.M., M.L. Chiou, Y.C. Liao, H.C. Ho, T.H. Wu, P.F. Lee, C.H. Chang and K.T. Shao. 2003. Deep-sea fish diversity around Taiwan, Province of China. *In: Report on DEEP SEA 2003, an international conference on governance and Management of Deep-sea Fisheries*. Queenstown, New Zealand, 1–5 December 2003. FAO Fisheries Report No.772; 84 p

## About the Author

Dr. Natinee Sukramongkol, Ph.D. is a Fishery Oceanographer of the Capture Fishery Technology Division, SEAFDEC Training Department in Samut Prakan Thailand. She is responsible for the technical support and coordination of the Project on “Deep-Sea Fisheries Exploration in Southeast Asia”.