

REVIEW WORK ON THE
DEEP-SEA FISHERY RESOURCES AND ITS UTILIZATION IN
THE SOUTHEAST ASIAN REGION

Samutprakarn, Thailand, December 2012



Deep-Sea Fishery Resources and Its Utilization in the Southeast Asian Region

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Preparation of this article

The “Deep-Sea Fishery Resources and Its Utilization in the Southeast Asian Region” attempt to summarize available information on the “Deep Sea exploration” in the Southeast Asian Region and Adjacent Waters. The preparation of this article is based on the report and presentation from SEAFDEC member countries during the meeting and training/workshop under the Japanese Trust Fund Project on “Development of Demersal Fishery Resources Living in Un-trawler Fishing Ground in the Southeast Asian Region: Deep-Sea Fisheries Exploration in the Southeast Asia” during the year 2007 and 2011.

Geographic Background of the South China Sea and the Adjacent Waters

The South China Sea is covered 3,500,000 sq km from western of the Pacific Ocean to the southwestern part of the sea from Gulf of Thailand to the Malacca strait. It is connected with the East China Sea by the Taiwan Strait. A process of the extension culminated in seafloor spreading around 30 million years ago resulting in the V-shaped basin as present. The southwestern part of the sea from the Gulf of Thailand to the Java Sea is the great continental shelf called “Sunda Plateform” occupying 50.2% of the whole area and the water is generally shallow (less than 61m) throughout this area (Tang, 2001; Tonnesson, 2005). In the northern part of the sea, a deep basin or sea valley lying off Palawan Islands which reach 5,016m and this zone is also has an abyssal plain with a depth of about 4,300m (Wyrcki, 1961).

At the southwestern reaches, the Andaman Sea narrows to form the Straits of Malacca, which separate the Malay Peninsula from Sumatra Island. The 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 coastal is roughly 1,200 kilometers long (north-south) and 650 kilometers wide (east-west), with an area of 797,700 km². Its average depth is 870 meters and the maximum depth is 3,777 meters.

More than 200 islands and reefs were identified, most of them within the Spratly Islands. The largest singular feature in the area of the Spratly Islands is a 100 km wide seamount called Reed Table mount, also known as Reed Bank, in the northeast of the group, separated from Palawan Island of the Philippines by the Palawan Trench (Tonnesson, 2005). It was an island until it sunk about 7,000 year ago and completely submerged with a depth of 20 m. With an area of 8,866 km², it is one of the largest submerged atoll structures of the world (Tonnesson, 2005).

What is “Deep Sea”?

The “deep-sea” can be classified into four zones in common; the mesopelagic is uppermost and ranges from 200 to 1,000 m; the bathypelagic occupies the 1,000-4,000 m depth zone; the abyssopelagic goes from 4,000 to 6,000 m and the hadal zone for the habitat of the deep ocean trenches (FAO, 2005). Various consideration had been made for define of what is the deep sea, some works used the depth-based zonation of mesopalagic as the start of the deepwater habitat. According to the recent “FAO Workshop on the Vulnerable Ecosystems and Destructive Fishing in Deep-Sea Fisheries” (FAO, 2008), *the “deep sea” is clarified as “The marine environment that extends downwards from the continental shelf break, i.e. waters deeper than 200 m to its maximum depth.* Deep-sea fisheries currently only operate at depths of less than about 2,000 m. However, the deep-sea environment extends to the maximum depths of the ocean and future prospective exploitation that may occur in deeper waters is included”.

Initiative and Fishing Practices on the Deep-Sea Exploration in the Region

Though there is a great continental shelf of almost 50% occupies the area of 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 the shallow-water fishes in the region have been well documented, but the deep-sea fauna are not yet fully investigated (Yeh et al, 2003). The known deep sea pelagic resources are those of tunas, billfishes, and sharks, which are already being utilized but the resources available in the Exclusive Economic Zone (EEZs) of the countries in the Southeast Asian Region especially the demersal resources beyond 100m on the continental shelf and slope are only little or no information available. Besides, there were no surveys have been specifically directed at the deep-sea demersal and mesopelagic resources in the region.

The investigation of the deep-sea fishery resources in the Asian region have been engaged during the late 70's, the Norwegian research vessel Dr. Fridtjof Nansen in association with the FAO assisted in survey on the marine fishery resources of many countries bordering the Indian Ocean included the Waters of Indonesia, Malaysia, Myanmar, and Thailand (Nishida and Sivasubramaniam, 1986). During 1979-1980, R/V Fridtjof Nansen which well equipped for acoustic survey and fishery resources survey were conducted 49 bottom trawl operated in Myanmar Waters, 7 operations in Thai Waters, and 4 operations in Indonesia Waters (Nishida and Sivasubramaniam, 1986). From the acoustic survey and experimental trawling operations of R/V Fridtjof Nansen indicated substantial resources of deep-sea shrimp and lobsters in the unexploited ranges (200-350m) of the EEZs of Myanmar and Thai Waters (Nishida and Sivasubramaniam, 1986).

Early expenditure on the deep-sea fauna in the South China Sea region had been started in the **Philippines** waters since year 1843 (SEAFDEC, 2009-Rafael). At the beginning of the 20th century, the US Bureau of Fisheries organized long series of deep-sea sampling in the Pacific, Hawaiian Islands, the Philippines and Indonesia using the vessel name "Albatross". The "Albatross" stayed in the Philippines from February 1908 to January 1910 and conducted the dredging and trawling survey of about 292 stations (sea depth more than 185m) (SEAFDEC, 2009-Rafael). From those Albatross expenditure, numerous taxonomic works were produced and many new crustacean species in the Philippines waters had been described included a living fossil of the glypheid (*Neiglyphea inopinata*) (SEAFDEC, 2009-Rafael). Another major series of deep-sea exploration in the Philippine waters was lead by the French National Museum of Natural History (known as "MUSORSTOM"). The explorations were conducted aboard R/V Vauban and R/V Coriolis in the year 1976, 1981, and 1985 at Southwest off Luzon, Mondoro, and Marinduque, respectively. The survey was focused on recapture of Neiglyphea (glypheid lobsters) specimens.

The significance of deep-sea resources survey in Philippines waters were conducted under the project "Census of Marine Life" (2005 to 2008) which was focused on taxonomy and morphology on the deep-sea benthic fauna (SEAFDEC, 2009- Rafael). As the Philippines territorial waters of about 88% is the deep water zones, the survey were covered the areas at Panglao (2004), Western Pacific off Luzon Island (2007), and off Lubang and Mindoro (2008) from sea depth at 100 to 2,250m. The exploration in many areas off Philippines waters since the year 2004 reported the significant catches of pandalid shrimps (e.g. *Heterocarpus woodmasoni*, *H. hayashii*, *H. dorsalis*) which was abundant at sea depth between 200-600m. SEAFDEC/TD in collaboration with the Bureau of Fisheries and Aquatic Resources (BFAR) has been conducted the deep sea fisheries resources on the continental shelf slopes where depth ranged between 200 and 1,000 m at Lingayen Gulf which located on the northwestern Luzon of the Philippines in the year 2008 (SEAFDEC, 2008). The catch composition of the deep-sea demersal fish caught from beam-trawl at Lingayen Gulf more than 50% were belong to family Macrouridae, Colocongridae, and Sternoptychidae, respectively (SEAFDEC, 2008). The catch per unit area (CPUA) according to depth range indicated an interesting distribution of the potential deep-sea fisheries resources at Lingayen Gulf. An average CPUA for all crustacean and fish caught from beam trawl was reported at 207 kg/km² and highest at depth between 200-400m at 348 kg/km² (SEAFDEC, 2008).

In **Thai Waters**, the attempt to assess the state of demersal resources in the Andaman Sea (west coast of Thailand at sea depth between 16 and 85 m) was conducted during the 5th Thai-Danish Expedition (FTDE) in the year 1966 using the national research vessel R.V. Thanarat (Seidenfaden et al., 1968). Fishes collected during the FTDE were identified into 80 species from 41 families and the specimens contained 64 species are deposited at Phuket Marine

Biological Center (Hylleberg and Boonyanate, 1993). Three major survey on deep-sea demersal in the Andaman Sea at the sea depth more than 200 m were conducted in the year 1975, 1981, and 1987 (DOF Thailand, 1983; SEAFDEC, 1982; Nishida and Sivasubramaniam, 1986; Ananpongsuk, 1989). The survey covered the continental slope at depth from 200m to 550m off Marid coast (Myanmar), off southwest of Phuket, to Adang Island (Thailand). In 1981, during the joint survey of Thai-Japanese-SEAFDEC using NAGASAKI-MARU, the predominant groups of deep-sea prawns, deep-sea lobsters, cephalopods, Nemipteridae, Synodontidae, and Elasmobranchii were recorded at the depth range 200-400 m around the continental slope off Myanmar and Thai Waters (SEAFDEC, 1982; Nishida and Sivasubramaniam, 1986). At least 35 fish families were identified after the deep-sea trawl survey in the Andaman Sea of Thailand during 1981-1987 (DOF Thailand, 1983; Ananpongsuk, 1989; Nishida and Sivasubramaniam, 1986). The species frequently found at the water depth greater than 200 m were Family Nomeidae (*Cubiceps squamicep*), Family Polymixiidae (*Polymixia japonicus*; *Polymixia berndti*), and Family Macrouridae (*Coelorhynchus* sp.; *Hymetnocephalus* sp.; *Nezumia* sp.; *Malacocephalus laevis*) (SEAFDEC, 1982; Ananpongsuk, 1989). Moreover, the decapod and cephalopod group such as deep-sea shrimp, spiny lobster, and crab were also reported with the CPUE of deep-sea shrimp between 3.7 kg/hr and 14.1 kg/hr from the survey area (Ananpongsuk, 1989).

In 1987, during the M.V. Paknam survey at sea depth between 400-421 m southwestern off Phuket Island, the maximum CPUE has been report at 181.8 kg/hr which 20.3 kg/hr was the useful species, 11.5 kg/hr was crustacean, and 150.0 kg/hr was trash fish (Ananpongsuk, 1989). Recently, a comprehensive survey under the project "Biodiversity of the Andaman Sea Shelf (BIOSHELF)" by the scientific corporation program between Denmark and Phuket Marine Biological Center (PMBC), Thailand has been conducted during 1996-2000 (Aungtonya et. al., 2000). The survey covered the areas from the Burmese border in the north to the Malaysian border in the south of Thai Waters using R.V. Chakratong Tongyai (Aungtonya et. al., 2000). Deep-sea fauna including polychaetes, crustaceans, mollusks, and fishes from the survey were collected as materials for study during the PMBC-DANIDA International Workshop held at PMBC, Thailand during 1997-1998 (Bussarawit et. al., 2008).

There was an evident shown that the deep-sea survey in **Myanmar** had been conducted since 1968 (SEAFDEC, 2009-Aung Htay Oo). However, the significant survey was conducted during 1979-1980 by the FAO/UNDP using R.V.-Dr. Fridtjof Nansen and the estimated biomass of demersal fishes in Myanmar Waters was reported between 750,000 and 800,000 tonnes (Sætersda et al, 1999). Off Myanmar Waters, the average trawl catch rate was reported to yield 259 kg/hr at the depth range 90-100 m (Sivasubramaniam, 1985). *Priacanthus macrocanthus* and *Peristedion weberi* were report most significant at the depth between 100 and 150 m, though *Nemipterus japonicus* was the most frequently occurs species and at the greater depth (151-350 m) Sea robins (*Peristedion weberi*) and deep sea lobsters (*Puerulus* sp.) were noticeably significant (Rijavec and Htun, 1984). In 1985, DOF of Myanmar had been collected the data from 533 shrimp trawls and reports the catch rates of about 31.2 kg/hr which closed to the results from the Thai-Myanmar joint survey at 31.6 kg/hr (SEAFDEC, 2009-Aung Htay Oo). There was no information on the deep-sea fisheries resources (at depth of more than 200m) from trawl survey on the continental shelves and slopes off Myanmar waters. However, the recent collaborative survey at the un-trawlable areas between Thai-Myanmar using R.V. Chulabhorn in 1990 were reported the commercial fish species distributed at the continental slope areas (e.g. yellow snapper at average catch rates of 1.7 kg/100hooks; banded grouper at average catch rates of 0.9 kg/100hooks). In 2007, M.V. SEAFDEC 2 had been conducted the bottom trawl survey on the continental shelf at eastern central part off Myanmar waters up to 100m depth and reported the highest catch rates of lizard fish (*Saurida undosquamis*) of about 20% of the total catch (91 kg/hr) (SEAFDEC, 2010-Han Win).

Deep-sea trawl surveys in the waters of **Indonesia** was first initiated at the Indian Ocean subareas of south off Java in 1972 and 1975 with assistance from the fisheries research agency from Korea under a bilateral agreement (SEAFDEC, 2009-Bambang). After the first attempted, the joint exploration on fisheries and stock assessment for demersal fish among the Government of Indonesia, the Federal Republic of Germany, the Commonwealth of Australia, and the FAO/UNDP as coordinating agency Jetindofish Project were carried out in the Indian Ocean subareas of the deep-sea resources survey from 1979 to 1981 (SEAFDEC, 2009-

Bambang). 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, during the year 1980, R/V Fridtjof Nansen was conducted the bottom trawl surveys at the west coast of Sumatra under the agreement between the Government of Indonesia and the FAO/SCSDEVPRO, an estimated standing stocks of those areas to be 65,000 tones of demersal fish with the report notes that the survey was made under the insufficient time and more research is needed (Aglen et al, 1981).

The extensive deep-sea fisheries researches in Indonesian waters were made by R/V Baruna Jaya-I in Banda Sea, Arafura Sea, and Timor Sea in 1992 and 1993 (Badrudin et al, 2004; Badrudin et al, 2005). The survey was conducted on the continental shelf and slope from sea depth at 200 m to 1,000 m Sumino and Iskandar, 1993; Soselisa et al, 1993; Wudianto and Barus, 1993). Recently, a joint survey of fishery resources was implemented between the Government of Indonesia and OFCF (Overseas Fishery Cooperation Foundation) of Japan. The survey has been made by 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 which indicated the 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 during year 2004-2005. The survey was also revealed that the area was serve as a habitat for the commercially useful species as Red roughy (*Haplostethus crassispinus*), Black roughy (*Haplostethus rubelloterus*), Alfonsino (*Beryx splendens*), and Blackthroat seaperch (*Deoderlrieinia berycoides*) (OFCF and AMFR, 2006).

The results from the survey indicated that the fishery resources in the deep water areas of Indian Ocean are still less exploited as the surveys have been conducted in the various part of west off Sumatera, south off Java, and south off Lombok Island to eastern off Timor (Aglen et al, 1981; Lohmeyer, 1982; OFCF and AMFR, 2006). However, the density of the demersal stock in the Indian Ocean was found lower than those of Java Sea and the Fish density tend to increase toward the coast (SEAFDEC, 2009). High density of the deep-sea shrimp was found at depth between 200m and 300m (Lohmeyer, 1982). In the Arafura Sea and Timor Sea showed the stock density of deep-sea prawn fluctuate between 280 kg/km² and 1970 kg/km² at sea depth from 400m to 800m (Sumiono and Iskandar, 1993). The catch rates of Caridean prawn (*Aristeus virilis*; *Heterocarpus woodmasoni*) and marine lobsters (*Metanephrops sibogae*) tend to decrease from Arafura Sea to Timor Sea but *Aristeomorpha foliacea* (Giant Red shrimp) tend to increase (Sumiono and Iskandar, 1993).

Stock density estimated for the demersal fishes at sea depth from 200m to 1,000m in Arafura Sea (sub area of Tanimbar) and Timor Sea were 475 kg/km² and 294 kg/km², respectively. The demersal fish stock in the sub areas of Western Sumatera was found fluctuated between 829 kg/km² and 1,773 kg/km² at the sea depth from 500m to 1,000m (Badrudin et al, 2006). The highest demersal fish stock density was occurred at the sea depth between 500m and 750m 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 part of Indonesia were Ophidiidae, Macrouridae, Myctophidae, Alepocephalidae, Plesiobatidae, Acropomatidae, and Trichiuridae. The major species in term of number and highest relative abundance (CPUE) are *Lamprogrammus niger*, *Trichiurus lepturus*, the lantern fish (*Diaphus* sp.), the rat-tails macrouridae (*Caelorinchus divergens*), the neoscopelids (*Neoscopelus macrolepidotus*), the spinyfins (*Diretmoides pauciradiatue*), the alepocephalid (*Bajacalifornia erimorensis*), and the trachichthyds (*Haplostetus crassispinus*) (Badrudin et al, 2006; Sumiono, 2009).

The deep-sea resources survey in **Vietnam** was conducted under the two major projects namely "Viet-Xo Joint Survey" during 1978-1988 and the "ALMRV phase I and II" during 1996-1997 and 2000-2005 (SEAFDEC, 2009-N.V. Nghia). The Viet-Xo joint surveys were conducted the otter trawl in the deep-sea areas of about 1,312 stations (at sea depth of more than 200m) and report the catch rates fluctuated from 30 kg/hr to 460 kg/hr (SEAFDEC, 2009-N.V. Nghia). The ALMRV (Assessment of the Living Marine Resources in Vietnam) survey which supported by DANIDA was comprising of two phases surveys off Vietnam Waters. The ALMRV phase I was conducted the otter trawl survey in the deep-sea area of about 63 stations and the ALMRV

phase II was conducted the otter trawl, trap, and bottom longline on the continental slope of about 28 stations.

The first attempted on the marine resources survey by the **Malaysia's** national research vessels in the EEZ of Malaysia Waters were conducted during the year 1985-1987 using R.V. Rastrelliger and during 1996-1997 using K.K. Manchong (SEAFDEC-Sallehudin, 2009). However, the access to the deep-sea resources at the area more than 30 nm offshore has been conducted recently in the year 2004 to 2005 aboard K.K. Manchong (SEAFDEC-Sallehudin, 2009). According to the limited EEZ area of the coast of Peninsular Malaysia, therefore, the expansion of the trawl fishery into the deeper end of its EEZ are limited at the sea depth about 185m in the east and 100m in the west coast of Peninsular Malaysia (FAO, 1999). At the west coast of Peninsular Malaysia, R/V Fridtjof Nansen undertook a visit in 1980 and reported the catch rates of about 395 kg/hr from trawling at 90 m depth in the northern part (Sivasubramaniam, 1985). The survey in the Malaysian EEZ off Sarawak waters indicated the average catch rates of demersal fish of sea depth between 92m and 185m at 44.8 kg/hr during 1987, 109.7 kg/hr during 1998, and 82.4 kg/hr during 2004-2005 (SEAFDEC-Sallehudin, 2009). The dominant fish species are the common species in the area such as *Priacanthus macrocanthus*, *Saurida tumbil*, *S. longimanus*, *Decapterus kurroides* while the deep-sea species found during the survey in 2004-2005 were the *Lophiomus* spp. (Ghost shark) and *Malakichthys elegans* (SEAFDEC-Sallehudin, 2009). At the untrawlable areas in sub-area of Sarawak Waters, the majority fish caught by bottom vertical longline (BVL) were Ariidae, Lutjanidae, Squalidae, Lethrinidae, Nemipteridae, Potunidae, and Muraenidae (SEAFDEC-Sallehudin, 2009).

The relatively short history of **Brunei Darussalam** on the fishery research survey at offshore areas started in the year 2004. Recent and advance information on the fishery resources at the continental shelves and slopes (sea depth between 100 and 400m) off Brunei waters were derived under the collaborative survey with Southeast Asian Fisheries Development Center (SEAFDEC) using M.V. SEAFDEC 2 since the year 2008. The otter-trawl survey indicated fish density along continental slope rang from 0.63 to 1.53 mt/km² with average of about 1.2 mt/km² (SEAFDEC, 2009-Matzaini). The species composition from the demersal trawl on the continental shelf and upper slope (100-200m) was reported dominant by the lizard fish (*Saurida tumbil*) and nemipterids (*Nemipterus* sp.). Meanwhile, at the lower continental slope (200-400m) was reported the different species composition which dominant by the silverbelly seaperch followed by lantern fishes, and beard fish (SEAFDEC, 2009-Matzaini). Moreover, a significant amount of deep-sea shrimps (e.g. *Heterocarpus* sp., *Plesionika* sp.) were caught from beam trawl at the sea depth between 215-374m (SEAFDEC, 2009-Matzaini).

Issues and Challenges for Fisheries in the Southeast Asian Region

The exploration since the year 2004 in many areas off Philippines and Indonesia waters where the sea depth ranged between 200 and 1,000 m provided general knowledge about the diversity and abundance which indicated the high diversity in the area. The survey was revealed the areas those serve as a habitat for the commercially useful species as Red roughy (*Haplostethus crassispinus*), Black roughy (*Haplostethus rubelloterus*), Alfonsino (*Beryx splendens*), and Blackthroat seaperch (*Deoderlrieinia berycoides*) on the West Coast of Sumatra and Java of Indonesia and significant catches of pandalid shrimps (e.g. *Heterocarpus woodmasoni*, *H. hayashii*, *H. dorsalis*) on the continental shelf and slope off the West Coast of the Philippines waters (OFCF and AMFR, 2006; SEAFDEC, 2008). The results from the joint explorations indicated that the fishery resources at the various parts of Indonesia and Philippines are still less exploited and likely to be vulnerable to the marine ecosystems, particularly a low-productivity species and sensitive deep-sea habitats. Besides, there may be direct impacts to the countries where their fleets are currently conducting or planning to expand fisheries to the deep water areas.

As the human demand on fishery resources increased, there was the bench mark of commercial deep-sea fishery started in Indonesia since the year 2008 (SEAFDEC, 2010). The commercial deep-sea fishing practice such as gill-net, trawl, bottom longline, multiple hook and line, and trap has been attempted in Indonesia and Philippines (SEAFDEC, 2010). However, the impacts of the deep-sea fishing practices are not yet study and there was no specific regulation related to deep-sea fishing practice in the region including the demand to utilize the deep-sea resources also lack of knowledge. As the FAO International Guidelines for the Management of Deep-sea

Fisheries in the High Seas were adopted in 2008 and may consider including those within national jurisdiction. Therefore, the extent of implication of management requirement for deep-sea fisheries in EEZs should also carefully study.

SEAFDEC Activities on Deep-Sea Fisheries Resource Exploration

The project has been supporting investigations of deep-sea fishery resources in the Southeast Asian waters in close collaboration with the SEAFDEC Member Countries. Together with the HRD activities (e.g. training; workshop; on the job training) were conducted to encourage the Member Countries to take initiatives in conducting deep-sea resources exploration in their EEZ waters in order to investigate the status and potentials of the deep-sea fishery resources. From the point of view of the international concerns on ecosystem approach for the deep-sea fisheries and based on the data collected through the actual surveys since 1998, collaboration and coordination with other relevant initiatives were also enhanced. The initial progress report on the project had been communicated to the project participants and public in the forum of set of preliminary reports on the results of the survey; set of guidelines and standard operation procedures in the level of scientific survey/operation; set of posters of fishes and the initial set of collection and catalogue of fishes collected from the survey.

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